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A Possible Case of Hypopigmentation in the Southern Spotted Skunk (*Spilogale angustifrons celeris* Hall, 1938)

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Abstract: Several chromatic anomalies have been reported in Neotropical mammals including hypopigmentation. This abnormality is a genetic mutation affecting melanin biosynthesis, pigment granule trafficking, or membrane sorting which results in insufficiently pigmented indviduals. The southern spotted skunk (*Spilogale angustifrons celeris* Hall, 1938) inhabits the areas from the mountains of Nicaragua to central Costa Rica. An individual of this species, which was found dead in northwestern Costa Rica, exhibited brown reddish discolored parts on its coat instead of black, which appeared to be a case of hypopigmentation. This is the first case of a chromatic disorder reported in the southern spotted skunk within the whole natural distribution range of this species. There are only few cases of chromatic aberrations reported in the mammals of Costa Rica.

Keywords: Anthropic impacts; carnivore; Costa Rica; chromatic disorder; mammal.

Introduction

Color disorders are pigmentation anomalies that cause abnormal discoloration of the skin and its derivatives of vertebrates (Lucati and López-Baucells, 2017). There are several types of chromatic abnormalities including some that have been reported in different groups of vertebrates including mammals (McCardle, 2012). Chromatic disorders can be genetic or environmental (Lucati and López-Baucells, 2017). However, there is still no uniform criteria to determine or even name these anomalies. Despite this, several efforts have been made in these directions; there are excellent publications defining color disorders in snakes (Borteiro *et al*., 2021), birds (van Grouw, 2013; Mahabal *et al*., 2017), and mammals (Abreu *et al*., 2013; Lucati and López-Baucells, 2017; Mahabal *et al.,* 2019). In the Neotropics, chromatic anomalies have been reported in several orders of mammals, and there have been several publications with reports of cases in different groups, mostly bats (Chiroptera); such cases included albinism, leucism, and piebaldism (Abreu *et al.,* 2013; Mello *et al.*, 2016).

One of the chromatic aberrations that have been identified in mammals is hypopigmentation. It is an anomaly that includes or is equivalent to instances of erythrism, flavism, rufism, silvering and tawny (Lucati and López-Baucells, 2017), depending on the case. Hypomelanism is a similar condition sometimes classified under hypopigmentation and consists of an inherited disorder resulting in beige, golden, yellowish, or reddish individuals with insufficiently pigmented skin (Červený, 1980; Zamolo *et al.,* 2013). Perhaps a more exhaustive classification is needed for mammals such as those proposed for other tetrapods. However, for the time being, those color disorders, implying mutations and affecting melanin biosynthesis, pigment granule trafficking, or membrane sorting, should be called hypopigmentation (Lucati and López-Baucells, 2017; Mello *et al*., 2016).

The southern spotted skunk (*Spilogale angustifrons* Howell, 1902) is distributed across the areas from southern Mexico to Costa Rica, which are elevated up to 3000 m (Reid, 2009). The subspecies *Spilogale angustifrons celeris* (Hall, 1938) inhabits the areas extending from the mountains of Nicaragua to central Costa Rica (Dragoo,

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2009). It is mainly found in forested habitats in the northern section of the country (Dragoo, 2009). This species also uses varied habitats ranging from grasslands to rainforests, including rocky terrains, pine forests, dense scrubs, and farmlands (Reid, 2009). This skunk has a head-body length of 210-240 mm, and the tail is 101-145mm. It weighs 240-533g with males being slightly larger than females (Dragoo, 2009). The southern spotted skunk is black with a complex pattern of white stripes and spots (Reid, 2009). It has a white patch between the eyes and on the last third of its tail (Dragoo, 2009). *Spilogale angustifrons* is a species recognized a few years ago, therefore, little is known about its conservation status. It is thought to be common in some areas, but in Costa Rica it is rare and is protected under the list of species with reduced or threatened populations (SINAC, 2017). In fact, it is classified as Least Concern (LC) by the IUCN Red List (Helgen *et al.,* 2016).

Materials and Methods

Anthropic impacts on wildlife such as road killings and electrocutions have been investigated by researchers. One of the roads under study is Route 159, a paved road that runs between Playa Panamá and Playa Hermosa at Sardinal, Carrillo, Guanacaste in the Tropical dry Forest (TdF) of northwestern Costa Rica. The TdF as a life zone is characterized by its biotemperature (greater than 17°C), a potential evapotranspiration to a precipitation ratio of 1–2, and low rainfall (500– 2000 mm of precipitation a year) (Holdridge, 1967; Kalacska *et al.,* 2004). Rain is concentrated during the rainy season, and there are four to six months with basically no precipitation (Janzen, 1983). Normally, the TdF has less species than lowland wet forests, but it has more structural and physiological diversity in life forms (Kalacska *et al.,* 2004). The majority of the woody species are deciduous mainly due to the long dry season (Frankie *et al*., 1974). As a result, there is a mix of deciduous and evergreen species causing a phenological complexity not encountered in wet forests (Kalacska *et al.,* 2004). The study area at the sides of Route 159 is composed of secondary forests, pasturelands, open areas, and some buildings at about 200 m (Figure 1).

Results

A southern spotted skunk was found dead on Route 159 (10° 34’ 54.7” N, 85° 39’ 41.9” W; Figure 2) on May 6, 2021. The individual was an adult male with a head and body length of about 240 mm. Some parts of this individual exhibited a brown reddish coloration instead of black which appeared to be a case of hypopigmentation (Figure 2). Indeed, this is the first case of a chromatic disorder in the southern spotted skunk to be reported within the whole natural distribution range of this species.

Discussion

There are few reported cases of chromatic aberrations in the mammals of Costa Rica. In fact, only seven reports for bats: one albino, five leucistic, and one piebald (Mora and Sánchez, 2022) were found. There are also reports of melanism in jaguars (*Panthera onca*), jaguarundi (*Herpailurus yagouaroundi*), northern tiger cats (*Leopardus tigrinus oncilla*), margays (*Leopardus wiedii*) (Mooring *et al*., 2020) and a leucistic coyote (Arroyo-Arce *et al.,* 2019). However, several of these cases were wrongly diagnosed or named. Additionally, a rare case of color shifting from black to yellow has been reported in the howler monkey (*Alouatta palliata*) (Galván *et al.,* 2019). Even though hypopigmentation is a common phenomenon, no reports of the existence of this color disorder, or any other, were found for *Spilogale angustifrons* throughout its distribution range. In fact, hypopigmentation as such was not reported in any of the mammals of Costa Rica.

Pigmentation of the skin, hair, and the eyes is controlled by multiple alleles, and different alleles control the amount of pigmentation (Mc Cardle, 2012). Eumelanins are responsible

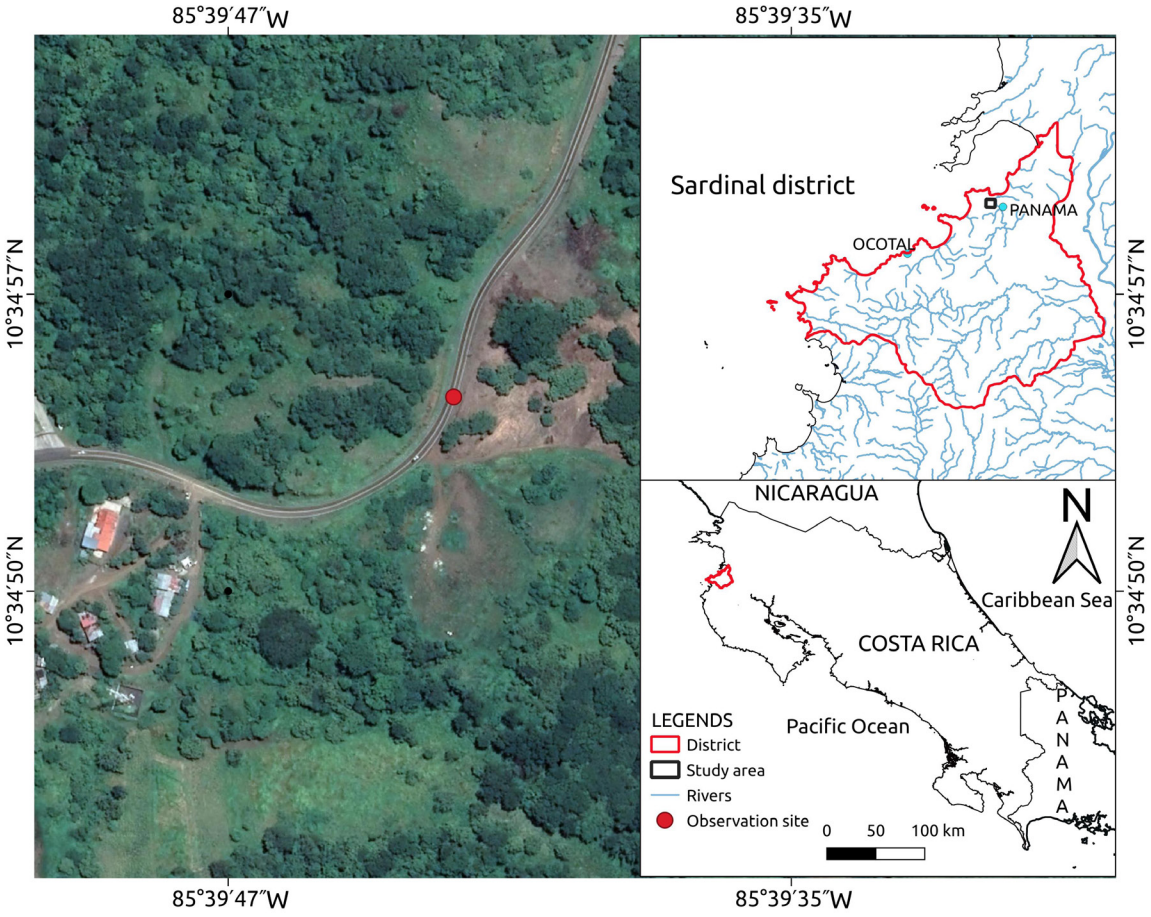

Figure 1. Point where a Southern Spotted skunk (*Spilogale angustifrons celeris* Hall, 1938) was found dead on Route 159, Sardinal, Carrillo, Guanacaste, Costa Rica. Figure by G. Chaves (Cachí).

Figure 2. A Southern Spotted skunk (*Spilogale angustifrons celeris* Hall, 1938) found dead on Route 159, Sardinal, Carrillo, Guanacaste, Costa Rica.

for black, grey, and dark brown pigments, while pheomelanins are responsible for warm reddish brown colors to pale buff including orange and yellow (Ito and Wakamatsu, 2003; van Grouw, 2021). With the exception of the white stripes, the pelage of the spotted skunk is pitch black, which is a consequence of the production and subsequent deposition of eumelanin in hairs (Ito and Wakamatsu, 2003). It was assumed that the dead skunk showed a major proportion of pheomelanin compared to eumelanin which normally colors individuals, or a lower concentration of eumelanin in its pelage at any case. At least in albino animals, phaeomelanin becomes affected first, and then eumelanin is reduced step by step (Acevedo *et al*., 2008). In Brown mutations (incompletely colored melanin), the number of eumelanin pigment granules is unchanged, but the pigment's color is altered due to incomplete synthesis (van Grouw, 2021). Brown has not been used to name color aberrations in mammals. In this abnormality, eumelanin is changed in color (qualitative reduction) due to incomplete melanin synthesis, but phaeomelanin is unaffected (van Grouw, 2021). The result is that the original black color becomes brown with the eyes and feet being slightly lighter than normal (van Grouw, 2021). It was not possible to note or compare this last condition in the dead skunk. Nevertheless, some relevant phenomena could be the case for the skunk reported here. An appropriated determination or diagnosis, other than hypopigmentation, is very difficult given the fact that breeding tests are impossible, nor was it possible for the researchers to conduct hair analyses. This is true for most wild animals, as a result, almost all aberrations can be identified only by appearance, or the phenotype of the individuals (van Grouw, 2021). However, one important point to be noted is that hypopigmentation can lead to poor vision, greater predation risk, lower mating success, and lower survival rates (Laikre *et al*., 1996; Caro, 2005). On the other hand, factors such as deforestation, low habitat quality, pollution, poor-quality diet, and hybridization events may be linked to pigmentation anomalies (Aximoff *et al*., 2020).

Chromatic aberrations are caused by either a deficiency or excess in melanin (Hofreiter and Schoneberg, 2010; Abreu *et al*., 2013). Although they have been reported in many mammals, they are relatively uncommon in these vertebrates. At least in part, this may be due to , the lack of interest in reporting these abnormalities in scientific journals. However, it is necessary to collect information on these cases as they could have been a consequence of some factors related to human activities (Galván *et al.,* 2019). Understanding the possible evolutionary costs or benefits derived from color disorders is essential to explain adaptations to the increasingly changing landscape (Bilandžija *et al*., 2013). Monitoring chromatic abnormalities in large-scale geographic studies may help identify populations exposed to environmental stress or inbreeding (Mc Cardle, 2012). Researchers should be encouraged to report records of chromatic abnormalities in wildlife to help achieve an understanding of this phenomenon and the insights behind the ecological and physiological implications of these conditions which may leave a significant impact on animal survival (Fertl *et al*., 2004; Samson *et al*., 2017). Records of chromatic disorders in wild animals are rare as the abnormal colored individuals are often more susceptible to predation and can be subject to immunological deficiencies (Sazima and Di-Bernardo, 1991; Aximoff *et al*., 2021).

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