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## Artículo

### Anomalous coloration in Neotropical mammals: New cases of pigmentation disorders in Venezuelan mammals revealed by review of natural history museums

Franger J. García, Marjorie Machado, Guillermo Flórez,  
Pascual J. Soriano, Hillary J. Cabrera

**Abstract.** Pigmentation disorders in vertebrates are considered as a rare phenomenon in nature and their possible causes are linked to factors such as environmental contamination, inbreeding and heritable condition of some mutations. In recent years, the information concerning with this topic in Neotropical mammals has considerably increased. This study documents new cases of chromatic anomalies in Venezuelan mammals, derived from a review of specimens deposited in natural history museums from Venezuela. We report the first cases of albinism for two frugivorous bats (Chiroptera: Phyllostomidae: Carolliinae and Stenodermatinae) and for the red-rumped agouti (Rodentia: Dasyproctidae); likewise, three cases of leucism in two frugivorous bats (Chiroptera: Phyllostomidae: Carolliinae and Stenodermatinae) and one nectarivorous species (Chiroptera: Phyllostomidae: Glossophaginae). The piebaldism was the phenotypic condition with more records in individuals and species (34 cases, 11 species). In recent years, the importance of natural history museums and the value of vertebrate specimens associated with them has gained relevance in different fields of biology and conservation of biological diversity; hence, the contribution of our study demonstrates the utility of reviewing scientific collections to increase the knowledge in different areas of the biological sciences.

**Key words:** Albinism; hypopigmentation; leucism; melanism; piebaldism.

Coloración anómala en mamíferos neotropicales: Nuevos casos de desórdenes de pigmentación en mamíferos venezolanos revelados por la revisión de museos de historia natural.

**Resumen.** Los desórdenes de pigmentación en vertebrados son considerados como un fenómeno raro en la naturaleza y sus posibles causas están vinculadas a factores como contaminación ambiental, endogamia y condición hereditable de algunas mutaciones. En recientes años, la información sobre este tópico se ha incrementado considerablemente en mamíferos neotropicales. En este estudio se documentan nuevos casos de anomalías cromáticas en mamíferos venezolanos derivado de una revisión de especímenes depositados en museos de historia natural de Venezuela. Se reportan los primeros casos de albinismo para dos murciélagos frugívoros (Chiroptera: Phyllostomidae: Carolliinae y Stenodermatinae) y para el picure de grupa roja (Rodentia: Dasyproctidae); de igual manera, se reportan tres nuevos casos de leucismo para dos especies de murciélagos frugívoros (Chiroptera: Phyllostomidae: Carolliinae y Stenodermatinae) y para una especie nectarívora (Chiroptera: Phyllostomidae: Glossophaginae). La condición cromática de piebaldismo fue la mejor representada con 34 casos en 11 especies. En recientes años, la importancia de los museos de historia natural y el valor de los especímenes de vertebrados asociados con éstos han ganado relevancia en diferentes campos de la biología y conservación de la diversidad biológica; por lo tanto, la contribución de este estudio demuestra la utilidad de las colecciones científicas para incrementar el conocimiento en diferentes áreas de las ciencias biológicas.

**Palabras claves:** Albinismo; hipopigmentación; leucismo; melanismo; piebaldismo

## Introduction

In recent years the information concerning with pigmentation disorders or chromatic anomalies in Neotropical mammals has considerably increased (e. g., Abreu *et al.* 2013, Falcão 2014, Rengifo *et al.* 2014, Tello *et al.* 2014, Boher *et al.* 2016, Brito and Valdivieso-Bermeo 2016, Lucati and López-Baucells 2016, Mello-Torres and Salazar-Candelle 2016, Rose *et al.* 2017, Nacimiento *et al.* 2018, Romero *et al.* 2018, Zortéa and Silva 2018). This kind of alteration has received different definitions; however, currently six cases of chromatic anomalies for mammals are proposed: Albinism, leucism, piebaldism, hipomelanism, partial melanism and melanism (Abreu *et al.* 2013, Lucati and López-Baucells 2016).

Albinism is a genetic mutation and hereditary, characterized by the lack of melanin due to the absence of the tyrosinase enzyme in melanocytes (Lucati and López-Baucells 2016). Individuals with this condition have a pelage generalized white coloration, reddish eyes and pink skin. Leucism is also another genetic mutation (hereditary), that occurs due to the lack total of melanin in skin or pelage produced to the failure of melanocytes to reach hair follicles or skin; it shows as a white or whitish coloration throughout the body of organisms without affecting the retina (Lucati and López-Baucells 2016). Piebaldism (genetic and hereditary), occurs due to the absence total of melanin in part of skin or pelage lacking of melanocytes (Lucati and López-Baucells 2016).

However, these patterns might derive from many different causes and are not necessarily linked to a certain genetic mutation. Some infectious diseases might result in piebald pigmentation patterns (e. g., Bologna and Pawelek 1988) as well as acquired progressive diseases like vitiligo lead to a piebald pigmentation patterns and can with time also end in leucism phenotypic condition (e. g., Muller 2017). To be sure about the hereditary origin of such a hypopigmented pattern, it would be essential to know about the individual's life history. And even if a hypopigmentation derives from a genetic origin, there are multiple genes that may be responsible (e. g., Peters *et al.* 2016).

On the other hand, the excess of melanin known as melanism, partial melanism and hypomelanism, generally can appear by genetic mutations and are hereditary (Lucati and López-Baucells 2016). However, there are cases of partial melanism produced by diseases, malnutrition and lack exposure to sun (Lucati and López-Baucells 2016). The coloration can be blackish or brown (melanism and partial melanism) or beige, yellowish or reddish (hypomelanism).

In Venezuela, there are few records in the literature on pigmentation disorders in the mammal fauna; mostly, they refer to bats captured with mist nets or observed occasionally in their diurnal roosting (Setzer 1950, Ochoa and Sánchez-Hernández 1988, Soriano *et al.* 1993, Muñoz-Romo *et al.* 2014, Mello-Torres and Salazar-Candelle 2016). In others, documenting cases of albinism for the first time for the spiny pocket mouse, *Heteromys anomalus* (Rodentia, Heteromyidae) and for the canid *Cerdocyon thous* (Boher-Benti *et al.* 2016). However, there is not an exhaustive review in scientific collections or natural history museums, limiting the information to cases mentioned above and to only two records of bats deposited in the Museo de Historia Natural La Salle (Caracas, Capital District; Linares 1967) and the Museo de Ciencias Naturales de Guanare

(Guanare, Portuguesa State; Soriano *et al.* 1993).

Therefore, in this study we made an effort to review some of the Venezuelan scientific collections of local importance, due to their history, geographic location and number of specimens deposited in their collections, in order to report new cases of chromatic anomalies or pigmentation disorders in mammals of Venezuela.

## Materials and methods

We limit our review only to the study skins (without taking into account those specimens preserved in ethanol or formalin). All specimens are deposited in four Venezuelan biological collections: Colección de Vertebrados de la Universidad de los Andes (CVULA, Mérida State), Museo de la Estación Biológica de Rancho Grande (EBRG, Aragua State), Museo de Historia Natural La Salle (MHNLS, Caracas, Capital District) and Museo de Zoología de la Universidad de Carabobo (MZUC, Carabobo State).

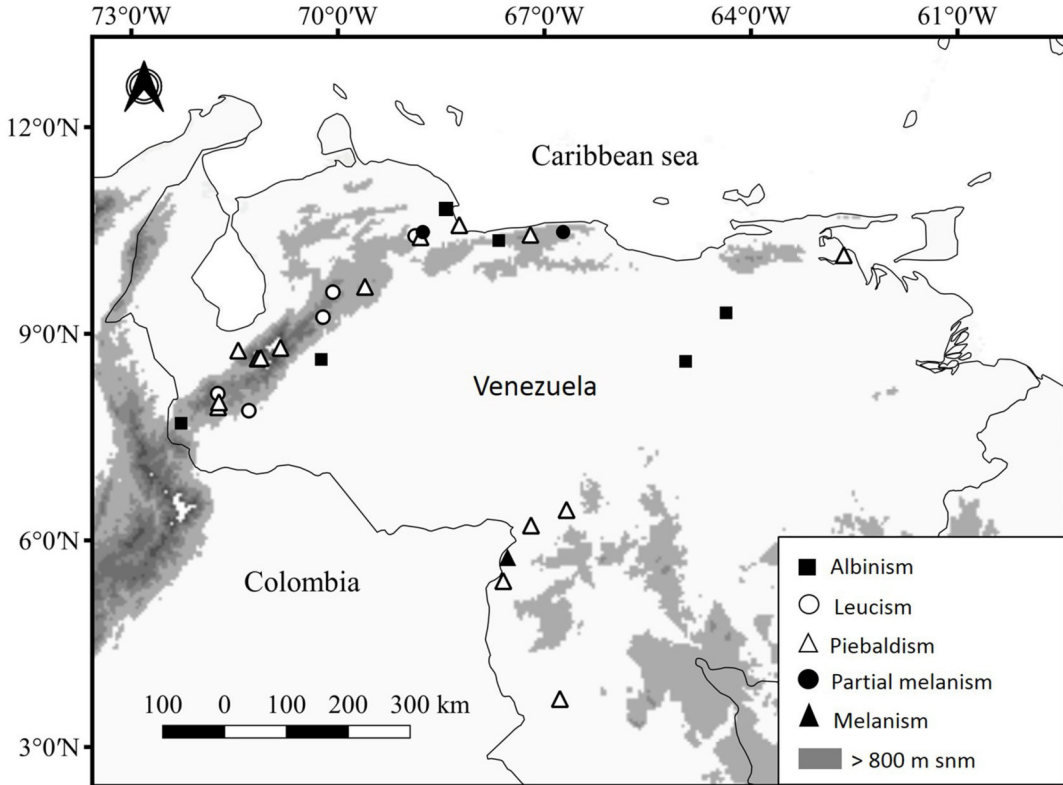
We identify each case following the classification proposed by Lucati and López-Baucells (2016). Information on specimens includes the locality with Universal Transverse Mercator coordinates (UTM), altitude [in meters above sea level (m a.s.l.)], municipality, state and a brief description of the chromatic anomaly. We complement all the information with an exhaustive review of the literature in which were reported cases of chromatic anomalies for Venezuelan mammals.

With respect to the zoological nomenclature, we consider previous records of the yellow-shouldered bat, *Sturnira lilium* as *Sturnira giannae*, recently described (Velazco and Patterson 2019). We treated the Andean population of the rodent, *Nephelomys* from Uribante (Táchira State), as *Nephelomys* sp. (Soriano *et al.* 1999).

## Results and discussion

We report new cases for small mammals (16 species), one medium-sized species and one large-sized species with chromatic anomalies in Venezuela. When we complement the information with literature, the account was 26 (Table 1). Figure 1, shows the geographic location of each case, highlighting the Andean region as the zone with more cases of chromatic anomalies.

Is notable the first records of two frugivorous bats with albinism (Phyllostomidae: Carollinae and Stenodermatinae), as well as the evidence of three new cases of leucism for one frugivorous bat species specialized in consuming *Piper* plants (Phyllostomidae: Carollinae); one bat species specialized in *Solanum* plants (Phyllostomidae: Stenodermatinae), and one bat species specialized in consuming nectar (Phyllostomidae: Glossophaginae).



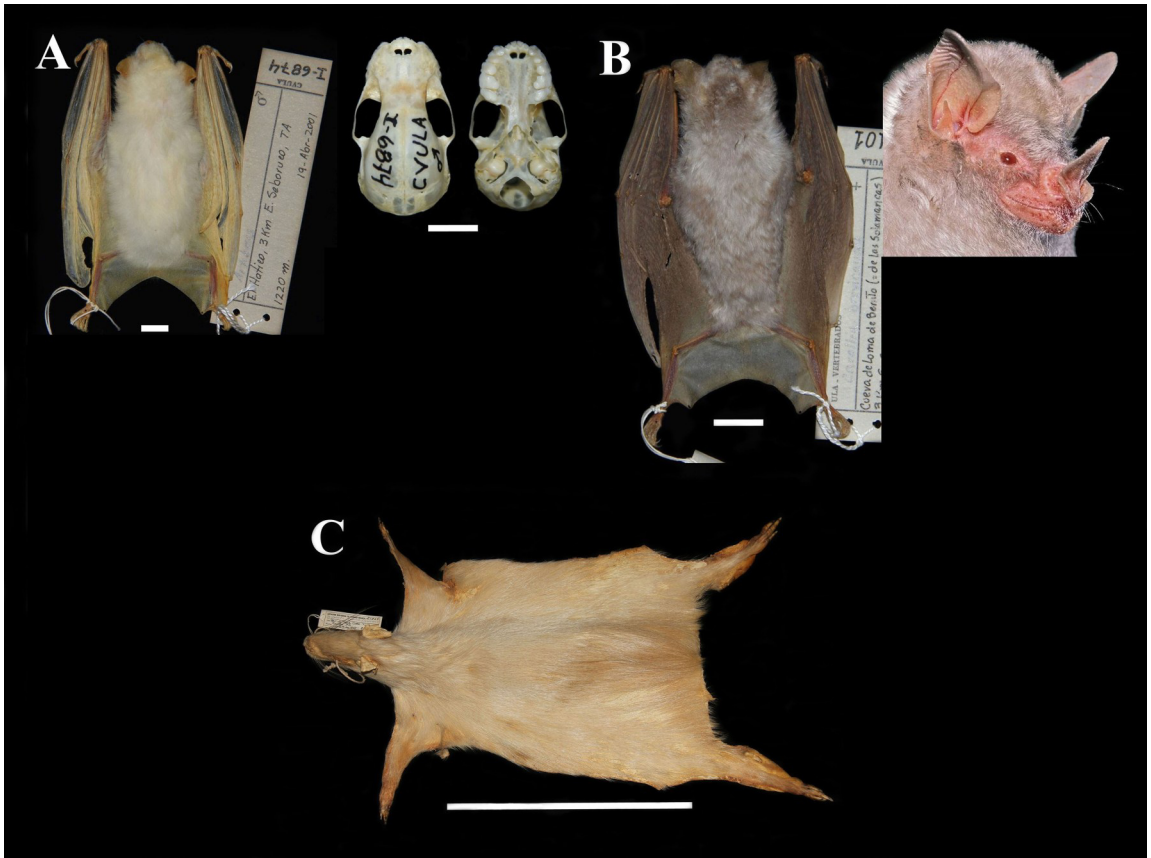
**Figure 1.** Map of Venezuela showing updated geographic distribution of pigmentation disorders or chromatic anomalies for mammalian fauna.

### Albinism cases:

CHIROPTERA Blumenbach, 1779, Phyllostomidae Gray, 1825, Stenodermatinae Gervais, 1856, *Artibeus phaeotis* (Miller, 1902) (CVULA-I-6874), represents an adult male, collected on April 19, 2001, in “El Hatico (Latitude: 8.14151; Longitude: -72.09404), 3 Km Eastern Seboruco, 1220 m a.s.l., Táchira State”. It has a completely white pelage, with dull white on wing membranes, ears and extremities (Figure 2). The specimen's tag does not specify the coloration of the eyes (only the phrase: “albino individual”). Carollinae Miller, 1924, *Carollia brevicauda* (Schinz, 1821) (CVULA-I-7101), an adult female collected on May 17, 2002, in the “cueva de Lomas de Benito (= Cueva de las Salamancas) (Latitude: 8.13091; Longitude:-71.74503), 3 Km South Guaraque, 2020 m a.s.l., Mérida State”. It has a white-grayish pelage, with reddish eyes and dark brown on ears, wing membranes and extremities (Figure 2). RODENTIA Bowdich, 1821, Dasyproctidae Bonaparte, 1838, *Dasyprocta leporina* (Linnaeus, 1758) (EBRG-21064), a young female collected on June 27, 1995, in the “Refugio de Fauna Silvestre Cuare, fundo Los Pozones (Latitude: 11.665; Longitude: -70.21), 0–100 m a.s.l., Falcón State. It has an entirely white pelage (Figure 2).

**Table 1.** Current information of Venezuelan mammals with pigmentation disorders or chromatic anomalies. The superscripts in the names of the species indicate: 1: documented for the first time; Literature: 2: Setzer (1950); 3: Ochoa and Sánchez-Hernández (1988); 4: Soriano *et al.* (1993); 5: Muñoz-Romo *et al.* (2014); 6: Mello-Torres and Salazar-Candelle (2016); 7: Lucati and López-Baucells (2016); 8: Boher-Benti *et al.* (2016).

Species	Pigmentation condition				
	Piebaldism	Leucism	Albinism	Melanism	Partial Melanism
<b>DIDELPHIMORPHIA</b>					
<b>DIDELPHIDAE</b>					
<i>Marmosops carri</i> <sup>1</sup>	X				
<b>CHIROPTERA</b>					
<b>PHYLLOSTOMIDAE</b>					
<i>Anoura caudifera</i> <sup>1</sup>		X			
<i>Anoura</i> sp. <sup>7</sup>			X		
<i>Artibeus amplus</i> <sup>5,7</sup>	X				
<i>Artibeus phaeotis</i> <sup>1</sup>			X		
<i>Carollia brevicauda</i> <sup>1,4,7</sup>			X		
<i>Carollia perspicillata</i> <sup>1</sup>		X			
<i>Chrotopterus auritus</i> <sup>1</sup>					X
<i>Glossophaga longirostris</i> <sup>2,7</sup>			X		
<i>Lonchorhina fernandezii</i> <sup>3,7</sup>	X				
<i>Lophostoma silvicola</i> <sup>1</sup>	X				
<i>Phylloderma stenops</i> <sup>1</sup>	X				
<i>Phyllostomus discolor</i> <sup>1</sup>	X				
<i>Sturnira erythromos</i> <sup>1</sup>		X			
<i>Sturnira giannae</i> <sup>6</sup>	X				
<b>VESPERTILIONIDAE</b>					
<i>Myotis keaysi</i> <sup>1</sup>					X
<b>MOLOSSIDAE</b>					
<i>Molossus molossus</i> <sup>4,7</sup>			X		
<b>CARNIVORA</b>					
<b>FELIDAE</b>					
<i>Panthera onca</i> <sup>1</sup>				X	
<b>RODENTIA</b>					
<b>SCIURIDAE</b>					
<i>Notosciurus granatensis</i> <sup>1</sup>	X				
<b>HETEROMYIDAE</b>					
<i>Heteromys anomalus</i> <sup>8</sup>			X		
<b>CRICETIDAE</b>					
<i>Ichthyomys pittieri</i> <sup>1</sup>	X				
<i>Necomys urichi</i> <sup>1</sup>	X				
<i>Necomys rattus</i> <sup>1</sup>	X				
<i>Nephelomys meridensis</i> <sup>1</sup>	X				
<i>Nephelomys</i> sp. <sup>1</sup>	X				



**Figure 2.** Cases of albinism in Venezuelan mammals (Chiroptera and Rodentia). A. Dorsal view of the skin (scale = 10 mm) and skull of *Artibeus phaeotis* (CVULA-I-6874; scale = 5 mm). B. Dorsal view and region of head (animal still alive), showing the reddish eyes in *Carollia brevicauda* (CVULA-I-7101; scale = 10 mm). C. Skin of *Dasyprocta leporina* (EBRG-21064; scale = 200 mm).

### Leucism cases:

CHIROPTERA Blumenbach, 1779, Phyllostomidae Gray, 1825, Glossophaginae Bonaparte, 1845, *Anoura caudifera* (É. Geoffroy St.-Hilarie, 1818) (MHNLS-798), an adult female collected on August 31, 1961, in “Minas de Aroa (Latitude: 10.42110; Longitude: -68.87795), 500 m a.s.l., Yaracuy State”. It has a dull white pelage with dark brown on ears, wing membranes and extremities (Figure 3). Stenodermatinae Gervais, 1856, *Sturnira erythromos* (Tschudi, 1844) (EBRG-24426), an adult male collected on April 27, 1998, in the sector “Buenos Aires (Latitude: 9.60472; Longitude: -70.07297), Dinira National Park, 1900 m a.s.l., Lara State”. The individual has a white-grayish pelage with dark brown on the ears, wing membranes and extremities (Figure 3). Carollinae Miller, 1924, *Carollia perspicillata* (Linnaeus, 1758) (CVULA-I-8769), an adult male collected on January 13, 2011, in “Caparo (Latitude: 7.88369; Longitude: -71.29400), 30 Km Eastern Cantón, 200 m a.s.l., Barinas State”. It has a whitish-brown pelage, with dark brown on ears, wing membranes and extremities.



**Figure 3.** Cases of leucism in Venezuelan mammals (Chiroptera). A. *Anoura caudifera* (MHNLS-798). B. *Sturnira erythromos* (EBRG-24426). Scale = 20 mm.

### Piebaldism cases:

DIDELPHIMORPHIA Gill, 1872, Didelphidae Gray, 1821, Didelphinae Gray, 1821, *Marmosops carri* (J.A. Allen and Chapman, 1897) (MZUC-868), an adult male collected on January 12, 2008 in the “Estación Experimental Bajo Seco (Latitude: 10.43861; Longitude: -67.20428), 1700 m a.s.l., Vargas State”. It has small white spots on the upper and lower dorsum (Figure 4). CHIROPTERA Blumenbach, 1779, Phyllostomidae Gray, 1825, Phyllostominae Gray, 1825, *Lophostoma silvicola* (D’Orbigny, 1836) (EBRG-15740), an adult male collected on March 29, 1987, in the “serranía de los Pijiguaos (Latitude: 6.44222; Longitude: -66.67944), 620 m a.s.l., 140 Km Southwestern Caicara, Bolívar State”. The individual has a small white spot on the middle dorsum. *Phyloderma stenops* Peters, 1865 (two adult individuals), a pregnant female (EBRG-2737), collected on May 23, 1981, in “Medio alto, caño Yagua, cerca de cerro Cucurito (Latitude: 3.69777; Longitude: -66.77583), 120 m a.s.l., Atabapo, Amazonas State”. It has several small white spots on the dorsum and head; a male (EBRG-17695), collected on March 11, 1992, in “Boca caño La Brea (Latitude: 10.14255; Longitude: -62.65166), 100 m a.s.l., Reserva Forestal de Guarapiche, Sucre State”. It also has small white spots on the dorsum and head. *Phyllostomus discolor* (J.A. Wagner, 1843) (EBRG-5603), an adult female collected on October 03, 1965, in “35 Km Northwestern Puerto Cabello (Latitude: 10.57777; Longitude: -68.23694), 02 m a.s.l., Boca de Yaracuy, Falcón State”. It has several small white spots on the dorsum and head.

RODENTIA Bowdich, 1821, Sciuridae G. Fisher, 1817, Sciurinae G. Fisher, 1817, *Notosciurus granatensis* (Humboldt, 1811) (CVULA-I-8430), an adult female collected on January 27, 2006, in the “Destierro (Latitude: 8.75693; Longitude: -71.44851), 7 Km North Azulita, 560 m a.s.l., Mérida State”. It has small and scattered white spots on the mid dorsolateral and lateral region of the head. In the belly, it has long white spots on the chest, inguinal area and on the tail. Cricetidae G. Fisher, 1817, Sigmodontinae J.A. Wagner, 1843, *Necomys urichi* (J. A. Allen and Chapman, 1897) (CVULA-I-1198), an adult male collected on March 19, 1978, in “Páramo de Mucubají (Latitude: 8.79578; Longitude: -70.83446), 3650 m a.s.l., Mérida State”. It exhibits a small whitish spot on the middle region of dorsum. *Nephelomys meridensis* (Thomas, 1894), we confirmed the presence of 12 individuals of *N. meridensis* with this genetic condition. Three individuals have more evidence of piebaldism (Figure 4): CVULA-I-1009: an adult male has a white spot on the dorsal region of the head. It was collected on February 24, 1979, in “Monte Zerpa (Santa Rosa), 6 Km North Mérida (Latitude: 8.62959; Longitude: -71.16312), 2060 m a.s.l., Mérida State”; CVULA-I-1010: an adult female has a wide white spot on the lower dorsolateral region. Likewise, it was collected on February 24, 1979, in “Monte Zerpa (Santa Rosa), 6 Km North Mérida (Latitude: 8.62959; Longitude: -71.16312), 2160 m a.s.l., Mérida State”, and CVULA-I-5648: another adult female, has a wide spot white on dorsal-lateral anterior and lower region of dorsum. It was collected on September 19, 1993, in “San Javier del Valle (Latitude: 8.66234; Longitude: -71.11924), 8 Km North Mérida, 2370 m a.s.l., Mérida State”.

The following individuals of *Nephelomys meridensis* have less evidence of piebaldism, restricted to small areas of the body: CVULA-I-6134 (a small white spot on the middle dorsum): an adult male collected on January 28, 1995, in “Cerro Alto (Latitude: 8.81666; Longitude: -70.53333), 2 Km Northwestern Santo Domingo, 1460 m a.s.l., Mérida State”. Six adult male specimens have a small white spot on the dorsal region of the head. CVULA-I-2740: collected on August 7, 1986, in the “Blanquito (Latitude: 9.64166; Longitude: -69.51305), Yacambú National Park, 1600 m a.s.l., Lara State”; CVULA-I-7045: collected on August 08, 1986, in the “Avileño (Latitude: 9.68305; Longitude: -69.60722), Yacambú National Park, 9 Km South Sanare, 1600 m a.s.l., Lara State”; CVULA-I-1092, 1094, 1095: collected on September 13–17, 1979 and July 07, 1980, in “Monte Zerpa (Latitude: 8.62959; Longitude: -71.16312), 3 Km North Mérida, 2100–2400 m a.s.l., Mérida State”; CVULA-I-1066: collected on June 15, 1980, in “La Carbonera (Latitude: 8.64416; Longitude: -71.41583), La Culata National Park, 2500 m a.s.l., Mérida State”. An adult male (CVULA-I-1001), has a white spot on the lower dorsum. It was collected on February 25, 1979, in “Monte Zerpa (Latitude: 8.62959; Longitude: -71.16312), (Santa Rosa), 6 Km North Mérida, 2200 m a.s.l., Mérida State”. Another individual adult male (CVULA-I-0840), collected on February 26, 1979, in “Monte Zerpa (Latitude: 8.62959; Longitude: -71.16312), (Santa Rosa), 6 Km North Mérida, 2200 m a.s.l., Mérida State”, has small white spots on dorsal region of the head and middle dorsum.

Cricetidae G. Fisher, 1817, Sigmodontinae J.A. Wagner, 1843, *Nephelomys* sp: Ten individuals (CVULA-I-1639, 2316, 3505, 3518, 3519, 3520, 3539, 3539, 3540, 3541), collected on January 30, 1985 and March 25, 1985, in “Uribante



(Latitude: 7.96583; Longitude: -71.71166), 1020–1150 m a.s.l., 10–14 Km Southeastern Pregonero, Táchira State”. All have a small white spot on the dorsal region of the head. *Nectomys rattus* Pelzeln, 1883 (EBRG–14924), an adult male collected on September 20, 1967, in “25 Km Southeastern Puerto Ayacucho, Paria (Latitude: 5.41000; Longitude: -67.59833), 0–100 m a.s.l., Amazonas State”. It has a small white spot on the lower dorsum. *Transandinomys talamancae* (J.A. Allen, 1891) (MZUC–880), an adult female collected on May 22, 2011, in “El Silencio (Latitude: 10.41683; Longitude: -68.79141), 1400 m a.s.l., Yurubí National Park, Sierra de Aroa, Yaracuy State”. It has a small white spot on the nape. *Ichthyomys pittieri* Handley and Mondolfi, 1963 (EBRG–28236, 28237), two adult females collected on June 04–26, 1987, in “La Toma, Parque Nacional Henri Pittier (Latitude: 10.39944; Longitude: -67.68027), 1100 m a.s.l., Aragua State”. An adult male collected on May 12, 1986 in “Rancho Grande, Parque Nacional Henri Pittier (Latitude: 10.35277; Longitude: -67.68388), 1200 m a.s.l., Aragua State”. All specimens have small white spots on the dorsum.



**Figure 4.** Cases of Piebaldism in Venezuelan mammals (Rodentia and Didelphimorphia). A, B, C. *Nephelomys* sp. (CVULA–I–1009, 1010, 5648), D. *Marmosops carri* (MZUC–868). Scale = 10 mm.

**Partial melanism cases:**

CHIROPTERA Blumenbach, 1779, Phyllostomidae Gray, 1825, Phyllostominae Gray, 1825, *Chrotopterus auritus* Peters, 1865 (MZUC-957), an adult male collected on March 23, 2007, in “Piedra de la Guaca (Latitude: 10.44555; Longitude: -68.86166), 459 m a.s.l., quebrada Cumaraguita, Sierra de Aroa, Yaracuy State”. It has a small dark-gray spot on the lower right side of dorsum. Vespertilionidae Gray, 1821, Myotinae Tate, 1942, *Myotis keaysi* J.A. Allen, 1914 (EBRG-22611), an adult female collected on August 25, 1999, in “El Parque Recreacional Cueva El Indio (Latitude: 11.52104; Longitude: -66.82111), 500–1000 m a.s.l., La Guairita, Miranda State”. It has a dark-gray spot from right side of head to the lower extremities (Figure 5).

**Melanism cases:**

CARNIVORA Bowdich, 1821, Felidae Fisher, 1829, *Panthera onca* (Linnaeus, 1758) (EBRG-4486): an adult individual (unknown sex), collected on November 17, 1993, in “Campo florido (Latitude: 5.41000; Longitude: -67.59833), 0–100 m a.s.l.. Aproximadamente 70 Km Sur de Puerto Ayacucho, Departamento de Atures, Amazonas State” (Figure 5). An adult male (EBRG-17032), collected on June 1983, in “Río Hacha (Latitude: 4.36926; Longitude: -61.69055), 400 m a.s.l., Bolívar State”. Both specimens have a blackish coloration.



**Figure 5.** Cases of partial melanism and melanism in Venezuelan mammals (Chiroptera and Carnivora). A. *Myotis keaysi* (EBRG-22611; scale = 10 mm). B. *Panthera onca* (EBRG-4486; scale = 200 mm).

Chiroptera and Rodentia, were the mammalian orders with most evidence of chromatic anomalies in the revised collections (nine and eight species, respectively). Complementary, the literature refers eight species to Chiroptera and one species to Rodentia in Venezuela (Boher-Benti *et al.* 2016; Lucati and López-Baucells 2016). The higher numbers of chromatic anomalies in Chiroptera and Rodentia in this country could be due to the higher numbers of species these clades contain or to larger focus on collecting these species by mammalogists (Sánchez-Hernández and Lew 2012).

Chiroptera is second most diverse order in the Neotropical region with more than 380 species in 98 genera (Solari and Martínez-Arias 2014). However, records on pigmentation disorders, particularly those related to albinism for frugivorous bats are very scarce. Only seven species in this trophic guild have been recorded with albinism in Argentina (one case), Brazil (three), Cuba (two), French Guiana (two) and Mexico (two): *Artibeus cinereus*, *A. jamaicensis*, *A. lituratus*, *A. planirostris*, *Carollia perspicillata*, *Sturnira erythromos* and *Rhinophylla pumilio* (Lucati and López-Baucells 2016; Zalapa *et al.* 2016; Zortéa and Silva 2018).

Our records of *Artibeus phaeotis* and *Carollia brevicauda* are added to the previously known list of bats of the world with pigmentation disorders (Lucati and López-Baucells 2016; Zalapa *et al.* 2016; Zortéa and Silva 2018). Likewise, the record of *Dasyprocta leporina*, represents the first confirmation of albinism in the species and the second record for a rodent in Venezuela (Boher-Benti *et al.*, 2016).

Regarding the leucism, our records in the present study represent the first case with this condition for *Sturnira erythromos* (Lucati and López-Baucells 2016) and the second case in *Carollia perspicillata* in the Neotropics (Rocha *et al.* 2013). Another species added to the list with this condition is *Anoura caudifera*; this taxon was originally documented with "partial albinism" (Linares, 1967) and then corrected to "piebaldism" (Lucati and López-Baucells 2016), but a detailed review allowed us to classify it as a case of leucism.

The only melanism records in the revised collections are two jaguar specimens (*Panthera onca*), from the lowland rainforests, in the South of Orinoco river. Although anecdotal cases of melanism for this felid exist in several localities from the American continent (Hoogesteijn and Mondolfi 1992), documented records in the literature are related to animals kept in captivity in a zoo (Schneider *et al.* 2012).

The piebaldism, in spite of being chromatic anomaly more representative in this study, can be the least observed or taken into account by the researchers when capturing animals. In our situation, the piebaldism was the phenotypic condition more frequent (34 cases in 11 species), then leucism (four cases in four species), albinism (three cases in three species), partial melanism (two cases in two species) and melanism (two cases in one species).

Pigmentation disorders in vertebrates are considered as a rare phenomenon in nature (Rose *et al.* 2017; Nascimiento *et al.* 2018; Zortéa and Silva 2018) and their possible causes are linked to factors such as environmental contami-

nation, inbreeding, heritable condition of some mutations can increase their presence in a population or community of organisms (Zalapa *et al.*, 2016; Romero *et al.*, 2018). Our data from the Venezuelan Andes (Cordillera de Mérida), suggest that some of these factors might be associated with rodent populations in that region. For example, all records of piebaldism derived from our review for *Nephelomys* sp., are from the same population (Uribante, Táchira State), which implies that perhaps, the inbreeding is occurring in that locality for this species. Also, other example applies to the rodent, *Nephelomys meridensis*, in which most of records of piebaldism are from Monte Zerpa (Mérida State).

Particularly, the Cordillera de Mérida, which is an area isolated from the rest of the tropical Andes by the Táchira depression, has suffered systematic fragmentation and disturbance of its forests since the pre-Columbian era (Soriano *et al.* 1999). Possibly, these factors may be one of the many causes that drives some rodent populations to manifest this type of phenotypes in their individuals in that place.

In recent years, the importance of natural history museums or scientific collections and the value of vertebrate specimens associated with them has gained relevance in different fields of biology and conservation of biological diversity (McLean *et al.* 2016; Castillo-Figueroa and Pérez-Torres 2018; Hope *et al.* 2018). Furthermore, costs related to the collection and preparation of mammal specimens for museums and the total value for the maintenance and functioning of a collection of mammals have been calculated (Bradley *et al.* 2013; Camacho *et al.* 2018). In a study on the contribution of Venezuelan scientific collections to biological and environmental sciences (Bisbal 2013), the author found that for vertebrate groups, topics related to biogeography, systematics and taxonomy were the most addressed, making clear the importance on the role of natural history museums and scientific collections in the discovery and contribution of new information.

With respect the previous information of pigmentation disorders for mammals from Venezuela deposited in museums, records were limited two cases in two bats species, *Molossus molossus* (Molossidae; Soriano *et al.* 1993) and *Anoura caudifera* (Phyllostomidae; Linares 1967). Therefore, our study demonstrates the utility of reviewing scientific collections to increase the knowledge of this kind of information and other topics (Castillo-Figueroa and Pérez-Torres 2018; Nascimiento *et al.* 2018).

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Franger J. García <sup>1,2\*</sup>, Marjorie Machado <sup>2</sup>, Guillermo Flórez <sup>3</sup>, Pascual J. Soriano <sup>4</sup>  
Hillary J. Cabrera <sup>5</sup>

1 Programa de Pós-graduação em Zoologia, Universidade Estadual de Santa Cruz, Rodovia Jorge Amado, Km 16, CEP 45662-900 Ilhéus, Bahia, Brasil. E-mail: [figarcia@uesc.br](mailto:figarcia@uesc.br); [cormura@yahoo.com](mailto:cormura@yahoo.com)

2 Departamento de Biología, Facultad Experimental de Ciencias y Tecnología, Universidad de Carabobo, Valencia, Venezuela. E-mail: [marjoriesilvera@gmail.com](mailto:marjoriesilvera@gmail.com)

3 Pós-graduação em Evolução e Diversidade, Centro de Ciências Naturais e Humanas, universidade Federal do ABC, Brasil. E-mail: [gflorezmontero@gmail.com](mailto:gflorezmontero@gmail.com)

4 Departamento de Biología, Facultad de Ciencias, Universidad de Los Andes, Mérida, Venezuela. E-mail: [pascual@ula.ve](mailto:pascual@ula.ve)

5 Universidad Central de Venezuela (UCV), Escuela de Biología, Caracas, Venezuela. E-mail: [hilla3108@gmail.com](mailto:hilla3108@gmail.com)