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First record of albinism in the Quichua Porcupine, *Coendou quichua* in Ecuador

Primer registro de albinismo en el Puercoespín Quichua, *Coendou quichua* en Ecuador

Jorge Brito[1]*, Pamela Lojan[1], Jason Crespo[2], and Jaime Culebras[3,4]

[1]Instituto Nacional de Biodiversidad (INABIO). Calle Rumipamba 341 y Av. de los Shyris, C. P. 17-07-8976, Quito. Pichincha, Ecuador. E-mail: jorgeyakuma@yahoo.es (JB); pamelojan@gmail.com (PL).
[2]Bosque Protector La Perla. Vía a Quinindé km 136, La Concordia. Santo Domingo de los Tsáchilas, Ecuador. E-mail: jcrespo.w@hotmail.com (JC).
[3]Photo Wildlife Tours. Calle Isla Isabela 1021 y Río Coca, Quito. Pichincha, Ecuador. E-mail: jaimebio85@gmail.com (JC).
[4]Fundación Cóndor Andino. Calle Tamayo 24-260 y Lizardo García, Quito. Pichincha, Ecuador.
*Corresponding author

Anomalous coloration is a phenomenon that is regularly observed in mammals. Cases of albinism are relatively uncommon; for example, they have been reported in less than 2 % of rodent species. For the first time, we report a case of albinism in a porcupine, based on a specimen collected in northwestern Ecuador. An injured Quichua Porcupine exhibiting anomalous coloration was rescued in a roadway in proximity to the Bosque Protector La Perla, situated within the province of Santo Domingo de los Tsáchilas. It was preserved as a museum specimen in skin, skull and skeleton. Identification was confirmed by external skull characters, but we also sequenced the molecular marker cytochrome b (Cyt *b*) for phylogenetic support. The specimen is an old female. The animal exhibited yellowish dorsal quills and white quills on the belly. The eyes are red, while the face, ears, hands, and feet are pink. Genetic analysis of the mitochondrial marker Cyt *b* confirmed the identification of the specimen as *Coendou quichua*. This report presents the first documented case of albinism in *Coendou quichua*. Furthermore, this report increases the number of species of the genus *Coendou* with cases of albinism to 3, and represents the third mammal species reported in Ecuador with this condition. We also present a phylogeny and comment on the possibility of cryptic diversity within the genus.

Key words: Color aberration; Neotropical mammals; Northwestern Ecuador.

La coloración anómala es un fenómeno que se observa con regularidad en los mamíferos. Los casos de albinismo son relativamente infrecuentes; por ejemplo, se han descrito en menos del 2 % de las especies de roedores. Informamos por primera vez de un caso de albinismo en un puercoespín, a partir de un espécimen recogido en el noroeste de Ecuador. Un puercoespín Quichua herido que presentaba una coloración anómala fue rescatado mientras atravesaba una carretera en las proximidades del Bosque Protector La Perla, situado en la provincia de Santo Domingo de los Tsáchilas. Se conservó como espécimen de museo en piel, cráneo y esqueleto. La identificación se confirmó por los caracteres externos y del cráneo, pero también secuenciamos el marcador molecular citocromo b (Cyt *b*) para obtener apoyo filogenético. El espécimen es una hembra vieja. El animal exhibe púas amarillentas en el dorso y púas blancas en el vientre. Los ojos son rojos, mientras que el hocico, las orejas, las manos y los pies son rosados. El análisis genético del marcador mitocondrial Cyt *b* confirmó la identificación del espécimen como *Coendou quichua*. Este reporte presenta el primer caso documentado de albinismo en la especie de roedor *Coendou quichua*. Además, este reporte incrementa a 3 el número total de especies del género *Coendou* con casos de albinismo, y añade a 3 especies de mamíferos registradas en Ecuador con esta condición. También presentamos una filogenia y comentamos la posibilidad de diversidad críptica dentro del género.

Palabras clave: Aberración cromática; mamíferos neotropicales; noroeste de Ecuador.

Chromatic fur disorders, including albinism, melanism, and leucism, are teratologic conditions that have been documented in vertebrates such as fishes (Manoel *et al.* 2017), reptiles (García-Roa 2020), amphibians (Culebras and Angiolani-Larrea 2023), birds (Cadena-Ortíz *et al.* 2015), and various mammal groups, including rodents (Abreu *et al.* 2013; Brito and Valdivieso-Bermeo 2016; Romero *et al.* 2018; Medina and Medina 2019; Sanmartín *et al.* 2024). Aberrant colorations are the consequence of genetic mutations that disrupt various stages of melanogenesis, the metabolic pathway responsible for the synthesis of melanin, the pigment that produces mammalian coloration (Slominski *et al.* 2004). Anomalous colorations are regularly observed in mammals. Cases of albinism are relatively uncommon (Romero *et al.* 2018; Pommer-Barbosa *et al.* 2022), and for rodents they have been reported in less than 2 % of species (Romero *et al.* 2018).

A mammal who is albino lacks melanin in their skin, hairs, and eyes and is incapable of producing normal, viable melanosomes (Jackson 1994). Coloration may be relevant in predator avoidance and camouflage, as well as in the regulation of some physiological processes (Caro 2005;

Harris *et al.* 2019). In this context, it is possible that the occurrence of aberrant coloration may compromise individual fitness (Galante-Rocha *et al.* 2017).

Some instances of the albino phenotype have been documented in New World porcupines (Erethizontidae), including *Erethizon dorsatum* (Dunn 1921; Struthers 1928; Reeks 1942; Shadle 1946; Hewston 1962; Roze 2012), *Coendou rufescens* (Romero *et al.* 2018), and *C. longicaudatus* (Pommer-Barbosa *et al.* 2022). The Quichua porcupine, *Coendou quichua*, is one of 16 species that compose the genus *Coendou*, as outlined by Voss (2015), and Menezes *et al.* (2021). It is characterized by dorsal fur appears completely spiny, with defensive quills bicolored and tricolored (Voss 2015), and coloration anomalies have never been reported for this species. The species is endemic to the Neotropics and is distributed from Panamá, across the Andean region of Colombia, to western Ecuador (Voss 2015; Ramírez-Chaves *et al.* 2016). The species ranges from sea level to about 3,300 m (Voss 2015). This paper reports a case of albinism for *C. quichua*, based on a specimen collected in northwestern Ecuador.

On December 18, 2023 (18:40 hr), an adult female of *C. quichua* was rescued exhibiting anomalous coloration (Figure 1a) while traversing a roadway in the vicinity of the Bosque Protector La Perla (0° 2' 15.38" S, 79° 24' 21.73" W; 220 m), situated within the province of Santo Domingo de los Tsáchilas in northwestern Ecuador. The animal was kept in captivity at an animal rescue center, but unfortunately succumbed to its injuries while undergoing veterinary care. The specimen was preserved as skin, skull, and skeleton, and subsequently deposited in the mammal collection (MECN) of the Instituto Nacional de Biodiversidad (INABIO) in Quito, Ecuador. DNA extraction, PCR amplification and sequencing with Oxford Nanopore Technologies were performed at the Nucleic Acid Sequencing Laboratory of the Instituto Nacional de Biodiversidad (INABIO) in Quito.

DNA was extracted from the liver using GeneJET Genomic DNA Purification Kit (K0722). The amplification was achieved through Polymerase Chain Reaction (PCR), using the primers MVZ05 and MVZ16 (Smith and Patton 1993), and the GoTaq ® Green Master Mix 2X kit to amplify the sequence of the cytochrome b (Cyt *b*). PCR conditions were initial denaturation at 95 °C for 2 min, 35 cycles at 95 °C/30 sec, 45 °C/30 sec, and 72 °C/80 sec with final extension of 72 °C/5 min. The expected amplicons length is about 1200 bp. The sequencing of the mitochondrial cytochrome b (Cyt *b*) marker of the individual was performed using a minION mk1c with Flongle Flow Cells R10.4.1 and Rapid Barcoding Kit 96 (SQK-RBK114.96) following standard protocols. Data was High-accuracy (HAC) basecalled. The resulting fastq file were filtered at a Q score of 9, and consensus sequences were produced with NGSpecies ID (Sahlin *et al.* 2021).

We used a total of 30 sequences of genus *Coendou* for phylogenetic analysis. We downloaded available sequences of closely related individuals for Cyt *b* and we obtained additional outgroup sequences from GenBank (http://www.ncbi.nlm.nih.gov/genbank/). The alignment was performed by the MAFFT algorithm in Mesquite version 3.81 (Maddison and Maddison 2023) to edit. We generated a maximum-likelihood tree in IQ-TREE (Trifinopoulos *et al.* 2016), under default settings. We employed 3 models corresponding to 3 different data partitions. The models and their associated sequence partitions are: Model TNe+G4 for codon position 1, Model TN+F+I for codon position 2 and Model TN+F+I for codon position 3. For each analysis, we utilized a bootstrap approach with 1000 replicates. Uncorrected p-distances were calculated using MEGA 11 (Tamura *et al.* 2021).

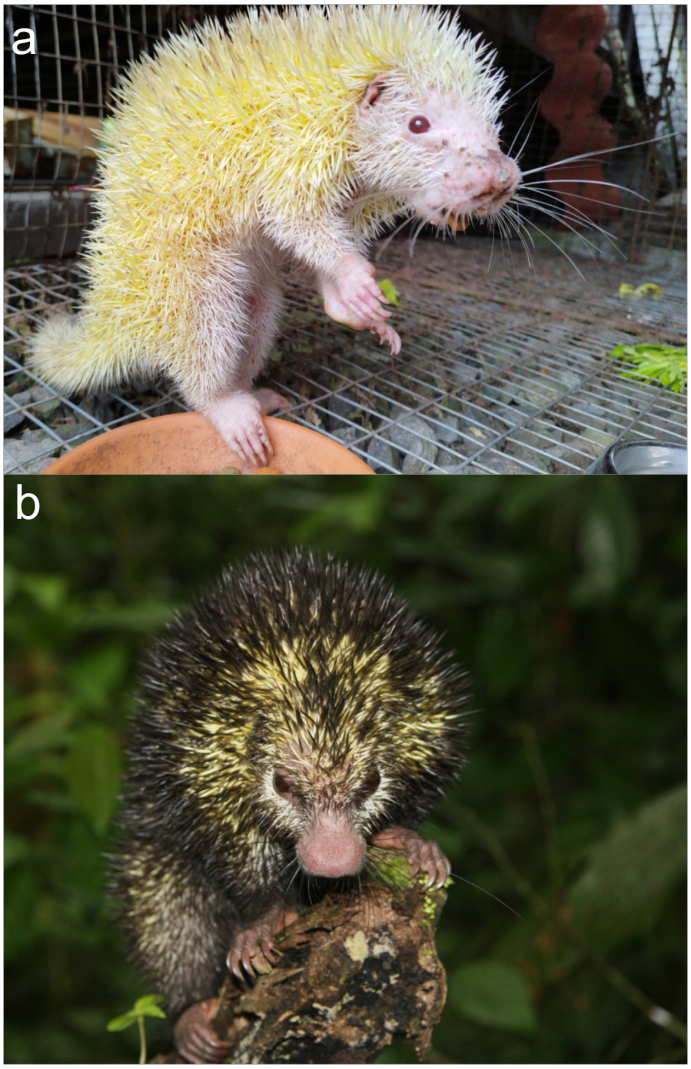

Figure 1. Albino (a) and normal (b) coloration of *Coendou quichua*, from Bosque Protector La Perla, Ecuador. Photographs by J. Crespo. Images available at jcrespo.w@hotmail.com.

The specimen (MECN 7959) is an old female with well-worn molars (Figure 2), with the following standard measurements: head-body length = 350 mm, tail length = 245 mm, hind leg length = 60 mm, ear length = 10 mm, and weight = 998 g. It exhibited the presence of yellowish dorsal quill and white quills on the belly. The eyes are red, while the face, ears, hands, and feet are pink (Figure 1a), contrast-

ing with the typical coloration of the species (Figure 1b).

We sequenced 1140 base pairs (pb) of the Cyt *b* marker (GenBank accession PQ046267). The phylogenetic analysis has confirmed the identity of *C. quichua* (Figure 3) with an uncorrected mean intraspecific genetic distance of 0.4 % with specimen KMH 2218 from Cotopaxi, Ecuador (Jarrín 2001).

The fact that the specimen of *C. quichua* (MECN 7959) reached adulthood suggests an exception to the hypothesis of selection against the albino phenotype, considering that albino mammals are negatively selected due to their difficulty in hiding from predators (Harris *et al.* 2019). However, some authors (Peles *et al.* 1995) argue that selection against the albino phenotype may be less effective in species that occupy habitats with high productivity and good vegetation cover (Peles *et al.* 199). Perhaps in *C. quichua* this hypothesis is plausible to explain the survival of the albino individual to sexual maturity, since this individual was recorded in a typical biogeographic Chocó rainforest with high primary productivity and abundant vegetation cover (Quinto-Mosquera and Moreno 2017). Furthermore, Tinbergen (1960) suggested that some predators may avoid albino prey because of a kind of neophobia.

This is the second DNA sequence of *C. quichua* for Ecuador and constitute the first DNA sequence of the Ecuadorian Pacific lowlands. The uncorrected mean intraespecific distance is 3.8 % with specimen LACM 27376 from Cesar, Colombia (Voss 2013); and 2.2 % with specimen USNM 296308 from Panamá (Voss 2013). Our phylogeny results were similar to those published by Cardoso *et al.* (2024). These values are within the range found in mammalian sister species (Bradley and Baker 2001) and have been used to show the presence of cryptic diversity within the genus *Coendou* (Leite *et al.* 2011; Voss 2013). Therefore, it is possible that 3 species compose *C. quichua*, and the application of the available name *C. rothschildi* for specimens from the Chocó rainforest need to be reevaluated, in accordance with the suggestions made by Ramírez-Chaves *et al.* (2016).

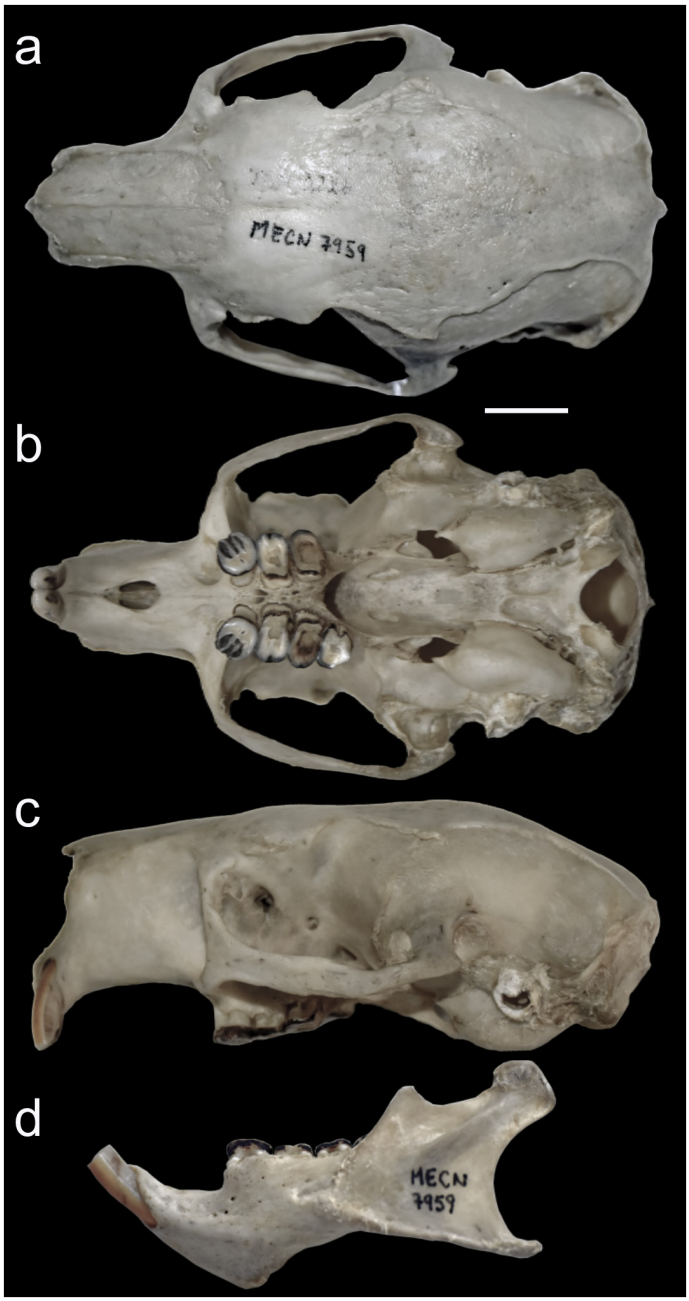

Figure 2. Dorsal (a), ventral (b), and lateral (c) cranial views, and (d) mandibular lateral view of albino *Coendou quichua* (MECN 7959, Bosque Protector La Perla, Ecuador). Note the wear of the molars and incisors. Scale bar = 10 mm. Photographs by J. Brito. Images available at jorgeyakuma@yahoo.es.

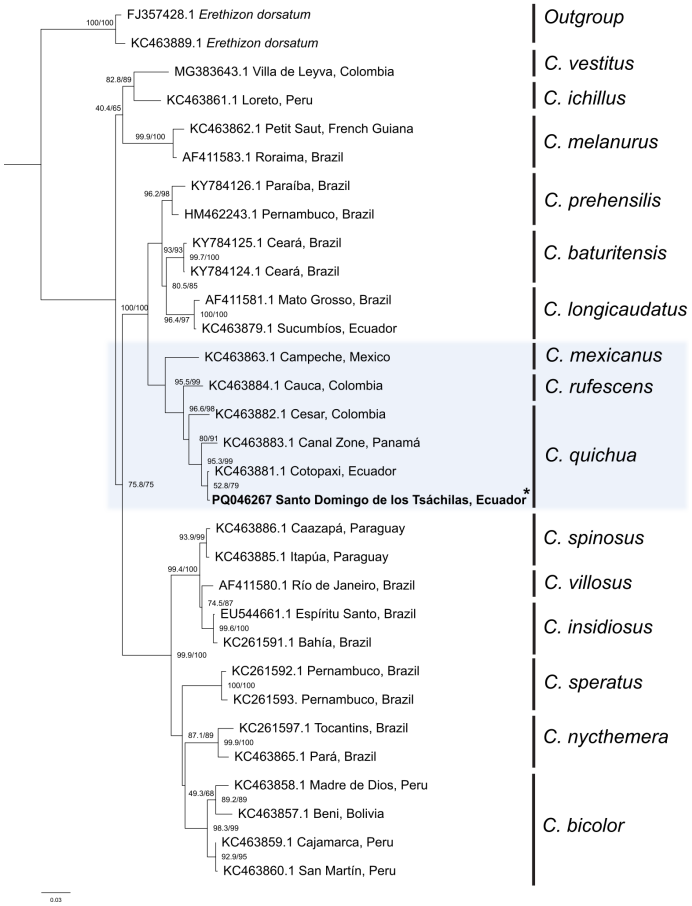

Figure 3. Phylogenetic tree of the Erethizontidae family obtained by Maximum-likelihood (ML) tree with Cyt *b* sequences. The sequence of the albino *Coendou quichua* clusters within the same clade as *Coendou quichua* from Cotopaxi, Ecuador, Colombia, and Panamá along with *C. rufescens* and *C. mexicanus*. The numbers along the branches represent a SH-aLRT (Shimodaira-Hasegawa approximate likelihood radio test) support (%) followed by ultrafast bootstrap support (%). This entire clade is highlighted in gray.

In conclusion, this is the first documented case of albinism in the species *C. quichua*, which also represents the third record of albinism for the genus and the fourth for Erethizontidae. This record also represents the third documented case of albinism in mammals from Ecuador (Brito and León 2014; Romero *et al.* 2018; this study). Prior to this, albinism was reported in *C. rufescens* (Romero *et al.* 2018) and *Vampyrum spectrum* (Brito and León 2014). To gain a deeper understanding of this phenomenon in natural populations, further studies on albinism, particularly in rodents, are needed.

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