

Anomalous colour in Neotropical mammals: a review with new records for *Didelphis* sp. (Didelphidae, Didelphimorphia) and *Arctocephalus australis* (Otariidae, Carnivora)

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(With 1 figure)

Abstract

Anomalous colourations occur in many tropical vertebrates. However, they are considered rare in wild populations, with very few records for the majority of animal taxa. We report two new cases of anomalous colouration in mammals. Additionally, we compiled all published cases about anomalous pigmentation registered in Neotropical mammals, throughout a comprehensive review of peer reviewed articles between 1950 and 2010. Every record was classified as albinism, leucism, piebaldism or eventually as undetermined pigmentation. As results, we report the new record of a leucistic specimen of opossum (*Didelphis* sp.) in southern Brazil, as well as a specimen of South American fur seal (*Arctocephalus australis*) with piebaldism in Uruguay. We also found 31 scientific articles resulting in 23 records of albinism, 12 of leucism, 71 of piebaldism and 92 records classified as undetermined pigmentation. Anomalous colouration is apparently rare in small terrestrial mammals, but it is much more common in cetaceans and microchiropterans. Out of these 198 records, 149 occurred in cetaceans and 30 in bats. The results related to cetaceans suggest that males and females with anomalous pigmentation are reproductively successful and as a consequence their frequencies are becoming higher in natural populations. In bats, this result can be related to the fact these animals orient themselves primarily through echolocation, and their refuges provide protection against light and predation. It is possible that anomalous colouration occurs more frequently in other Neotropical mammal orders, which were not formally reported. Therefore, we encourage researchers to publish these events in order to better understand this phenomenon that has a significant influence on animal survival.

Keywords: albinism, hypopigmentation, leucism, Neotropical mammals, piebaldism.

Coloração anômala em mamíferos Neotropicais: uma revisão com novos registros para *Didelphis* sp. (Didelphidae, Didelphimorphia) e *Arctocephalus australis* (Otariidae, Carnivora)

Resumo

Colorações anômalas ocorrem em muitos vertebrados tropicais. Entretanto, estas são consideradas raras em populações selvagens, havendo poucos registros para a maioria dos táxons. Reportam-se, neste estudo, dois novos casos de coloração anômala em mamíferos. Além disso, por meio de uma extensa revisão bibliográfica, foram compilados os casos publicados sobre coloração anômala em mamíferos neotropicais entre 1950 e 2010. Cada registro foi classificado como albinismo, leucismo, piebaldismo ou, eventualmente, como coloração indeterminada. Como resultados, reportou-se o registro de um espécime leucístico de gambá (*Didelphis* sp.) no sul do Brasil e de um espécime de lobo-marinho sul-americano (*Arctocephalus australis*) com piebaldismo no norte do Uruguai. Também foram analisados 31 artigos científicos, resultando em 23 registros de albinismo, 12 de leucismo, 71 de piebaldismo e 92 registros classificados como de pigmentação indeterminada. A coloração anômala aparentemente é rara em pequenos mamíferos terrestres, mas é muito mais comum em cetáceos e microquirópteros. Dos 198 registros encontrados, 149 ocorreram em cetáceos e 30 em morcegos. No caso dos cetáceos, este resultado sugere que machos e fêmeas com este padrão anômalo de pigmentação são reprodutivamente exitosos e, conseqüentemente, sua frequência está aumentando nas populações naturais. Com relação aos morcegos, este fenômeno pode estar relacionado ao fato de estes animais orientarem-se primariamente por meio de ecolocalização e seus refúgios oferecerem proteção contra luz e predação. É possível que a coloração anômala ocorra mais frequentemente em outras ordens de mamíferos neotropicais, as quais não foram formalmente reportadas. Desta forma, mostra-se importante encorajar os pesquisadores a publicar estes eventos em vida selvagem para um melhor entendimento deste fenômeno, que tem influência significativa na sobrevivência destes organismos.

Palavras-chave: albinismo, hipopigmentação, leucismo, mamíferos neotropicais, piebaldismo.

1. Introduction

The two factors that determine colour patterns in mammals are the presence and distribution of pigmentation in the skin, hair and eyes (Fertl and Rosel, 2002; Hofreiter and Schöneberg, 2010). However, anomalous colour can occur occasionally due to an excess or deficit in the production of melanin in some regions of or throughout the entire body (Acevedo and Aguayo, 2008). According to Summers (2009), the terms “partial” and “total” for the two different levels of albinism (hypopigmentation) have become obsolete. Current zoological studies (Fertl and Rosel, 2002; Miller, 2005; Acevedo and Aguayo, 2008) have classified anomalous colouration as piebaldism, leucism (or partial albinism), albinism and melanism. There is still some divergence between authors, mainly because some studies do not take into account the differences between piebaldism and leucism (e.g. Geiger and Pacheco, 2006; Oliveira, 2009a).

Piebaldism is lack of pigmentation in some parts of the body, but presenting normal colouration in the eyes (Fertl and Rosel, 2002). Miller (2005) used the term partial albinism to refer to this phenomenon. Leucism are characterised by total or partial absence of pigmentation in the whole body (the individual has a body that is white, whitish or yellowish white colour), but the eyes and/or body extremities still have dark or blue pigmentation (Fertl and Rosel, 2002; Miller, 2005; Acevedo and Aguayo, 2008). Albinism records are those in which the individual presents a total absence of pigmentation in the whole body (white, whitish or yellowish white colour) and has eyes with no traces of pigmentation, but instead red or pink colouration (Fertl and Rosel, 2002; Miller, 2005; Acevedo and Aguayo, 2008).

Leucism, piebaldism, and albinism have been recorded in many species of Neotropical vertebrates, including snakes (e.g. Sazima and Di-Bernardo, 1991; Silva et al., 2010), anurans (e.g. Sanabria et al., 2010), birds (e.g. Veiga and Oliveira, 1995b; Franz and Fleck, 2009; Mancini et al., 2010), fish (e.g. Sazima and Pombal, 1986; Brito and Caramaschi, 2005) and mammals (e.g. Acevedo and Aguayo, 2008; Oliveira, 2009a, b). However, these events are considered rare in wild populations (Walter, 1914) because albino animals are more susceptible to predation (Sazima and Di-Bernardo, 1991; Parsons and Bonderup-Nielsen, 1995) and there are a number of pathologies that can arise in association with the albinism, such as visual (Pérez-Carpinell et al., 1992; Grant et al., 2001; Garipis and Hoffmann, 2003) and immunological defects (Manglani et al., 2004; Summers, 2009; Carretero et al., 2009). In the case of aquatic animals, Hain and Leatherwood (1982) and Fertl and Rosel (2002) also suggest that albino animals may exhibit lower heat absorption in colder waters. Other authors suggest that the survival of albino animals does not differ from that of non-albino individuals of cryptic or nocturnal species (Sazima and Pombal, 1986; Sazima and Di-Bernardo, 1991) and in those that have restricted predators (Rodrigues et al., 1999). Therefore, in order

to better understand the consequences of the anomalous coloration on the survival of wildlife mammals, it is essential to know the kind and frequency of these phenomena and the most susceptible orders.

In this paper, we review the cases of albinism, leucism and piebaldism recorded in Neotropical mammals. We also report new cases of anomalous colouration in *Didelphis* sp. Linnaeus, 1758 and *Arctocephalus australis* (Zimmermann, 1783).

2. Material and Methods

The new records of anomalous coloration reported here occurred in two opportunistic occasions. The photograph of the opossum was taken by Lieutenant Erneide Rissardo da Silva, from the Second Environmental Policy Squad (Segundo Pelotão de Policiamento Ambiental) of Torres, Rio Grande do Sul, Southern Brazil (for more details see the Results section).

The photograph of the South American fur seal was taken by one of the authors in Cabo Polonio, Rocha Province, Uruguay (for more details see the Results section). The authors of both pictures used a portable camera with 480 dpi of resolution. It is important to mention that without the photographs mentioned above, the present records would not be available. Thus, we believe that this record is a very helpful tool for documentation of natural history.

We conducted a review of the records of anomalous colouration in Neotropical mammals published in peer-reviewed journals between 1950 and 2010 through scientific portals (e.g. NCBI, Web of Science, Scielo, Scielo Brazil, Periódicos CAPES) using as key words the terms “albinism”, “albinismo”, “leucism”, “leucismo”, “anomalous color”, “piebaldism”, “piebaldismo” and “white color”. We did not include any personal communications in the results. The papers found were analysed by species and mammal order, the country where the record occurred and type of hypopigmentation. For marine mammals, we only included cases documented on the Neotropical coastal waters. The Neotropical region is defined as Central Mexico to the southernmost tip of South America (Udvardy, 1975).

Piebaldism records are related to a lack of pigmentation in only some parts of the body and normal eye colouration. Leucism are a total or partial absence of pigmentation in the whole body, but the eyes and/or body extremities still have dark or blue pigmentation. Albinism are a total absence of pigmentation in the whole body and red or pink eyes. This classification was based on Fertl and Rosel (2002), Miller (2005) and Acevedo and Aguayo (2008). When the authors of the analysed studies classified an individual as having only total or partial albinism, a more refined classification was used (piebaldism, leucism or albinism), based on the record description and available photos. When the information presented was insufficient to properly classify the anomalous colour type, these records were classified as “undetermined”.

3. Results

In this paper, we report two new cases of anomalous colouration in *Didelphis* sp. and *Arctocephalus australis*. We also found 31 scientific articles with records of albinism, leucism and piebaldism in Neotropical mammals.

3.1. Case 1: Record of opossum, *Didelphis* sp., with leucism

On 27 August 2010, a specimen of *Didelphis* sp. was found in a commercial establishment in Arroio do Sal city, Rio Grande do Sul state, Southern Brazil (29° 33' S and 49° 53' W). The animal was collected by the Second Environmental Policy Squad (Segundo Pelotão de Policiamento Ambiental) of Torres and released in the Environmental Reserve Tupancy Park (29° 29' S and 49° 50' W), in Arroio do Sal. The animal presented a white colour throughout the entire body and dark eyes, representing a case of leucism (Figure 1a).

Since it was rescued and released by the Second Environmental Policy Squad, the specimen could not be identified for the species level. Two species of the genus *Didelphis* occur in Rio Grande do Sul: *D. albiventris* Lund, 1840 and *D. aurita* (Wied-Neuwied, 1826) (Wilson and Reeder, 2005; Vaccaro and Canevari, 2007; Rossi et al., 2010). Both species are listed as of least concern on the Red List of the International Union for Conservation of Nature (IUCN), but they are not listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

3.2. Case 2: Record of South American fur seal, *Arctocephalus australis*, with piebaldism

On 23 October 2010, a specimen of *Arctocephalus australis* was observed and photographed by one of the authors (NSF) in Cabo Polonio (34° 24' S and 53° 47' W), Uruguay. The specimen, a sub-adult male, presented white spots in the ventral region, next to the neck and right pectoral fin (Figure 1b). These characteristics indicated that this is a record of piebaldism.

A. australis is a highly dimorphic pinniped, with males being larger than females. Until 1991, the main threat to the conservation of this species was poaching for skin and genitalia (Reeves et al., 1992). Currently, this species is protected and is listed in Appendix II of the CITES. In IUCN, the species is listed as of least concern on the Red List.

3.3. Compilation of the records of anomalous coloration in Neotropical mammals

Our review of the studies of anomalous coloration in Neotropical mammals resulted in 31 scientific articles and 198 individuals reported. Considering the records of the present study, we have 23 records of albinism, 12 records of leucism, 71 records of piebaldism, and 92 records classified as undetermined (Table 1). The Order Cetartiodactyla presented the largest number of records ($n = 152$, including 149 cetaceans), followed by Chiroptera ($n = 30$), Carnivora ($n = 9$), Rodentia ($n = 4$), Pilosa ($n = 2$) and Didelphimorphia ($n = 1$, present paper). Argentina was the country, which had most of the records ($n = 150$) followed by Brazil ($n = 37$), which presented cases in all orders that the phenomena was reported.

We were unable to verify whether the cases registered for Guiana dolphin, *Sotalia guianensis* (van Bénédén, 1864) (Nascimento et al., 2008), and Pantropical spotted dolphin, *Stenella attenuata graffmani* (Lönnerberg, 1934) (Fertl et al., 2004), were of albinism or leucism because the authors were unable to check the colour of the individuals' eyes. For sperm whale, *Physeter macrocephalus* Linnaeus, 1758, Fertl et al. (1999) did not include much information about this record, restraining an appropriate classification. In relation to the records of the Southern Right whale *Eubalaena australis* (Desmoulins, 1822) presented by Schaeff et al. (1999), we considered the pattern of colorations "white-blaze" and "partial-grey-morph with white-blaze" as piebaldisms and "grey-morph" and "partial-grey-morph" as undetermined, based on classification presented by these authors. Moreover, Schaeff et al. (1999) did not present the absolute number of individuals for each kind

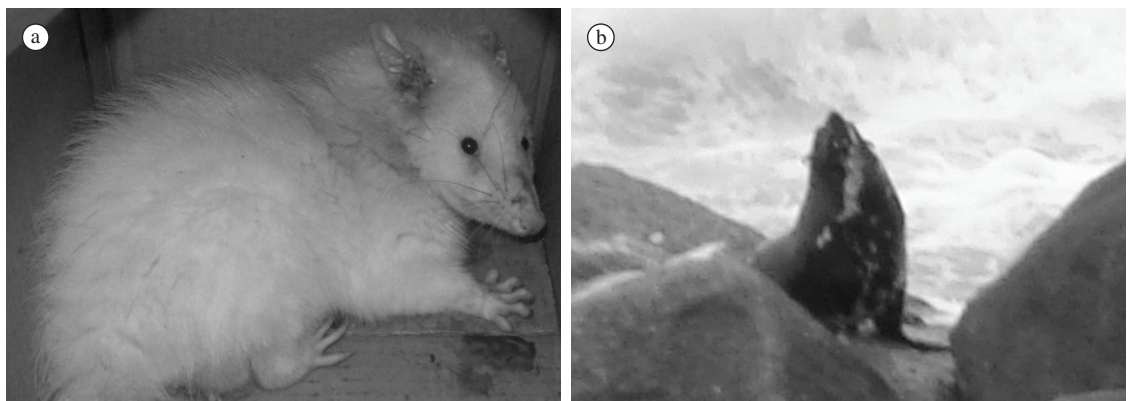


Figure 1. New records of anomalous colour in Neotropical mammals. (a) Leucistic opossum (*Didelphis* sp.) found on the coast of Rio Grande do Sul state, Southern Brazil (Photo: E.R. Silva). (b) South American fur seal (*Arctocephalus australis*) with piebaldism registered in Cabo Polonio, Uruguay (Photo: NS Freitas).

Table 1. Records of piebaldism, leucism and albinism in Neotropical mammals, with hypopigmentation type, country were the event was registered, number of cases and references with the mentioned records.

Species	Hypopigmentation	n	Country	References
Cetartiodactyla				
Balaenidae				
<i>Eubalaena australis</i> (Desmoulins, 1822)	Piebaldism Undetermined	58 88	Argentina Argentina	Schaeff et al. (1999)
Cerviidae				
<i>Mazama gouazoubira</i> (G. Fischer [von Waldheim], 1814)	Piebaldism	1	Brazil	Oliveira (2009b)
<i>Ozotoceros bezoarticus</i> (Linnaeus, 1758)	Leucism	1	Brazil	Rodrigues et al. (1999)
Delphinidae				
<i>Sotalia guianensis</i> (van Bénédén, 1864)	Undetermined	1	Brazil	Nascimento et al. (2008)
<i>Stenella attenuata graffmani</i> (Lönnberg, 1934)	Undetermined	1	Panama	Fertl et al. (2004)
Physeteridae				
<i>Physeter macrocephalus</i> Linnaeus, 1758	Undetermined	1	Peru	Fertl et al. (1999)
Tayassuidae				
<i>Pecari tajacu</i> ¹ (Linnaeus, 1758)	Leucism	1	Brazil	Veiga (1994)
Carnivora				
Mustelidae				
<i>Eira barbara</i> (Linnaeus, 1758)	Leucism	6	Brazil	Tortato and Althoff (2007)
Otariidae				
<i>Arctocephalus australis</i> (Zimmermann, 1783)	Piebaldism	1	Uruguay	This study
<i>Otaria flavescens</i> (Shaw, 1800)	Leucism Albinism	1 1	Chile Argentina	Acevedo and Aguayo (2008), López and López (1984)
Chiroptera				
Mollossidae				
<i>Eumops glaucinus</i> (Wagner, 1843)	Albinism	1	Brazil	Sodre et al. (2004)
<i>Nyctinomops laticaudatus</i> (E. Geoffroy, 1805)	Piebaldism	5	Brazil	Geiger and Pacheco (2006)
<i>Mollossus molossus</i> (Pallas, 1766)	Albinism	1	Brazil	Heatwole et al. (1964) apud Uieda (2000), Veiga and Oliveira (1995a)
Phyllostomidae				
<i>Artibeus cinereus</i> (Gervais, 1856)	Albinism	1	Brazil	Oliveira and Aguiar (2008)
<i>Artibeus jamaicensis</i> Leach, 1821	Piebaldism	1	Mexico	Sánchez-Hernández et al. (2010)

¹Synonym of *Tayassu tajacu* (Linnaeus, 1758); ²Synonym of *Proechimys albispinus* (I. Geoffroy, 1838).

Table 1. Continued...

Species	Hypopigmentation	n	Country	References
Chiroptera				
Phyllostomidae				
<i>Artibeus planirostris</i> (Spix, 1823)	Albinism	1	Brazil	Ujeda (2000)
<i>Desmodus rotundus</i> (E. Geoffroy, 1810)	Albinism	1	Argentina	Verschuren (1955) apud Ujeda (2000), Moreira et al. (1992), Ujeda (2000), Ujeda (2001), Ramirez et al. (2010), Sánchez-Hernández et al. (2010)
	Albinism	5	Brazil	
	Albinism	4	Mexico	
	Albinism	1	Trinidad	
	Undetermined	1	Brazil	
<i>Glossophaga longirostris</i> Miller, 1898	Albinism	1	Venezuela	Setzer (1950) apud Ujeda (2000)
<i>Lonchorhina fernandesi</i> Ochoa & Ibáñez, 1982	Piebaldism	3	Venezuela	Ochoa and Sanchez (1988)
<i>Sturnira erythromos</i> (Tschudi, 1844)	Albinism	1	Argentina	Barquez et al. (2003), Roncancio and Ramírez-Chaves (2008)
	Leucism	1	Colombia	
	Piebaldism	1	Argentina	
Didelphimorphia				
Didelphidae				
<i>Didelphis</i> sp. Linnaeus, 1758	Leucism	1	Brazil	This study
Pilosa				
Bradyrodidae				
<i>Bradypus variegatus</i> Schinz, 1825	Albinism	2	Brazil	Xavier et al. (2010)
Rodentia				
Cricetidae				
<i>Delomys dorsalis</i> (Hensel, 1873)	Albinism	1	Brazil	Cademartori and Pacheco (1999)
<i>Phyllotis andium</i> Thomas, 1912	Albinism	1	Peru	Ramirez and Arana (2005)
Dasyproctidae				
<i>Dasyprocta azarae</i> Lichtenstein, 1823	Leucism	1	Brazil	Oliveira (2009a)
Echimyidae				
<i>Trinomys albispinus</i> ¹ (I. Geoffroy, 1838)	Piebaldism	1	Brazil	Pessôa and Reis (1995)

¹Synonym of *Tayassu tajacu* (Linnaeus, 1758); ²Synonym of *Proechimys albispinus* (I. Geoffroy, 1838).

of anomalous coloration for the Southern Right whale. However, we were able to determine these values based on the frequency and total number of specimens presented in Table 2 of this paper (see Schaeff et al., 1999)

4. Discussion

In the present study, we found 198 cases of anomalous coloration in Neotropical mammals, and reported two new cases. The Order Cetartiodactyla had the highest number of records, including 59 cases of piebaldism, two cases of leucism and 91 records that we classified as undetermined. Moreover, 149 cetacean specimens were reported in scientific papers, including 146 Southern Right whales (*Eubalaena australis*) from the Argentine coast (Schaeff et al., 1999). According to Payne et al. (1983) five dorsal skin patterns have been documented among Southern Right whales: black, white-blaze, grey-blake, grey-and-whyte-blaze and partially albinistic. Partially albino right whales are white as calves but darken and become grey or brownish-grey as they age. Schaeff et al. (1999) suggested that two genes influence the dorsal skin color. The grey-morph and partial-grey-morph phenotypes (previously known as partial albino and grey-blaze, respectively) appear to be controlled by an X-linked gene, whereas the white blaze appears controlled by an autosomal gene (recessive phenotype). A number of forms of partial albinism have been identified in other mammals, including three which may be X-linked (Fraser et al., 1953; Tietz, 1963; Zipkowski et al., 1962).

In marine mammals, anomalously white individuals have been reported for 25 cetacean species and eight species of pinnipeds (otariids and phocids), with no known record for otters and sirenians (Acevedo et al., 2009). In the present study, we found articles reporting anomalous coloration in eight species of marine mammals, four otariids and four cetaceans (Table 1). However, Southern Right whales are the only species where such individuals are relatively common (Schaeff et al., 1999). According to Fertl and Rosel (2002), the costs of this anomalous coloration for marine mammals may include reduced heat absorption in colder waters, increased conspicuousness to predators, increased skin and eye sensitivity to sunlight, and impaired visual communication (Hain and Leatherwood, 1982). Despite the costs, some individuals do reach adult age and breeding status. The data presented by Schaeff et al. (1999) indicated that the occurrence of grey-morph females of southern right whale and the production of partial-grey-morph calves by black cows (female whales with calves) suggested that grey-morph males are fertile. Moreover, comparison of observed and expected frequencies of partial-grey-morph calves suggests that grey-morph males were as successful as black males in achieving fertilizations with black cows. However, additional data are required to further investigate the impact of dorsal color patterns on male fitness (Schaeff et al., 1999).

We also found many other records of aquatic mammals with anomalous coloration in other parts of the world outside

of the Neotropical region (e.g. Hain and Leatherwood, 1982; Fertl et al., 1999; Bruyn et al., 2007; Acevedo and Aguayo, 2008; Acevedo et al., 2009). The record of piebaldism in South American fur seal, *A. australis*, reported in this study is the first report of atypical coloration for the species, but anomalous colour has been recorded in other otariid species. On an earlier review of this anomaly in otariids, Acevedo and Aguayo (2008) reported cases in five otariid species: Antarctic fur seal, *Arctocephalus gazella* (Peter, 1875), Northern fur seal, *Callorhinus ursinus* Linnaeus, 1758, Steller sea lion, *Eumetopias jubatus* (Schreber, 1776), Californian sea lion, *Zalophus californianus* (Lesson, 1828), and South American sea lion, *Otaria flavescens* (Shaw, 1800). According to Acevedo et al. (2009), atypical coloration is rare in marine mammals, but this anomaly seems to be frequent in Antarctic fur seals from South Georgia and the South Shetlands Islands. This may be due to a decrease in this species' population caused by hunting during the XIX and XX centuries. The proposed theory is that these populations suffered a founder effect after the reduction, and it is possible that one of the founder individuals had atypical coloration, which raised the levels of this anomaly in the population (Bonner, 1968; Cárdenas and Yañez, 1983; Hofmeyr et al., 2005).

The Chiroptera was the second most abundant order in terms of records of anomalous coloration, with 18 cases of albinism, ten cases of piebaldism, one case of leucism and one record that we classified as undetermined. Ramirez et al. (2010) mention a case of albinism for the dwarf little fruit bat, *Rhinophylla pumilio* Peters, 1865, in French Guiana. However, the authors did not make a reference of these records, which make the analysis of this case impossible. Uieda (2000) also mentioned records of albinism in the Parnell's mustached bat, *Pteronotus parnellii* Gray, 1843, large fruit-eating bat, *Artibeus lituratus* (Olfers, 1818), and big-eared bat, *Macrotus waterhousii* Gray, 1843, all registered in Mexico. However, we had no access to the papers that originally related the case, and we did not know if they occurred in a Neotropical region. These cases were not included in the results due to the lack of significant information (Table 1).

Geiger and Pacheco (2006) mentioned that 21.2% of the bats studied by the authors in southern Brazil (Rio Grande do Sul state, 29° 36' S; 52° 40' W) showed some evidence of anomalous coloration. According to Uieda (2000), the survival of albino bats is not affected by this condition because bats' refuge provides light and predation protection. Moreover, these bats orient themselves primarily through echolocation (Feldhamer et al., 2007; Reis et al., 2007); hence, they are less affected by the visual problems associated with albinism. These factors may explain the higher incidence of anomalous coloration registered in flying mammals as compared to non-flying mammals.

In the present paper we report the first record of a Brazilian marsupial with leucism. Other cases of Neotropical small terrestrial mammals with anomalous coloration were registered on only three occasions and included one record of albinism in striped Atlantic forest rat,

Delomys dorsalis (Hensel, 1873) (Cademartori and Pacheco, 1999), one case of piebaldism in white-spined Atlantic spiny-rat, *Trinomys albispinus* (I. Geoffroy, 1838) (Pessôa and Reis, 1995), and one case of albinism in Andean leaf-eared mouse, *Phyllotis andium* Thomas, 1912 (Ramirez and Arana, 2005). These reports are also uncommon in other parts of the world. We found one case of piebaldism in the common shrew, *Sorex araneus* Linnaeus, 1758 (Gelling, 2003), and one case of albinism in the hoary-bellied squirrel, *Callosciurus pygerythrus* (I. Geoffroy Saint Hilaire, 1833) (Kalita, 2009). Because they represent the base of the trophic web for most of the large and medium vertebrates, small terrestrial mammals suffer a high risk of predation (e.g. Juarez and Marinho-Filho, 2002; Magrini and Facure, 2008; Sousa and Bager, 2008; Abreu et al., 2010). Additionally, anomalous colouration tends to strongly reduce the survival of these organisms, since these deficiencies make them visible to predators (Sazima and Di-Bernardo, 1991; Parsons and Bonderup-Nielsen, 1995). The visual problems associated with albinism (Pérez-Carpinell et al., 1992; Grant et al., 2001; Garipis and Hoffmann, 2003) can also result in a decrease of survival since these animals may be less capable of searching for resources and detecting predators.

In relation to terrestrial carnivores, Tortato and Althoff (2007) reported six records of tayras, *Eira barbara* (Linnaeus, 1758), with whitish yellow pelage in Santa Catarina state, Southern Brazil. These authors do not consider these records as albinism. However, following the classification adopted in the present study, we considered these cases as being records of leucism, since the animals presented some anomaly in the production of pigmentation. Presley (2000) suggested that albinism and the deficit in the production of pigmentation are more common in tayras than in other mustelids and mentioned the existence of a yellow morphotype in Guianas for tayras. We did not find records of anomalous colouration in other mustelids or in other terrestrial carnivorous mammals.

The Order Primates has at least 281 species in the world (Wilson and Reeder, 2005). Nevertheless, we did not find records of albino Neotropical primates in our review. The only record found was a personal communication mentioned by Veiga (1994) for the brown capuchin monkey, *Cebus apella* (Linnaeus, 1758). We found two records of hypopigmentation in primates from Africa: two records in the black crested mangabey, *Lophocebus aterrimus* (Oudemans, 1890) (Eppley et al., 2010) and one in the western gorilla, *Gorilla gorilla* (Savage, 1847) (Sabater Pi, 1967), showing that this anomaly is present in this order.

According to Wilson and Reeder (2005) the Order Pilosa has ten known species, all found in Central and Southern America. We found records of anomalous colouration only in the brown-throated sloth, *Bradypus variegatus* Schinz, 1825 (Xavier et al., 2010). The Order Cingulata, which is included in the superorder Xenarthra with Pilosa, is also predominantly Neotropical. All of the species are found in Central and Southern America, with the nine-banded armadillo, *Dasybus novemcinctus* Linnaeus, 1758, which

is the only species that can be found in the southern part of North America (Wilson and Reeder, 2005). However, we found no record of anomalous colouration in the species of these orders in any part of their distribution.

Some of the analysed studies still indicate the possibility of the existence of other terrestrial Cetartiodactyla with albino traces. Veiga (1994) related cases of atypical colouration in the red brocket deer, *Mazama americana* (Erxleben, 1777), but these records are from personal communication, which make it impossible to confirm the type of anomaly. This author also mentioned a possible record of another individual of collared peccary, *Pecari (=Tayassu) tajacu* (Linnaeus, 1758), near São José dos Pinhais city (Paraná state) (25° 32' S; 49° 11' W), Southern Brazil. In Midwestern Brazil (Goiás state), Rodrigues et al. (1999) mention a record of a pup of Pampas deer, *Ozotoceros bezoarticus* (Linnaeus, 1758), with albino characteristics (although they do not provide sufficient information to define the record as having albinism, leucism or piebaldism).

The high frequency of cases of atypical colouration of mammals in Argentina is probably due to the systematic and long term monitoring of the local population of the Southern Right whale (more than 20 years – Schaeff et al., 1999). However, in Brazil the number of records could be a direct result of the synergic effect among the large territorial area, the great mammal diversity and probably to the number of mammal specialists working in Brazil in comparison to other Neotropical countries (Reis et al., 2010). Nevertheless, this could just be an artefact of analyses that use only published papers, which ignores all the information presented in scientific congresses, popular science magazine articles, as well as personal communications. We know of the existence of some cases of anomalous colouration in Neotropical mammals that are not related in scientific papers, and are therefore not part of scientific community knowledge.

Anomalous colouration also occurs in mammals from other biographic regions of the world (e.g. Sabater Pi, 1967; Gelling, 2003; Kalita, 2009; Eppley et al., 2010). It is possible that cases of anomalous colour in some Neotropical mammalian orders are more frequent than related in this review. It is important to mention that there are probably many mammal specimens from different orders with anomalous colouration in museums and scientific collections inside and outside of Brazil, but collected in Neotropical region. Unfortunately, many of these records were not officially reported, probably due to the lack of knowledge by the collectors and/or collection managers about the importance of this phenomenon. Therefore, we highlight the relevance of photographs as valuable tools for documentation about natural history as a whole. In conclusion, researchers must be encouraged to report the records of albinism, leucism and piebaldism in wildlife in order to better understand this phenomenon and its insights into the ecological and physiological implications of this condition, which has a significant influence on animal survival (Fertl et al., 2004).

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