Short Note

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A short review and worldwide list of wild albino rodents with the first report of albinism in *Coendou rufescens* (Rodentia: Erethizontidae)

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Abstract: Aberrant pelage color patterns such as albinism have been reported in some mammal groups including rodents, but in spite of the group's richness, the phenomenon is relatively poorly documented in the literature. Albino specimens are reported in <2% of the species of rodents, four records of neotropical species were found (*Delomys dorsalis*, *Heteromys anomalus*, *Octodon degus*, *Phyllotis andium*). Of New World porcupines (Erethizontidae), albinism was documented only in the North American species *Erethizon dorsatum*. Here we report the first albino record from the Neotropics for this group, a stump-tailed porcupine (*Coendou rufescens*) in northern Ecuador.

Keywords: color aberration; hypopigmentation; neotropical mammals; northern Ecuador; stump-tailed porcupine.

Chromatic fur disorders such as albinism, melanism or leucism, are teratologic conditions (Romero and Pedersen 2017) that have been reported in some mammal groups, including rodents (Brito and Valdivieso-Bermeo 2016). These atypical colorations are the consequence of genetic mutations that affect different stages of the melanogenesis, the melanin metabolic pathway. The melanin in either of its two forms, eumelanin and pheomelanin, is the pigment responsible for mammalian coloration (Slominski et al. 2004). This pigment is stored and transported by specialized organelles called melanosomes into the mammalian melanocyte, the pigmentary cell cytoplasm. In mice, described mutations in more than 130 genes and 1000 alleles exist that can affect the distinct phases of the melanogenesis and consequently induce aberrant color morphs (Steingrímsson et al. 2006). Generally, the genetic information necessary to establish what mutation is responsible for an observed phenotype in wild specimens is unavailable and inference based on a visual evaluation of the affected individual is inviable. This has resulted in the proliferation of inappropriate and misused names or labels for the observed different phenotypes (Romero and Tirira 2017).

Albino lab mice (usually *Mus musculus*) and some of their variants have been bred for more than a century, in China, Egypt and Japan where it was apparently artificially selected for through domestication (Beermann et al. 2004). Further, it was used as a mammalian model to demonstrate Mendelian inheritance of the genetic traits (e.g. Cuénot 1902, Castle and Allen 1903). Based on the long and historical cumulative evidence available in mice (compiled and systematized in Lamoreux et al. 2010) the fur aberrant color phenotypes can be segregated in four main categories related to the melanogenesis phase that is affected: (1) leucistic white spotting (includes progressive graying), as consequence of defects in cellular development and survival; (2) leucistic dilution, by failures in the melanosomal transport of the pigment cell and transfer to keratinocytes; (3) non-agouti phenotype, product of defects in normal pigment-type switching process, alternate eumelanin/pheomelanin deposition, including melanism, a relatively common color aberration in some rodents populations; and (4) albinism, associated with the occurrence of melanosomal defects during cellular differentiation. When an individual totally lacks melanin in their skin, hairs and eyes and is incapable of making normal viable melanosomes, they are albino (Romero and Tirira 2017)

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Table 1: A worldwide list of albino records in rodents.

Taxon[a]	Country	Source
Aplodontidae (1 sp.)		
Aplodontia rufa	USA	Jewett 1935
Sciuridae (14 sp.)		
Ammospermophilus harrisii	USA	Neal 1964
Funambulus pennantii	India	Chaturvedi and Ghose 1984, Sharma 2004, Mehra et al. 2007
Funambulus tristriatus	India	Sayyed et al. 2015
Marmota monax	USA	Dunn 1921
Ratufa indica	India	Sayyed et al. 2014
Sciurus aberti	USA	Keith 1965
Sciurus carolinensis	USA	Dunn 1921
Sciurus vulgaris	Netherlands, Spain, UK, USA	Seton 1909, Barrett-Hamilton and Hinton 1921, Pettinga 1951, Balcelles and Palaus 1955, Hoekstra 2004
Spermophilus parryii	Alaska	Bee and Hall 1956
Tamias striatus	USA	Dunn 1921, Zinn 1954, Hough and Smiley 1963
Tamiasciurus hudsonicus	Canada, USA	MacFarlane 1905, Dunn 1921, Layne 1954, Wood 1965, Ferron and Laplante 2013
Urocitellus richardsonii[b]	USA	Hewston 1962
Xerospermophilus spilosoma[b]	USA	James and Hayse 1963
Xerospermophilus tereticaudus[b]	USA	Turkowski and Parker 1967
Gliridae (1 sp.)		
Glis glis	Slovenia	Kryštufek 2010, Holcová-Gazárková et al. 2016
Castoridae (1 sp.)		
Castor canadensis	Canada, USA	MacFarlane 1905, Hewston 1962
Heteromyidae (6 sp.)		
Chaetodipus baileyi	USA	Bateman 1967
Chaetodipus formosus	USA	Tagami and Hayden 1963, Egoscue and Lewis 1968
Dipodomys heermanni	USA	Von Bloecker 1930
Heteromys anomalus	Venezuela	Boher-Bentti et al. 2016
Liomys pictus	Mexico	Martínez et al. 2013
Perognathus sp.[c]	USA	Egoscue and Lewis 1968
Geomyidae (4 sp.)		
Geomys bursarius	USA	Hazard 1982
Thomomys bottae	USA	Bailey 1915, Storer and Gregory 1934
Thomomys mazama	USA	Walker 1955 is cited by Verts and Carraway 2000
Thomomys umbrinus	USA	Bradley 1963
Dipodidae (1 sp.)		
Zapus princeps	USA	Hart et al. 2004
Cricetidae (21 sp.)		
Arvicola amphibius	UK	Barrett-Hamilton and Hinton 1921, Stoddart 1969
Craseomys rufocanus[d]	Japan	Fujimaki 1974
Delomys dorsalis	Brazil	Cademartori and Pacheco 1999
Lemmus trimucronatus	Alaska	Bee and Hall 1956
Microtus arvalis	Germany, Czechoslovakia, Poland	Frank and Zimmermann 1957, Štusák 1987, Łopucki and Mróz 2010
Microtus duodecimcostatus	Spain	Sánchez-García 1992
Microtus lusitanicus	Spain	Miñarro 2012
Microtus montanus	USA	Warren 1929, Jannett 1981
Microtus ochrogaster	USA	Hays and Birgham 1964, Peles et al. 1995
Microtus pennsylvanicus	USA	Dunn 1921, Barrett 1975, Brewer et al. 1993
Microtus pinetorum	USA	Schantz 1960, Peles et al. 1995
Myodes gapperi	Canada	Bowman and Curran 2000
Myodes glareolus	Czechoslovakia, Germany, Norway, Poland, Slovakia	Literák and Zejda 1995, Łopucki and Mróz 2010, Steen and Sonerud 2012, Łopucki et al. 2013
Myodes rutilus	Alaska	Whitman 2009
Ondatra zibethicus	Poland, USA	Seton 1909, Dunn 1921, Łopucki and Mróz 2010

Table 1 (continued)

Taxon[a]	Country	Source
Peromyscus leucopus	USA	Dunn 1921
Peromyscus maniculatus	USA	Barto 1942
Phodopus campbelli	Rusia	Robinson 1996
Phyllotis andium	Peru	Ramírez and Arana 2005
Reithrodontomys megalotis	USA	Egoscue 1958
Sigmodon hispidus	USA	Gardner 1948
Muridae (10 sp.)		
Apodemus agrarius	Finland, Germany, Norway, Poland, Sweden	Zimmermann 1937, Hanström 1945, Brekke and Selboe 1974, Mäkelä and Viro 1980, Łopucki and Mróz 2010
Apodemus flavicolis	Czechoslovakia	Pachinger 1974
Apodemus sylvaticus	Poland, UK	Barrett-Hamilton and Hinton 1921, Štusák 1987
Bandicota bengalensis	India	Harrison 1950, Sayyed et al. 2014
Lemniscomys sp.[c]	UK	Barrett-Hamilton and Hinton 1921
Madromys blanfordi	India	Rajagopalan 1967
Mus musculus	UK, USA	Barrett-Hamilton and Hinton 1921, Dunn 1921
Otomys tropicalis	Congo	Pilot 1958
Rattus novergicus	UK, USA	Barrett-Hamilton and Hinton 1921, Dunn 1921
Rattus rattus	UK	Barrett-Hamilton and Hinton 1921
Hystricidae (1 sp.)		
Hystrix brachyura	India	Mandal and Ghosh 2000
Erethizontidae (2 sp.)		
Coendou rufescens[e]	Ecuador	This study
Erethizon dorsatum[f]	Alaska, Canada, USA	Pennant 1784, Seton 1909, Dunn 1921, Struthers 1928, Reeks 1942, Shadle et al. 1946, Hewston 1962, Roze 2012
Caviidae (1 sp.)		
Cavia porcellus	USA	Dunn 1921
Octodontidae (1 sp.)		
Octodon degus	Chile	Díaz et al. 2015

[a]*Sensu* Wilson and Reeder 2005; [b]after Helgen et al. 2009; [c]species not identified by the authors; [d]after Fabre et al. 2013; [e]after Voss et al. 2013; [f]corrected from the original specific epithet *dorsata* for grammatical concordance with the actual genus.

a phenotype characterized by red eyes, white fur and pinkish or white skin. In very low ratio, it is possible that only the melanosomes associated to the ocular systems are inviable, producing the red eyes phenotype, a rare case of albinism. Some information on aberrant coloration in mammals is available; however, this information is based on domestic mammals, particularly mice. Reports of albinism and color aberration in wild mammal populations are poorly documented in the literature (Romero and Tirira 2017). This is particularly evident in rodents, the largest group of mammals (i.e. 2480 species *sensu* Wilson et al. 2016, 2017).

At the end of the 18th century reports of aberrant "white" phenotype in wild rodents were already known (Pennant 1784). More than two centuries later, insofar as we know, albino specimens have been reported in <2% of the species into the order Rodentia (i.e. 64 sp. in 13 families, Table 1). Mostly in North American species (39 sp.) with a few European (16 sp.), Asiatic (7 sp.), South American (4 sp.) and African reports (1 sp.). 70% of the records correspond to cricetids (21 sp.), sciurids (14 sp.) or murids (10 sp.). The available records associated with neotropical species are only two cricetids, *Delomys dorsalis* from Brazil (Cademartori and Pacheco 1999) and *Phyllotis andium* from Peru (Ramírez and Arana 2005); one heteromid, *Heteromys anomalus* from Venezuela (Boher-Bentti et al. 2016); and one octodontid, *Octodon degus* from Chile (Díaz et al. 2015). Some incidence of albino phenotype was reported into the New World porcupines (Erethizontidae), but only in the North American species *Erethizon dorsatum* (Pennant 1784, Seton 1909, Dunn 1921, Struthers 1928, Reeks 1942, Shadle et al. 1946, Hewston 1962, Roze 2012). Here we report the first albino record from in the *Coendou* genus with the observation of a Stump-tailed Porcupine (*Coendou rufescens*). *Coendou rufescens* is one of the 13 species that composed the genus (Voss 2015). It's endemic to the Neotropics and inhabits the Andes in Colombia, Ecuador, Peru and was

apparently introduced in Northern Bolivia (Voss 2011). It prefers principally wet montane forest from 800 to 3,650 m asl (Voss 2015, Brito and Ojala Barbour 2016). Its distribution extent is restricted if compared to that of the common Brazilian porcupine, *Coendou prehensilis* (200,136.91 vs. 10,157,531.85 Km^2, respectively *sensu* Amori et al. 2013). It is a medium-sized nocturnal rodent (head and body length = 340–410 mm, Max weight = 5 kg), it is easily diagnosable by its short tail, approximately 40% of the combined length of the head and body. Generally, its body is densely covered with quills. Unlike all other South American porcupine species, dorsal quills are blackish in its central portion with yellowish or blackish base and tipped with reddish-brown bands. This coloration trait gives it its Latin name, *C. rufescens*, as in reddish. Its dorsum contrasts with the paler abdomen. Its throat and chin, generally present an irregularly spot surrounding the eyes that can cover the forehead, cheeks and the muzzle. Its tail, the dorsal surface of its hands and feet and its claws vary from dark brown to almost black (Figure 1).

On 22 February 2009, C. Racines-Márquez observed an apparent adult female of *C. rufescens* lacking the common coloration pattern described above (Figure 1). The individual had blackish to creamy quills, with red eyes and pinkish skin; even its claws lacked the characteristic blackish color. The specimen sighting was in San Francisco de Sigsipamba, Pimampiro, Imbabura province, in northern Ecuador (00°10′36″N, 78°11′38″W; 2,770 m asl, Figure 2). It was observed walking cross country 150 m through a fragmented agricultural landscape from a remnant Riparian Gallery Forest. This record was an opportunistic observation not associated with any particular field effort.

The present is the first report of albinism in New World porcupines of the genus *Coendou*, the fifth neotropical rodent's species for which cases of albinism have been reported and the first record for and albino rodent species in Ecuador. But why are these reports so rare?

The evolution of animal coloration in different species and in different body parts is subject to differential selective pressures. The coloration pattern can be relevant in predator evasion and camouflage, in inter and intraspecific communication, and in the regulation of some physiological processes (Caro 2005). In this context it is possible that the incidence of aberrant color patterns can compromise the individual fitness (Galante Rocha de Vasconcelos et al. 2017). In fact, for humans and domestic mammals a plethora of pathologies associated with albinism are described. In this context we

Figure 1: Normal (top) and albino (bottom) color pattern in *Coendou rufescens*, from Sangay National Park and San Francisco de Sigsipamba, Pimampiro, Ecuador, respectively.

infer that the low frequency of albinos observed in nature and reported in the literature is consequence of a strong selection against these mutations, but more research in this topic is necessary mainly in population genetics that will contribute to the understanding of the adaptive relevancy, if it exists, of the observed aberrant patterns and the responsible mutations. Knowledge of the incidence of this kind of report would be useful, allowing future studies to increase our understanding of a source of this often misunderstood variation in wild mammal populations. The accumulation, compilation, systematization and scientific publication of all data associated with this kind of records will be necessary.

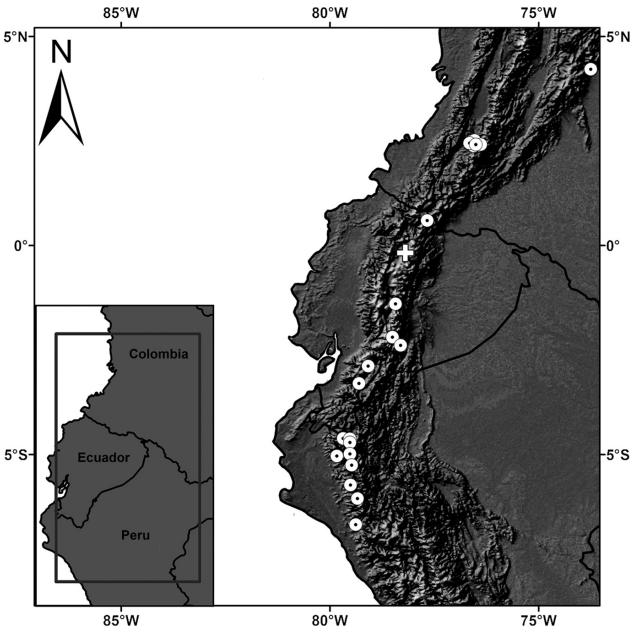

Figure 2: Distribution of *Coendou rufescens*: The plus symbol corresponds to the sighting locality of the albino specimen in San Francisco de Sigsipamba, Pimampiro, Imbabura province, in the Northern of Ecuador (0°10′36″N, 78°11′38″W; 2770 m asl), dots are the locations of the available bibliographic records in Colombia (Ramírez-Chaves et al. 2008, 2015, Voss 2015), Ecuador (Voss 2015, Brito and Ojala Barbour 2016) and Peru (More and Crespo 2016).

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