

Occurrence of leucism in *Eira barbara* (Carnivora, Mustelidae) in Brazil

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Abstract: The occurrence of anomalous coloration (albinism, leucism and melanism) in mammals is a rare phenomenon in nature, but this phenomenon has been reported for several species of mammals. In this study, we report on the occurrence of leucism in *Eira barbara* by examining three road-killed individuals and two sightings of live animals in Reserva Particular do Patrimônio Natural Santuário do Caraça, southeastern Brazil. In addition, we examined tayra specimens housed in mammal collections from Brazil and USA. The animals found dead and those sighted had a whitish yellow fur on the body and head, resulting in lighter coloration than the coloring pattern commonly observed in tayras. Despite these lighter color pattern, the specimens showed parts of soft tissue, such as iris and the skin, with pigmentation very similar to that present in individuals with the typical color pattern. This set of factors indicates the specimens recorded were in fact leucistic and not albino. Among the specimens examined in the scientific collections, we found nine individuals from different localities that presented the whitish yellow color pattern. Some studies attribute the higher frequency of cases of leucism due to small populations and / or with some mechanism of reproductive isolation. Thus, analysis of the genetic variability of populations containing individuals with such characteristics should be considered. On the other hand, the occurrence of polymorphic color phenotype in tayras indicates that hypotheses related to the fixation of recessive characteristics, or on possible environmental adaptive advantages of these phenotypes can be tested.

Keywords: *Leucism, fur coloration, tayra, Serra do Caraça*

Ocorrência de leucismo em *Eira barbara* (Carnivora, Mustelidae) no Brasil

Resumo: A ocorrência de coloração anômala (albinismo, leucismo e melanismo) em mamíferos é um fenômeno raro na natureza, mas ela tem sido relatada para diversas espécies. Neste trabalho nós relatamos a ocorrência de leucismo em *Eira barbara* por meio do exame de três indivíduos encontrados mortos atropelados por veículos e pela visualização direta de indivíduos vivos na Reserva Particular do Patrimônio Natural Santuário do Caraça, sudeste brasileiro. Em adição, nós consultamos coleções de mamíferos em museus do Brasil e dos Estados Unidos da América. Os animais encontrados mortos e os avistados apresentavam pelagem amarela esbranquiçada no corpo e na cabeça, resultando em uma coloração muito mais clara que o padrão de coloração comumente observado em iraras. Apesar deste padrão de coloração mais claro, os espécimes apresentavam partes do tecido mole, tais como a íris e a pele, com pigmentação muito semelhante àquela presente em indivíduos com padrão de coloração típico da espécie. Este conjunto de fatores indicou que os espécimes registrados eram de fato leucísticos e não albinos. Dentre os espécimes examinados nas coleções científicas, nós encontramos nove indivíduos de diferentes localidades que apresentavam o padrão de coloração esbranquiçado. Alguns estudos atribuem a frequência elevada de casos de leucismo a pequenas populações e / ou com algum mecanismo de isolamento reprodutivo. Dessa forma, análises da variabilidade genética de populações contendo indivíduos com essas características devem ser consideradas. Por outro lado, a ocorrência de fenótipos de coloração polimórficos em iraras indica que hipóteses podem ser testadas tanto com relação à fixação de características recessivas, quanto sobre possíveis vantagens adaptativas ambientais desses fenótipos.

Palavras-chave: *Leucismo, coloração de pelagem, irara, Serra do Caraça*

Introduction

Mammalian hair and skin coloration are related to concealment intra and interspecific communication, protection from ultraviolet (UV) radiation and to physiological functions (Caro 2005). The hair, skin and eye color are primarily determined by the quantity and distribution of eumelanin (black and brown coloration) and pheomelanin (red and yellow coloration), which are produced by melanocytes present in the epithelium, iris, and hair (Prota 1980; Sanchez-Ferrer et al. 1995). The occurrence of phenotypic variations in the coat of animals is related to geographic distribution, seasonal climatic variations, age, sex, weight, and other factors (Ortolani 1999; Stoner et al. 2003; Kawanishi et al. 2010; Ancilloto & Mori 2017). Anomalous colors occur when integumentary pigments are present in excess or in deficient amounts in parts or in totality of the body; white is the complete lack of pigment (Prota 1980; Ortolani 1999; Caro 2005; Fertl & Rosel 2002). Such conditions have been categorized as melanism, leucism and albinism (Fertl & Rosel 2002).

Leucism is a condition involving the partial or total reduction of pigmentation without affecting soft tissues such as eyes and skin, which retain normal coloration (Miller 2005; Acevedo & Aguayo 2008). The causes of leucism are often attributed to the presence of recessive mutant alleles (Bensch et al. 2000), or to the lack of production of tyrosinase, the enzyme involved in melanin biosynthesis, so that the body cannot synthesize melanin (Sanchez-Ferrer et al. 1995). Leucism differs from albinism, which is caused by a recessive disorder, causing the individual to have pink skin and eyes, and in mammals, a white fur (Cademartori & Pacheco 1999; Rodrigues et al. 1999; Oliveira 2009). Leucism is commonly confused with partial albinism or piebaldism (Fertl & Rosel 2002; Miller 2005), a type of disorder related to the lack of pigmentation in certain areas of the body of the animal, but maintaining normal eye color. On the other hand, melanism is an increase in the amount of pigment in an individual (Acevedo & Aguayo 2008).

In a recent study, 198 cases of abnormal coloration in 26 Neotropical mammal species was reported (Abreu et al. 2013), with cases being much more common in cetaceans, chiropterans and rodents (Pessôa & Reis 1995; Fertl et al. 2004; Abreu et al. 2013; Neves et al. 2014). Except for the report of the occurrence in pinniped species (Acevedo & Aguayo 2008; Abreu et al. 2013), anomalous colors in other Carnivora is known in *Eira barbara* (Trolle 2003; Reis et al. 2005; Tortato & Althoff 2007), in *Nasua narica* (Silva-Caballero et al. 2014), and in *Lontra longicaudis* (Arriaga-Flores et al. 2016).

Eira barbara (Linnaeus, 1758), from the Mustelidae family, is known as tayra and is a species unique in its genus. It is found from central Mexico to northern Argentina (Presley 2000). In Brazil, the tayra occurs in almost all of the territory, where it is more common in areas of dense vegetation (Cheida et al. 2006). The color of tayras may vary throughout its distribution area, but the dark brown coat of its body is predominant, with varying amounts of white or tan on the head and throat extending to the chest (Presley 2000). In Panama, specimens are usually completely black, but individuals presenting fur variations with a yellow-whitish body have been described in Guyana (Presley 2000) and in the Madidi National Park, Bolivia (Tarifa et al. 2001).

In Brazil, there are four reports of tayras with a yellow-whitish body; one individual was registered in the Jauaperi region, in the sub-basin of the Rio Negro, in the state of Amazonas (Trolle 2003); whitish tayras were sporadically sighted on the Monte Alegre farm, in the state of Paraná (Reis et al. 2005); six records of tayras were made in the State Biological Reserve of Sassafras in the state of Santa Catarina (Tortato & Althoff 2007). One recent record was made in the surroundings of the Itatiaia National Park, Rio de Janeiro state (Aximoff & Rosa 2016). In this study, we reported on the occurrence of individuals of *Eira barbara* with leucism characteristic at the Reserva Particular do Patrimônio Natural (R.P.P.N.) Santuário do Caraça in Minas Gerais, southeastern Brazil. In order to

expand the account of occurrence of leucism in tayras, we consulted some of the most representative mammal collections from Brazil, and also the mammal collection of the American Museum of Natural History (USA).

Material and Methods

The R.P.P.N. Santuário do Caraça is located (20°0'51"S, 43°29'28"W; 11,233 ha) between the cities of Catas Altas and Santa Bárbara, Minas Gerais, in southeastern Brazil. The "Santuário do Caraça" forms a mountainous setting, surrounding an interior plateau, whose altitude ranges from 750m to 2072 m above sea level. It is situated on the slopes of the mountain range known as the Serra do Espinhaço, and possesses a mosaic of different plant communities including semi deciduous forests, cerrado, and open areas such as high-altitude rocky fields (Talamoni et al. 2014).

We obtained the records of three tayras in 2009, all road-killed and found on the main road of the R.P.P.N. Two of them were taxidermized and their respective skulls and skins were deposited in the Mammalian Collection of the Museu de Ciências Naturais (MCNM PUC Minas) of the Pontifícia Universidade Católica de Minas Gerais. Two other records of tayras were made in the reserve, one occurred in 2012 and another in 2016.

We also examined the specimens of tayras deposited in the mammal collections of some Brazilian museums: Museu Nacional da Universidade Federal do Rio de Janeiro (MN-UFRJ), Museu de Zoologia da Universidade de São Paulo (MZUSP), Museu Paraense Emílio Goeldi (MPEG), Museu de Ciências Naturais da Pontifícia Universidade Católica de Minas Gerais (MCNM-PUC Minas), Museu João Moojen (MJM) and Mammal Collection of the Department of Zoology of Universidade Federal de Minas Gerais (UFMG collection), as well as the mammal collection of the American Museum of Natural History (AMNH).

Results

In this study, we report on 13 tayras with recorded characteristics of leucism, of which 11 are related to skins deposited in museums (Table 1). Some of the skins have biometric data available, while others do not (Table 1). Of the tayras found dead and deposited in MCNM-PUC Minas, one showed a pale cream color on the body and head (Figure 1A), while another (Figure 1B) had an intermediate color between a pale cream color and the common color pattern, typical for tayras in the state of Minas Gerais (Figure 1C). Another tayra found dead in 2009 (Figure 1D) also featured a pale cream color and the same was donated to a didactic collection in an educational institution, and therefore there was no collection number for this specimen. In 2012, a living tayra (Figure 1E) was sighted and photographed under an avocado pear tree, near the central area of the R.P.P.N., where there are several buildings and the constant presence of people. In 2016, a new sighting of a tayra showing the same characteristics of leucism occurred in the same place, and may have been the same individual sighted in 2012 (Figure 1F).

Regarding to museum specimens, we found nine individuals with pale cream color (Table 1, Figure 2 and 3). In the MPEG collection, we find four specimens deposited in the 1970s (Figure 2A - D, Table 1) from Oriximiná, state of Pará, in the Trombetas River basin, a tributary of the Amazonas River. In the UFMG collection a specimen from the same region was recently deposited (UFMG 4193, deposited in November 2009, Figure 2E, Table 1).

Four specimens have been recorded in the collection of MZUSP, being one from Boiuçu, state of Pará, two from the Public Garden of São Paulo, today known as Parque da Luz, and another from Iporanga in São Paulo (Figure 3A - D, Table 1). These specimens were compared with other species featuring a color similar to the pattern commonly known in tayras in Brazil and deposited in the last century: male (MZUSP 441, housed in 1901, Fig. 3E), Corupá, Santa Catarina. There is no biometric data available for these specimens (Table 1). The museums MN, João

Table 1. Collection site, sex and external measurements of leucistic tayras. Measurements are in millimeters, except weights, which are in grams.

Museum / Collection	Voucher number	Date	Locality	Geographic coordinate	Sex	Weight	Body length	Tail length	Hind foot length	Ear
MCNM	2981	Jan 11, 2009	R.P.P.N. Santuário do Caraça, Catas Altas, Minas Gerais	20°0'51" S 43°29'28" W	Female	2,450	550	283	98	32
MCNM	3012	Feb 22, 2009	R.P.P.N. Santuário do Caraça, Catas Altas, Minas Gerais	20°0'51" S 43°29'28" W	Male	9,150	691	394	114	39
MPEG	9210	Jul 15, 1978	Rio Trombetas, Oriximiná, Pará		Male	5,000	650	118	105-113	20-40
MPEG	10013	Apr 4, 1977	Cachoeira Porteira, Oriximiná, Pará	1°06'57.20" S 57°05'24.50" W	Female	4,100	630	450	95-105	25-35
MPEG	10014	Jul 26, 1978	Cachoeira Porteira, Oriximiná, Pará	1°06'57.20" S 57°05'24.50" W	Male	5,000	600	420	100-108	17-37
MPEG	10223	-	Porto Trombetas, Oriximiná, Pará	1°28'20.0" S 56°22'35.5" W						
UFMG	2981	Nov, 2007	Porto Trombetas, Oriximiná, Pará	1°28'20.0" S 56°22'35.5" W	Male	5,870	635	425	118	38
MZUSP	5186	Apr 26, 1965	Boiuçú, Pará	1°48'0.000" S 50°16'59.880" W	Female					
MZUSP	2061	Nov, 1905	Jardim Público de São Paulo (current Parque da Luz), São Paulo		Female					
MZUSP	2062	Dec, 1905	Jardim Público de São Paulo (current Parque da Luz), São Paulo		Male					
MZUSP	6295	Jan 28, 1944	Iporanga, São Paulo	24°58'41.67" S 48°59'27.00" W						

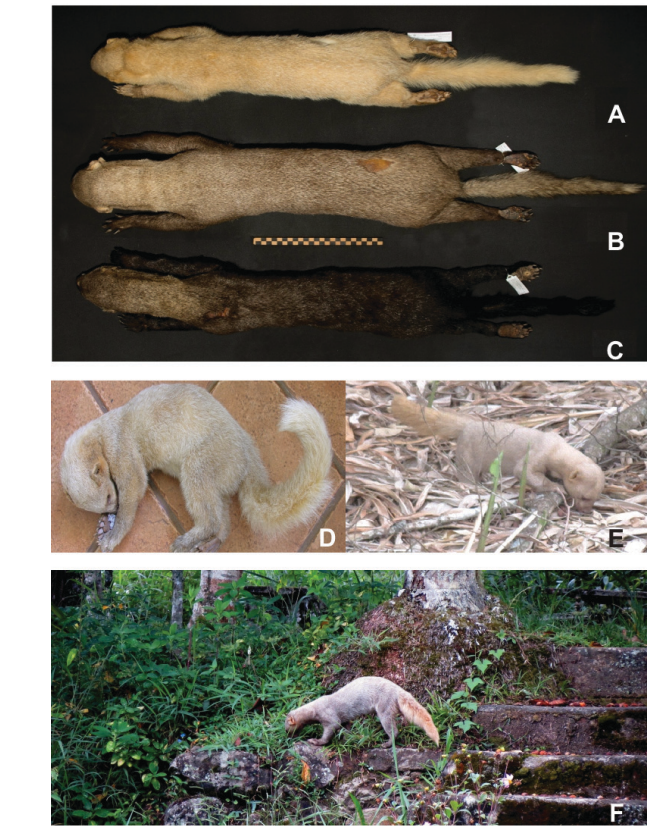


Figure 1. *Eira barbara* specimens with a yellow-whitish color recorded at R.P.P.N. Santuário do Caraça, Minas Gerais, Brazil. A. Female found dead in the road. Voucher number: MCNM 2981, registration date: 11/01/2009. B. Male found dead in the road. Voucher number: MCNM 3012, registration date: 02/22/2009. C. Male collected in the Municipality of Belo Vale, Minas Gerais, Brazil. Voucher number: MCNM 1915, registration date: 21/01/2011; this specimen was used in this study to represent the default color of the species *E. barbara* in the state of Minas Gerais. D. *Eira barbara* specimen found dead in the road. Registration date: 06/12/2009. E. Male recorded living at R.P.P.N., registration date: 07/17/2012. F. Individual recorded living at R.P.P.N., date of registration: 03/2016.

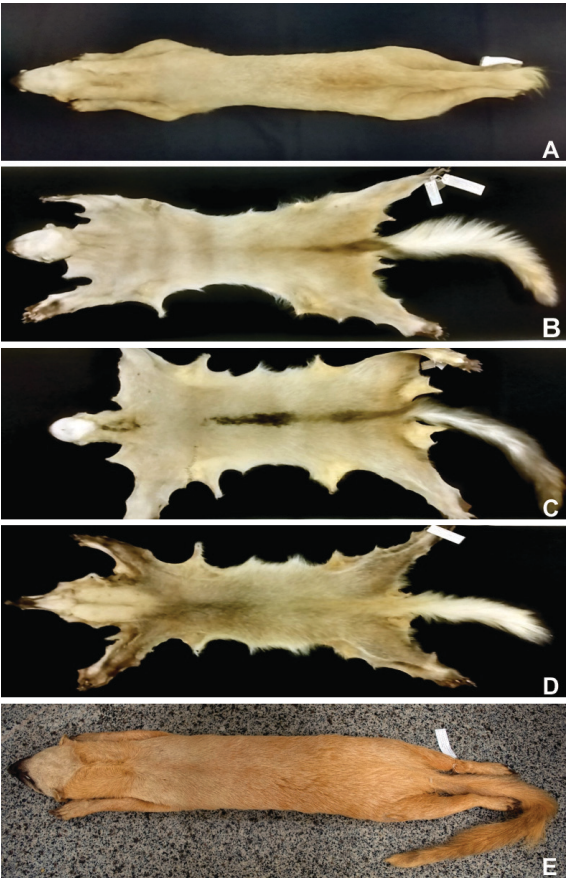


Figure 2. *Eira barbara* specimens with a yellow-whitish color recorded at Oriximiná, state of Pará, Brazil. A. Male collected in Rio Trombetas. Voucher number: MPEG: 9210, registration date: 15/07/1978. B. Female collected in Cachoeira Porteira. Voucher number: MPEG: 10013, registration date: 04/04/1977. C. Male collected in Cachoeira Porteira. Voucher number: MPEG: 10014. Registration date: 26/07/1978. D. no biological data, individual collected in Porto Trombetas, Voucher number: 10223, no date. E. Male collected in Porto Trombetas. Voucher number: UFMG: 2981, registration date: 11/2007.



Figure 3. *Eira barbara* specimens with a yellow-whitish color in Brazil. A. Female collected in Boiucú, state of Pará. Voucher number: MZUSP: 5186, registration date: 26/04/1965. B. Female collected at Jardim Público of São Paulo (current known as Parque da Luz), but of unknown origin, state of São Paulo. Voucher number: MZUSP: 2061, registration date: 11/1905. C. Male collected at Jardim Público of São Paulo (current Parque da Luz), but of unknown origin, state of São Paulo. Voucher number: MZUSP: 2062, registration date: 12/1905. D. Individual collected in Iporanga, in the state of São Paulo. Voucher number: MZUSP: 6295, registration date: 28/01/1944. E. Male collected in Corupa, in the state of Santa Catarina. Voucher number: MZUSP: 441, registration date: 1901 year. This specimen was used in this study to represent the default of a very old skin presenting the common color pattern for *E. barbara*.

Moojen and the AMNH do not have any tayra with characteristics of leucism in their collections.

Discussion

Based on the available definitions about anomalous color (Fertl & Rosel 2002), and on the characteristics shown by individuals such as a lack of color in the guard hairs, maintenance of color in the under-hairs and body extremities (nose, ears, feet and tail) having dark pigmentation, we consider that the recorded individuals can be considered to have leucism. There is no information in the literature regarding the analysis of the consequences of the variation in coat color in tayras throughout its area of distribution, nor in relation to the consequences of leucism. Mammalian hair and skin color provides concealment for the mammals (Deblase & Martin 1980), while it is expected that leucism and/or albinism imposes on the individuals a greater difficulty in camouflage, possibly subjecting them to a greater risk of predation (Parsons & Bonderup-Nielsen 1995). Peles et al. (1995), however, in a rare study addressing this topic, it was shown that albinism in meadow voles (*Microtus pennsylvanicus*) proved not to be a disadvantageous trait in grassland habitats with high nutritional quality and heavy vegetative cover.

The MZUSP and MN are the natural history museums with the largest collections of mammals in the country. The rarity of older specimens and the absence of deposit of newly collected specimens in these two collections may indicate the rarity of leucism in tayras. Of the museum specimens analyzed, two of the MZUSP are dated to the beginning of the 20th century, both from Jardim Público, where today it houses the Parque da Luz within the city of São Paulo. Parque da Luz was created in 1825 as a Botanical Garden and in 1838 it was named the Jardim Público. Throughout the second half of the nineteenth century the Jardim Público underwent a series of reformulations, and the last major reform was the creation of a zoo, the first in the city of São Paulo, in the 1890s. This zoo housed species native to Brazil and some exotic (Ohtake & Dias 2011). In the middle of the nineteenth century and at the beginning of the twentieth century the area around Jardim da Luz was already quite urbanized (Ohtake & Dias 2011) and it was practically impossible that wild tayras could live freely in this central region of the city. Thus, the specimens of tayras from the Jardim Público were probably not native to the park and surrounding areas and may have come from other regions of Brazil.

Another specimen of the MZUSP collection comes from Boiucú, in the state of Pará. Considering the records of Oriximiná, this region of the Amazon basin holds the largest number of cases of leucism in tayras. In addition, there is already the case reported in the region of the Jauaperi River, a sub-basin of Rio Negro (Toller 2003), a tributary of the Amazon River. It is notable that between the first and last record for the region of Oriximiná there is a time interval of 30 years. In Oriximiná and in the village of Porto Trombetas, in the mid-Amazonas region, several socio-environmental conflicts have been registered in the last five decades due to the establishment of a bauxite extraction plant in the region (Monteiro 2005; Wanderlei 2008). The local extraction of bauxite has led to numerous negative impacts such as deforestation, the contamination and silting of rivers and the displacement of riparian and “quilombola” peoples (Wanderlei 2008). The surroundings of the Caraça reserve is also characterized by intense mining activities (Marent et al. 2011), however, the reserve, with its more than 100 km², borders the Parque Nacional Serra do Gandarela (Marent et al. 2011), which has 312 km² of forested area (ICMBio 2017).

The occurrence of leucism is based on the expression of recessive alleles and individuals with leucism are more frequent in small and isolated populations because endogamy causes recessive alleles to be expressed (Bensch et al. 2000). Thus, if reproductive isolation occurs among local populations of tayras, it is necessary to understand it. Considering the number of records reported the analysis of the patterns of genetic diversity within and among local populations would be important. The occurrence of the leucistic phenotype observed in the Oriximiná and Caraça populations may represent an opportunity to investigate the possibility of establishing a recessive trait in these populations, such as the near fixation of melanism, another recessive color anomaly, observed in leopards of the Malay Peninsula (Kawanishi et al. 2010). On the other hand, the occurrence of different coloration phenotypes in tayras throughout its distribution area, provides an opportunity to investigate possible adaptive advantages of these phenotypes (Silva et al. 2016) in relation to the ecological conditions present in their areas of occurrence.

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Author Contributions

Sonia Talamoni: substantial contribution in the concept and design of the study; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Claudia Guimarães Costa: substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Pedro Igor Macário Viana: contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Lauro Palú: contribution to data collection; contribution to manuscript preparation and critical revision.

Raphaella Barcelos Oliveira: contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Leila Maria Pessôa: contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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