

Records of chromatic disorder in *Molossus molossus* and *Sturnira bakeri* (Chiroptera) from western Ecuador

Registros de desorden cromático en *Molossus molossus* y *Sturnira bakeri* (Chiroptera) en el occidente de Ecuador

Jaime A. Salas *^{1,2,3}

<https://orcid.org/0000-0003-3468-5178>
jaime.salasz@ug.edu.ec

Lisette Torres¹

<https://orcid.org/0000-0002-3006-3446>
lisette.trs@gmail.com

Karina Marcillo¹

<https://orcid.org/0000-0001-7784-3338>
karinmaroth@gmail.com

Marcia Méndez¹

<https://orcid.org/0000-0003-2804-6652>
marcia.mendez2017@gmail.com

*Corresponding author

1 Universidad de Guayaquil-Facultad de Ciencias Naturales, Carrera de Biología, Ecuador.

2 Universidad Espíritu Santo, Samborondón. Ecuador.

3 Fundación Desarrollo y Biodiversidad-FUNDEBIO.

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Resumen

Reportamos casos de leucismo en las especies de murciélagos *Molossus molossus* y *Sturnira bakeri* capturados en tres localidades de tierras bajas del occidente de Ecuador, los cuales incluyen tres hembras grávidas, cinco juveniles, cuatro subadultas, y seis adultos. Los ejemplares de *M. molossus* presentaron manchas blancas en distintas partes blandas del cuerpo (orejas, trago, propatagio y uropatagio) y en el pelo (garganta y abdomen), mientras que el ejemplar de *Sturnira bakeri* presentó un parche blanco-amarillento en la región dorsal, a nivel del omoplato, muy contrastante en murciélagos de hombros amarillos. En América del Sur, se tiene poco conocimiento sobre los trastornos cromáticos en los murciélagos, por lo que es necesario informar estos casos e investigar los factores que los provocan.

Abstract

Herein we report cases of leucism in *Molossus molossus* and *Sturnira bakeri* from three locations of lowlands of western Ecuador, which include three gravid females, five juvenile, four subadult, and six adults. The *M. molossus* specimens showed white spots on several parts in the soft part of body (ears, tragus, propatagium, uropatagium), and fur (throat, abdomen), while individual of *S. bakeri* presented a whitish-yellowish patch on its dorsal region, very contrast in yellow-shoulder bats. Although South America has a significant information gap about chromatic disorders in bats, been necessary to continue reporting cases of chromatic disorders to try to determine their causes.

Palabras claves:

Molossus molossus; *Sturnira bakeri*; anomalías pigmentarias; tierras bajas de la costa ecuatoriana.

Keywords:

Molossus molossus; *Sturnira bakeri*; chromatic disorders; Ecuadorian coastal lowland.

Introduction

Diverse faunal groups can show atypical or abnormal coloration on the body; these abnormalities have been classified according to their phenotypic characteristics as albinism, leucism and melanism. In albinism, the pelage and skin are whitish, and the coloration of the eyes is red; in leucism, white spots appear on various regions of the body, but the coloration of the eyes is normal; and in melanism, hyperpigmentation or darkening of hair tones is present (Uieda 2000, Sánchez-Hernández et al. 2010, Tello et al. 2014, Lucati & López-Baucells 2016, Zortúa & Silva 2018). These pigmentary disorders are attributed to the expression of mutant alleles (Bensch et al. 2000, Moller & Mousseau 2001) or the enzyme tyrosinase absence, which produces melanin in vertebrates (Lucati & López-Baucells 2016, Za-

lapa et al. 2016). The colour abnormalities have also been attributed to environmental or biological factors (Holyoak 1978, Lucati & López-Bauchells 2016, Moller & Mousseau 2001) such as geographic isolation that limits connectivity between populations, inducing inbreeding (Bensch et al. 2000, Chętnicki et al. 2007).

These chromatic disorders have been reported in individuals of the Phyllostomidae, Mormoopidae, Molossidae, and Vespertilionidae families from North and South America (Caire & Thies 1988, Geiger & Pacheco 2006, Hernández-Mijangos 2009, Idoeta et al. 2011, García-Morales et al. 2012, 2013, Ruelas et al. 2016, Zortéa & Silva 2018, Hernández-Aguilar & Santos-Moreno 2018). For example, in South America, cases of these conditions have been reported in molossids in the genera *Molossus*, *Eumops*, *Nyctinomops*, and *Tadarida* in Peru (Tello et al. 2014), Brazil (Veiga & Oliveira 1995, Sodr e et al. 2004, Geiger & Pacheco 2006, Nascimento et al. 2018), Venezuela (Soriano et al. 1993, Mu oz-Romo et al. 2014), and Argentina (Romano et al. 2015). In frugivorous phyllostomids, these cases have been reported in Venezuela (Mu oz-Romo et al. 2014, Melo-Torres & Salazar-Candelle 2016), Colombia (Roncancio & Ram rez-Chaves et al. 2008, Mar n-Vasquez et al. 2010, Velandia-Perilla et al. 2013, Olarte-Gonz lez et al. 2014, Chac n et al. 2015, Calder n- lvarez & Mar n-V squez 2018), Peru (Medina & L pez 2008, Ruelas et al. 2016), Argentina (Barquez et al. 2003), and Brazil (Oliveira & Aguiar 2008, Souza et al. 2013, Rocha et al. 2013, Falc o 2014, Rosa et al. 2017) in various species in the genera *Sturnira*, *Artibeus*, and *Carollia*.

In Ecuador, three cases of atypical colorations have been recorded in bats, all belonging to the Phyllostomidae family: leucism in *Carollia perspicillata* (Boada & Tirira 2010) and *Artibeus fraterculus* (Fern ndez de C rdova et al. 2017) and albinism in *Vampyrum spec-trum* (Brito & Le n 2014). Here, we report new cases of leucism in *Molossus molossus* Pallas, 1766 and *Sturnira bakeri* Velazco and Patterson, 2014 from the lowland of western Ecuador; these are the first documented cases of leucism in these bat species in Ecuador.

Materials and methods

The leucism cases were recorded in three localities from lowland of western Ecuador:

1) Bosque Protector Cerro Blanco (2 10'S; 80 0'W). This is a private reserve, managed by Fundaci n Pro-Bosque, and it is located at the southernmost end of the Chong n-Colonche Range on the edge of the urban area of the city of Guayaquil, in the province of Guayas. The predominant vegetation is secondary dry forest, with disturbed areas and small mature patches. Sampling was conducted near an artificial refuge, which is close to the main road and residential areas and a less than one kilometer from a mining area. The refuge is an abandoned house built of cement block walls and pillars and roofed with palm leaves, locally known as "cade". The bats were captured during the rainy season in February 2016.

2) Cerro Cachar  (1 46'S, 79 27'W). This is private land located eight kilometers from the city of Babahoyo in the province of Los R os. This is a forested remnant located in a transition zone between deciduous (dry) forests and evergreen (humid) forests. Cachar  is formed by a small rocky outcrop with fractured plutonic rocks, including a main cave and numerous cracks. The structure forms a small hill in the midst of a floodplain, and there are large areas of rice crops around it. Non-systematic samplings were carried out from December 2016 to June 2018, both in the cave and around the rest of the forest remnant.

3) Isla Santay National Recreation Area (2 13'S; 79 52'W). This protected area is managed by the Ministerio de Ambiente y Agua de Ecuador. It comprises a wetland located in the Guayas River and has flooded areas, shrub, and dry forest remnants towards the center; it is surrounded by mangroves. Isla Santay is between two large cities, Guayaquil y Eloy Alfaro (Dur n), in the province of Guayas. The island contains a small community, called "Ecoaldea"; the *M. molossus* individuals were captured in the houses of this community. The sampling was carried out in November of 2019.

Bats were caught using mist nets. External morphometric measurements (in mm) were taken using a digital caliper as follows: forearm length (FA), tail length (T), head-body length (HB), foot length (F), and ear length (E). The age class (juvenile, subadult, or adult) was determined by observing the epiphyseal-diaphyseal fusion (Brunet-Rossinni & Wilkinson 2009); the reproductive condition was determined by direct observation of primary sexual characteristics (Racey 2009). We followed the guidelines of the American Society of Mammalogists (Sikes et al. 2016) for animal handling.

The molossids were identified as *Molossus molossus* based on the following morphological and morphometric characteristics: smooth upper lip without grooves, small, rounded ears rising from the same point on the forehead, antitragus taller than wide, bicolored fur, and forearm length (FA) between 35 – 40 mm. These characteristics distinguish *M. molossus* from other species in the same genus that also inhabit western Ecuador, such as *M. bondae*, which has fur of a single color, and *M. rufus*, which has a FA greater than 50 mm (Eger 2008; D az et al. 2016; Tirira 2017). The populations of *M. molossus* that dwell in the western Andes in Ecuador are recognized as *M. m. daulensis* (Brosset 1965; Eger 2008). Before release, each individual was photographed, except for MZUGM-605.

The specimen of *Sturnira* was identified as *S. bakeri* due to the following characteristics: tetracolored dorsal hair, observable in stereo microscope, short and woolly fur approximately 5 mm in length between the shoulders, tricolor ventral hair, sparsely hairy forearm, dorsal surface of the femur, tibia, and foot densely covered by long hairs, IV metacarpal shorter than III metacarpal, and somatic measurements (FA, T, HB, F, E) in accordan-

ce with those described for the species. Cranio-dental diagnostic features observed were oval sphenorbital fissure, globular cranial box, narrow face, well-developed sagittal crest, absent anterior process of the glenoid fossa, and metaconid and entoconid in well-defined M1 and M2, separated from each other by a deep notch (Velazco & Patterson 2014; Sánchez & Pacheco 2016; Montoya-Bustamante et al. 2017). The collected specimens were deposited in the mammal collection of the Museo de Zoología of the Universidad de Guayaquil (MZUGM).

Results

The caught leucistic individuals of *Molossus molossus* were six individuals (♀ = 5; ♂ = 1) from Cerro Blanco, one sub-adult female (MZUGM-605) from Cerro Cacharí inside the cave, and ten individuals (♀ = 8, ♂ = 2) from Isla Santay. Table 1 shows external measurements, age, and reproductive conditions of these individuals. The specimens of *M. molossus* presented white spots or patches on the head, ears, legs, throat, propatagium, and uropatagium; bats from Isla Santay also presented dorsal and ventral fur with silverish tips.

The specimen of *Sturnira bakeri* was a pregnant female (MZUGM-705; FA= 44; HB=64.3; F= 17.7; E=15.8; Weight: 31 g), captured with mist-nets in the forest remnant of Cerro Cacharí; the individual presented a whitish-yellowish patch on its dorsal region, from the top

of the upper left scapular region to the apophysis of the scapula, in contrast to the coloration normally present in yellow-shouldered bats. Figure 1 shows the individuals with leucism of both species.

Discussion

Bats with chromatic disorders have not been reported before in reserves from western Ecuador (Carrera et al. 2010, Fernández de Córdova et al. 2017, Parker & Carr 1992, Salas 2008). Our leucistic individuals from Guayas represent the first cases for this geographical region, and were not apparently related to external morphology, age or reproductive condition (Eger 2008; Velazco & Patterson 2014; Díaz et al. 2016; Tirira 2017; García-Morales et al. 2012, 2013; Sánchez-Hernández et al. 2010).

The chromatic abnormalities found in *M. molossus* were observed in different body regions (ears, tragus, throat, chest, abdomen, back, wings, legs, propatagium, uropatagium), and constitute the first known cases of leucism for this species. Previously, only albinism cases had been reported in *M. molossus* (Nascimento et al. 2018, Soriano et al. 1993, Veiga & Oliveira 1995, Tello et al. 2014). The appearance of this condition in various individuals during a single sampling, near their known refuge was remarkable (Lucati & López-Baucells 2016, Uieda 2000, Zalapa et al. 2016), so it is likely they belonged to the same colony.

Table 1. External morphometric measurements (in mm) of leucistic *Molossus molossus* individuals: forearm length (FA), tail length (T), head-body length (HB), leg length (L) and ear length (E). KMR corresponds to the field acronym of Karina Marcillo-Rodríguez, MZUGM corresponds to the code of the mammal collection in Museo de Zoología of Universidad de Guayaquil, and IS is the field code that corresponds to Isla Santay.

N°	CODE	SEX	FA	T	HB	L	E	Age, reproductive condition
1	KMR 01	♀	37	18	52	17	10	Adult, pregnant
2	KMR 06	♀	36	19	50	11	11	Subadult, inactive
3	KMR 07	♀	36	33	46	12	8	Subadult, inactive
4	KMR 09	♀	35	22	51	11	11	Subadult, inactive
5	KMR 10	♀	34	25	54	14	9	Adult, Pregnant
6	KMR 13	♂	36	24	44	13	9	Adult, inactive
7	MZUGM-605	♀	34	30	52	15	10	Subadult, inactive
8	IS-27	♀	36	32	50	15	7	Adult, inactive
9	IS-28*	♂	37	36	50	22	7.5	Juvenile, inactive
10	IS-29	♀	36	33	54	18	9	Adult, inactive
11	IS-31**	♀	36	35	55	21	9	Juvenile, inactive
12	IS-34*	♀	36.5	37	47	19.5	8	Juvenile, inactive
13	IS-35	♀	35	31	39	-	10	Juvenile, inactive
14	IS-36*	♀	37	37	48	19	9	Adult, inactive
15	IS-40	♀	37	32	54	19	10	Adult, inactive
16	IS-41	♂	36.5	34	49	22	11	Adult, scrotal testes
17	IS-42***	♀	35	36	50	19	10.3	Juvenile, inactive

Notes: * Silver-tipped fur on back, ** various small spots on back and underside of right-wing, *** Fuzzy, silver-tipped fur on back, chin, and head.

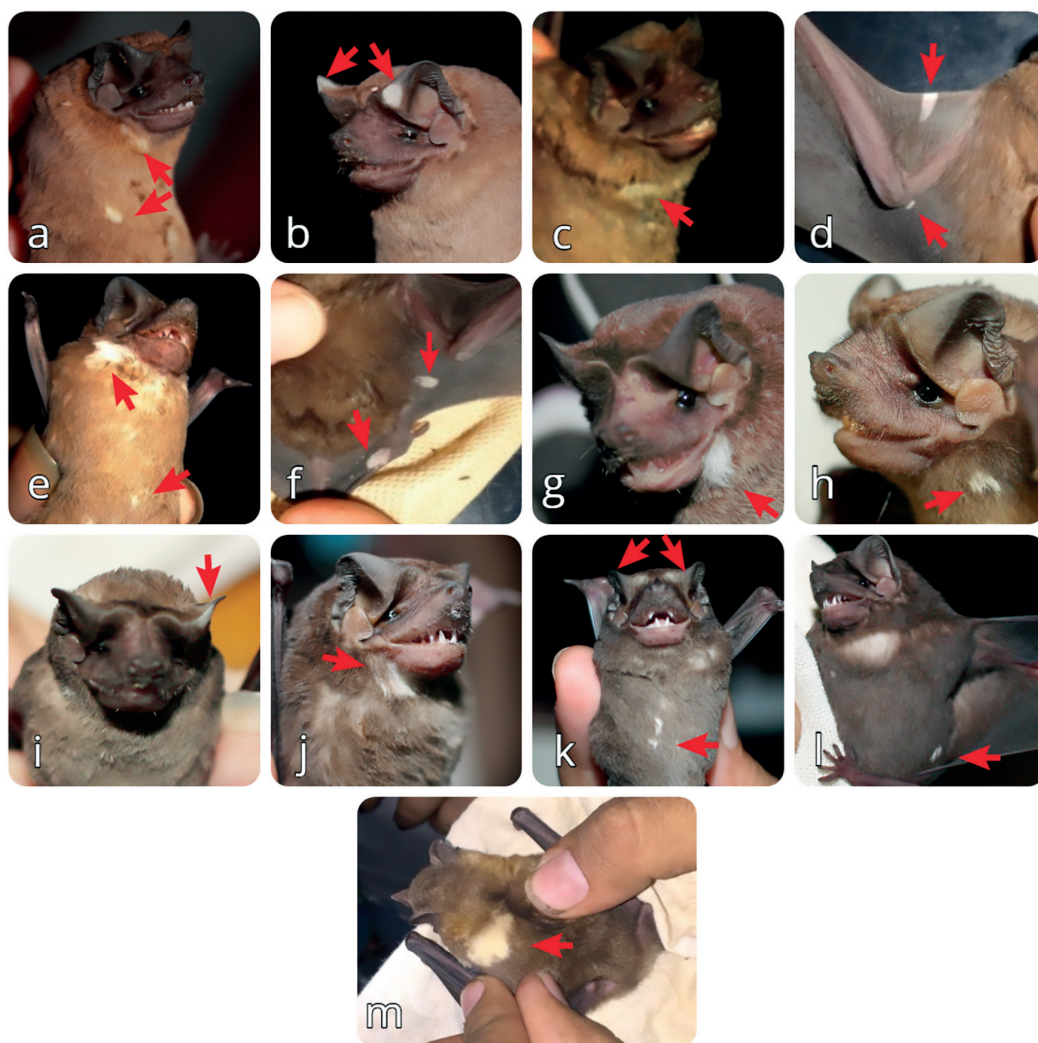


Figure 1. Leucistic bats: red arrows indicate pigmentary disorders. KMR corresponds to the field acronym of Karina Marcillo-Rodríguez for the individuals captured in Cerro Blanco, MZUGM corresponds to the code of mammal collection in the Museo de Zoología of Universidad de Guayaquil for individuals collected in Cerro Cacharí, and IS is the field code that corresponds to Isla Santay. *Molossus molossus*: a) KMR-01: pregnant female with various white spots on abdomen, b) KMR-06: subadult female with white spots on inner edge of ears, c) KMR-07: subadult female with whitish patch in pectoral region, d) KMR-09: subadult female with whitish spots on propatagium and left wing, e) KMR-10: pregnant female with extensive white patch on chest and various white spots on abdomen, f) KMR-13: male with white spots on right wing and uropatagium, g) MZUGM-605: subadult female with white spot on neck, h) IS-27: adult female with white spot on neck, i) IS-29: adult male with white spot on neck and inner edge of left ear, j) IS-35: adult female with white spot on neck and diffuse dorsal and ventral spots, k) IS-40: adult female with white spot on right leg, two small white spots on chest, and silverish discoloration on basal part of tragus and ears l) IS-41: female presents silver-tipped abdominal fur and white spot on left ventral side. *Sturnira bakeri*: m) MZUGM-705: pregnant female with whitish-yellowish patch on dorsal region, from the beginning of upper left scapular region to apophysis of scapula. All photos taken by Jaime Salas except for c, d, e, and f, which were taken by Lisette Torres.

In contrast to the leucistic *M. molossus* individuals, the *Sturnira bakeri* specimen was not captured near its refuge, but rather on its flight path through the forest, which is infrequently recorded for bats (Rose et al., 2017). Our report of leucism in *S. bakeri* is the first for the species, since previous cases have been recorded in different species of *Sturnira* such as *S. hondurensis* (García-Morales et al. 2012), *S. erythromos* (Barquez et al. 2003; Roncancio & Ramírez-Chaves 2008), *S. parvidens* (Zalapa et al. 2016), and *S. lilium* (Medina & López 2008; Melo-Torres

& Salazar-Candelle 2016), in pregnant females, males, and subadults of these species.

Although chromatic aberrations in bats seem to be a worldwide phenomenon, South America has a significant information gap (Lucati & López-Baucells 2016), and the little known comes from last few years (Hernández-Aguilar & Santos-Moreno 2018, Rose et al. 2017, Ruelas et al. 2016, Tello et al. 2014, Zortúa & Silva 2018). Therefore, these chromatic disorders and their causes should be investigated in order to complement available data on the subject.

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JAS: conceptualization, research, curation of specimens, wrote the initial manuscript, field work. analysis of data. LT: writing, proofreading and editing, field work. analysis of data. KM: writing, revision and editing, field work. analysis of data. MM: specimen curation, writing, proofreading and editing, field work, data analysis.

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