

## Brief Report

# Anomalous pigmentation in American primates: review and first record of a leucistic black howler monkey in southeast Mexico

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**Abstract** – Leucism is an aberration of color that occurs in individuals as a consequence of genetic mutations. Along with albinism and piebaldism, leucism is one of the most commonly reported types of chromatic anomalies in mammals, however, detailed descriptions of such conditions are rare. We report the first record of a leucistic black howler monkey (*Alouatta pigra*) in southern Mexico, an apparently healthy individual who was the male of a typical black howler group. Additionally, we compiled records of anomalous pigmentation in American primates published in peer-reviewed journals between 1960 and 2021, as well as social media posts regarding casual observations of individuals with such conditions. We found 11 scientific articles which described 13 records of anomalous pigmentation in a total of 44 individuals, from five species, three subspecies and one hybrid. Leucism was the most widely reported condition with six records. We discovered 19 online posts of 20 individuals with anomalous pigmentation, which included two species not reported in scientific literature. Our results suggest that anomalous coloration is not a significant threat to survival, but its occurrence raises interesting, and possibly alarming, questions about the causes of such conditions. We encourage researchers and civil society to formally report such observations of animals with color aberrations, to expand upon the understanding of this phenomenon and to get involved in the conservation of tropical forests.

**Keywords** – abnormal pigmentation, albinism, *Alouatta pigra*, leucism, piebaldism.

## Introduction

Coloration in mammals is determined by the distribution and overall presence of melanin in the skin, hair, eyes, and fur (Fertl and Rosel, 2002; Hofreiter and Schöneberg, 2010). Anomalous coloration is rare in primates (Abreu *et al.*, 2013; Aximoff *et al.*, 2020), but

there are several types of hereditary chromatic anomalies that involve loss of pigmentation, with piebaldism, albinism and leucism being the most commonly recognized in the scientific literature (Fertl and Rosel, 2002; Miller, 2005; Abreu *et al.*, 2013). Current classification of anomalous pigmentation is determined by the affected gene, and previously used terms such as

“partial” or “complete” albinism are no longer used (Summers, 2009).

Piebaldism is a lack of coloration or lighter pigmentation in parts of the fur and skin (Fertl and Rosel, 2002; Miller, 2005). Albinism is a complete lack of pigmentation throughout the body, resulting in white, whitish, or yellowish white hair color, and red or pink eyes (Fertl and Rosel, 2002; Miller, 2005; Acevedo and Aguayo, 2008). In contrast, leucism occurs when the body of the animal is partially or totally depigmented, but the body extremities and eyes remain pigmented (Fertl and Rosel, 2002; Miller, 2005; Acevedo and Aguayo, 2008; García-Morales *et al.*, 2012). While albinism can be diagnosed by observing the eye pigmentation (Fertl and Rosel, 2002), other abnormalities in pigmentation are often divergently defined by authors as either leucism or piebaldism (Abreu *et al.*, 2013), and a more refined classification is needed.

Albino and leucistic individuals have been reported in a variety of mammals in the American tropics, including several species of bats (Hernández-Mijangos, 2009; García-Morales *et al.*, 2010; Sánchez-Hernández *et al.*, 2012; Abreu *et al.*, 2013; Chacón *et al.*, 2015), white-nosed coatis *Nasua narica* (Silva-Caballero *et al.*, 2014), black agouti *Dasyprocta fuliginosa* (Mejia-Valenzuela, 2019) and lowland tapirs *Tapirus terrestris* (Landis *et al.*, 2020). Observations of piebaldism and undetermined anomalous coloration have also been consistently reported over the second half of the last century until present day. The most extensive review of such reports was conducted by Abreu *et al.* (2013) who compiled observations of hypopigmentation (albinism, leucism, piebaldism, and undetermined anomalous pigmentation) in American tropical mammals published in peer reviewed journals between 1950 and 2010. This review compiled 198 records, most of which came from cetaceans and chiropterans.

Few observations of anomalous pigmentation have been reported for American primates on peer-reviewed journals (Abreu *et al.*, 2013). The growing use of social media offers an additional

source of natural information. Social media provides scientists with citizen science observations, to report, map, and sometimes monitor individuals with anomalous pigmentation. By responding to posts, scientists can help create public awareness on scientific issues and wildlife conservation (Dickinson *et al.*, 2010; Jeawak *et al.*, 2018; Wu *et al.*, 2018).

Several authors suggest that individuals born with such conditions have a decreased probability of survival due to increased predation (Sazima and Di-Bernardo, 1991; Eppley *et al.*, 2010) and possible detrimental defects such as visual impairments (Summers, 2009; Henriques *et al.*, 2019). Reviewing reports of anomalous pigmentation in American primates, both published and those outside the scientific literature, is a starting point to conduct further research on such abnormal conditions. Here we report the first record of leucism in *Alouatta pigra* (Lawrence, 1933, Family Atelidae, Order Primates) and provide a review of anomalous pigmentation in American primates.

## Material and methods

The observation of a leucistic individual of black howler monkey occurred during routine primate monitoring in southern Mexico. This individual and its group ranged in a private 350 ha ranch of which only a third has been modified for agricultural activities. The remaining area consists of a medium height semideciduous forest, secondary vegetation, and large sections of flooded riparian vegetation.

We conducted a review on the reports of anomalous coloration in American wild primates (Order Primates) published in peer-reviewed journals between 1960 and 2021 through scientific portals (Scopus, Web of Science, Google scholar, Scielo, Scielo México) using the keywords “neotropical primates”, “albinism”, “leucism”, “piebaldism”, “pigmentation”, and “anomalous pigmentation”. Records were classified by families and species, country of observation and anomalous pigmentation types (as diagnosed by the original authors) following the analysis conducted by Abreu *et al.* (2013).

A search for additional reports was conducted on Facebook, Instagram, and Twitter using the in-platform search engines and the keywords “piebaldism”, “albinism” and “leucism” in conjunction with the keyword’s “primate” and “monkey” in English, Spanish and Portuguese. Only postings with photographic evidence, videos, and anecdotal recounts (posts that textually describe/report encounters) were included. We corroborated species identities and anomalous coloration diagnoses based on the photographs and videos. Duplicated and reposted photographs were carefully excluded.

## Results

On October 20th, 2020, a black howler monkey with anomalous pigmentation was observed and photographed by the authors in the southern Mexican state of Tabasco. The black howler monkey, or as identified by local people as “saraguato”, is one of three species of wild primates that inhabit the southeastern tropical

forests of Mexico, and one of its more defining characteristics is their mostly black pelage (Smith, 1970). The saraguato is one of the largest primates in the Americas and the species ranges from the Mexican states of Tabasco, Chiapas, and Yucatan peninsula into Belize and Guatemala (Smith, 1970; Horwich and Johnson, 1986; Watts and Rico-Gray, 1987). The black howler monkey we observed was an adult male, about 12-15 years old (fig. 1), with a condition leaning towards leucism. The individual lacked skin pigmentation had yellowish-white fur on its back and a yellowish-orange coloration on the flanks. The animal’s eyes maintain a dark pigmentation.

A local community member and the owner of a private ranch informed us of the animal and stated that it had been seen repeatedly for more than ten years. During our visit we observed the individual and its group for several hours and noted their general activity – traveling, resting, and feeding on the fruits of a hog plum tree (*Spondias spp.*). The group consisted of the leucistic male, two adult females



**Figure 1.** Individual black howler monkey (*Alouatta pigra*) with an anomalous pigmentation condition, an adult male registered in Tabasco, Mexico (Photo: Jorge Ramos-Luna).

**Table 1.** Records of anomalous pigmentation in wild primates of the American continent, anomalous pigmentation type (as proposed by the original authors), country, cases, and references (following to Abreu *et al.* 2013).

Species	Anomalous pigmentation	<i>n</i>	Country	References
<b>Atelidae</b>				
<i>Alouatta palliata</i> (Gray, 1849)	Undetermined	21	Costa Rica	Galván <i>et al.</i> (2019)
<i>Alouatta palliata mexicana</i> (Merriam, 1902)	Piebaldism, Undetermined	2	Mexico	Sánchez-Soto (2018)
	Leucism	1	Mexico	López-Platas <i>et al.</i> (2021)
<i>Alouatta pigra</i> (Lawrence, 1933)	Leucism	1	Mexico	This study
<i>Ateles geoffroyi</i> (Kuhl, 1820)	Albinism	1	Honduras	Espinal <i>et al.</i> (2016)
<i>Alouatta guariba clamitans</i> (Cabrera, 1940)	Undetermined	4	Brazil	Fortes and Bicca-Marques (2008)
	Leucism	1	Brazil	Aximoff and Vaz (2016)
<b>Cebidae</b>				
<i>Cebus capucinus imitator</i> (Linnaeus, 1758)	Albinism	1	Panama	Duquette <i>et al.</i> (2015)
<i>Sapajus apella</i> (Linnaeus, 1758)	Albinism	1	Brazil	Bicca-Marques (1988)
	Oculocutaneous albinism	1	Brazil	Henriques <i>et al.</i> (2019)
<b>Callitrichidae</b>				
<i>Callithrix jacchus</i> (Linnaeus, 1758)	Leucism	1	Brazil	Aximoff <i>et al.</i> (2020)
<i>C. jacchus/C. penicillata</i> hybrids	Leucism	4	Brazil	Aximoff <i>et al.</i> (2020)
<i>Callithrix penicillata</i> (E. Geoffroy, 1812)	Leucism	3	Brazil	do Vale <i>et al.</i> (2018)
	Leucism	3	Brazil	Aximoff <i>et al.</i> (2020)

and three immature individuals (two females and one male) who had no visible pigmentation anomalies. The animals remained calm in response to human presence (see supplementary video S1).

Our search on reports regarding anomalous pigmentation in American wild primates located 11 scientific articles, which report 13 records and a total of 44 individuals of five species, three subspecies and one hybrid (table 1). The most reported pigmentation disorder was leucism, with six records, followed by albinism with three records, three unclassified anomalous pigmentation observations, one piebaldism observation and one oculocutaneous albinism record. The country which had the most records was Brazil (*n* = 8). *Alouatta palliata* was the species with the most observed number of individuals with anomalous pigmentation (*n* = 21).

Regarding social media searching, we found 20 reports of 21 American primate individuals with anomalous pigmentation, belonging to five species, two subspecies and one unidentified species (table 2). Of these reports, two species (*Ateles hybridus* and *Saimiri boliviensis*) had not been previously reported on peer-reviewed articles. Most of the records came from Costa Rica (*n* = 12), and the rest came from Colombia, Brazil, Mexico, Honduras, Panama, and Peru. *Alouatta palliata* was the most reported species (*n* = 12), and most publications (*n* = 17) were posted on Facebook (see supplementary table S1 for additional data).

## Discussion/conclusion

We found published records of 44 individuals of American wild primates with different types of anomalous pigmentation, and we present a new record. These results expand upon the previous work of Abreu *et al.* (2013) for tropical

**Table 2.** Social media records of anomalous pigmentation in primates of the American continent, anomalous pigmentation type, country, year and social media platform of publication.

Species	Anomalous pigmentation	<i>n</i>	Year	Country	Social media platform
<i>Alouatta palliata</i>	Piebaldism	1	2014	Costa Rica	Facebook
	Leucism	1	2014	Costa Rica	Facebook
	Leucism	1	2014	Costa Rica	Facebook
	Leucism	1	2016	Costa Rica	Facebook
	Leucism	1	2019	Costa Rica	Facebook
	Leucism	1	2019	Costa Rica	Facebook
	Leucism	1	2019	Costa Rica	Facebook
	Leucism	1	2020	Costa Rica	Facebook
	Leucism	1	2020	Costa Rica	Facebook
	Leucism	1	2020	Costa Rica	Facebook
	Leucism	1	2021	Costa Rica	Instagram
<i>Alouatta palliata mexicana</i>	Albinism	2	2018	Mexico	Facebook
<i>Ateles geoffroyi</i>	Leucism	1	2021	Honduras	Facebook
	Albinism	1	2021	Colombia	Facebook
<i>Ateles hybridus</i>	Leucism	1	2018	Colombia	Facebook
<i>Callithrix sp.*</i>	Leucism	1	2021	Brazil	Instagram
<i>Callithrix jacchus*</i>	Leucism	1	2021	Brazil	Instagram
<i>Cebus capucinus imitator</i>	Leucism	1	2015	Panama	Twitter
<i>Saimiri boliviensis</i>	Leucism	1	2015	Peru	Facebook

\*Observation in captivity.

American mammals, in which no records for the Order Primates were found between 1950 and 2010 (except for an excluded personal communication regarding *Sapajus apella*, which we took into consideration), most of the records we found were published after the study by Abreu *et al.* (2013).

Additionally, we compiled anecdotal, photographic, and video reports for 20 individuals in social media platforms, of which, two species had not been reported in academic journals. Our search revealed observations of anomalous pigmentation reported in academic articles, including a leucistic *Cebus capucinus imitator* in Panama and an albino *Ateles geoffroyi* in Honduras (Duquette *et al.*, 2015; Espinal *et al.*, 2016). These findings exemplify that to monitor and understand these conditions in the wild, it is valuable to incorporate local people. However, our search revealed limitations, such as the necessity to conduct searches through text and tags, the variance and disagreements regarding pigmentation diagnoses, and possible duplicate observations of the same individuals over time.

While regular social media platforms offer a passive means to collect data from the public (Jaewak *et al.*, 2018), specialized citizen science social media platforms, such as iNaturalist, eMammal and Zooniverse (Arts *et al.*, 2015; Forrester *et al.*, 2017), provide active ways to engage the public and to compile data on wildlife. For example, on NaturaLista (a collaboration between Mexico's CONABIO and iNaturalist) there are 19,228 photographic records of wild primates in the Latin-America region (Naturalista, 2021). However, despite the machine learning advances of such platforms, a refined search on individuals with anomalous pigmentation as of today would currently require manual search conducted by trained primatologists. As proposed by Di Minin *et al.* (2018), further development and refinement of machine learning algorithms could be crucial to tackle conservation problems, such as wildlife trafficking and, in our case, could present a useful tool for an in-depth analysis of anomalous pigmentation cases. However, developing AI tools for such

work can be relatively easily done (Guo *et al.*, 2020).

The rise in number of records reported over time for primates raises several interesting questions and research possibilities. The frequency of unpigmented individuals in a population is dependent on mutation rate, which can be associated with low genetic diversity resulting from isolation and inbreeding depression (Espinal *et al.*, 2016). Despite this, the individual that we report inhabits a vast patch of forest, of approximately 200 hectares, further monitoring and genetic analysis of surrounding groups should be conducted. Despite this, Aximoff *et al.* (2020) also suggest that leucism might be linked to adverse environmental conditions, and other authors suggest the potential role of factors such as habitat quality, diet, pollution, and follicular damage (Camargo *et al.*, 2014; Espinal *et al.*, 2016; Galván *et al.*, 2019). Further analysis should be conducted to evaluate possible correlations between the presence of anomalous pigmentation in mammals and such conditions. As primates are mostly diurnal and are easier to observe than many other terrestrial mammalian groups, focusing on primates in such research may be advantageous.

Although our study follows a general grouping of anomalous pigmentation types, a more refined classification is crucial to understand the conservation implications of observations of aberration of color. For instance, the new record that we present, matches the physiological description proposed by Galván *et al.* (2019) of a form of sulphurated melanin, termed pheomelanin (Chaves, pers. comm.).

Evaluating the mutations underlying anomalous pigmentation provides a more refined diagnosis than just phenotype observation (Galván *et al.*, 2019; Henriques *et al.*, 2019). Such a refinement is difficult to conduct on wild individuals and on opportunistic observations alone. However, ability to conduct genetic analysis on dung samples provides an easily applied tool to determine the appropriate classification of anomalous pigmentation. For instance, the abnormally colored capuchin monkey reported by Henriques *et al.* (2019) in captivity presents a phenotype which in the wild could have been

identified as leucism (depigmented body and pigmented eyes), by collecting blood and conducting genetic analysis of the opsin gene, the authors diagnose it as oculocutaneous albinism.

*Alouatta palliata* was the species with the most observed and reported individuals with anomalous coloration (tables 1, 2). Galván *et al.* (2019) report recent changes in pigmentation phenotypes and suggested they were related to the growing use of sulfur-containing pesticides in Costa Rica. These pesticides favor pheomelanin synthesis in melanocytes and explain the pigmentation shift. The presence of similar anomalous pigmentation phenotypes (we would diagnose as piebaldism based on phenotype) is a common characteristic in the *Alouatta palliata mexicana* subspecies and the often-seen patterns of depigmented fur and skin have been used to differentiate individuals for at least three decades (Rodríguez-Luna, 1997; López-Platas *et al.*, 2021). Such anomalous coloration has been reported (Bradley and Mundy, 2008; Sánchez-Soto, 2018) and the most recent published observation comes from a fully leucistic individual from Mexico (López-Platas *et al.*, 2021). As suggested by Galván *et al.* (2019), temporal context on these changes and an analysis of possible connection to pesticide exposure should be evaluated. The tropical forests in the state of Tabasco, in which the leucistic black howler monkey was observed, have been severely modified by human activities such as agriculture, logging, and forest conversion to pastures, and such drastic changes in land use and land cover often led to long droughts and extensive flooding (Pozo-Montuy *et al.*, 2008; Pozo-Montuy *et al.*, 2011). Excessive pesticide use is a matter of concern in Mexico and high levels of toxic contaminants including pesticides that could cause anomalous coloration to have been found in soil, water and plant and animal species in some locations (Sud, 2020). Recently, Mexico had a 16.8% increase in pesticide use and the country's pesticide use per unit of crop output is 2.7 times the global average, and 3 times that of the United States (Schreinemachers and Tipraqsa, 2012).

Little is known about the consequences associated with leucism, although potential negative

effects on their fitness and survival could be expected (Aximoff *et al.*, 2020). Under natural circumstances, such individuals could be more prone to predation (Sazima and Di-Bernardo, 1991; Eppley *et al.*, 2010). Fur coloration in mammals is typically important for its camouflage function (Nedyalkov *et al.*, 2014) and anomalous fur color tends to be conspicuous against a forest background, leaving them vulnerable against natural predators and poaching (Nkosi and Twala, 2002; McCardle, 2012). For the case of the reported black howler monkey, its natural predator, the harpy eagle *Harpia harpyja*, is locally extinct, although tropical felids present potential risks. Regardless of these disadvantages, and exemplified by this record, some individuals can reach adulthood and breeding status.

This is the first published report of a black howler monkey with an anomalous pigmentation condition. Hence, further research must be carried out to understand the implications of this condition and to evaluate environmental and biological factors that could have led to it. Our research finding demonstrates the importance of community involvement for wildlife monitoring, and it also provides a unique opportunity to implement integrative conservation strategies focused on this unique individual, its group and surrounding forest.

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## Statement of ethics

Data collection for the record presented here was noninvasive and purely observational,

adhering to the Code of Best Practice for Field Primatology. Additional data were collected entirely noninvasively and required no contact with the study subjects.

## Conflict of interest statement

All authors declare that there are no conflicts of interest.

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## Author contributions

JCSS, JRL, and MFAV conducted the field observations. CAC helped writing and with suggestions in draft and final version. All authors contributed to the literature review and writing of the manuscript.

## Supplementary material

Supplementary material is available online at: <https://doi.org/10.6084/m9.figshare.18692798>

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