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First report of a color anomaly in a white-eared opossum *Didelphis albiventris* Lund, 1840 in an urban area of Mendoza, Argentina

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ABSTRACT
Instances of color alterations in the marsupial *Didelphis albiventris* have been scarcely documented. Urban environments provide good opportunities to study synanthropic nocturnal animals like opossums. In a neighborhood of Mendoza, Argentina, a female *D. albiventris* was reported by a resident. The animal was captured using a Tomahawk trap and anesthetized for a detailed clinical examination, which revealed leucism and poor body condition. Morphometric measurements, reproductive parameters, and both clinical and ecological observations were studied to investigate potential links to the color anomaly. Nutritional deficiencies in urban settings might be associated with this unusual coloration.
Keywords: hypopigmentation, leucism, morphometric measurements, nutritional deficiencies, synanthropic marsupials

RESUMEN - Primer reporte de una anomalía del color en una comadreja overa *Didelphis albiventris* Lund, 1840, en un área urbana de Mendoza, Argentina
Las alteraciones del color en el marsupial *Didelphis albiventris*, han sido escasamente documentadas. Los entornos urbanos ofrecen buenas oportunidades para estudiar animales nocturnos sinantrópicos como las zarigüeyas. En un barrio de Mendoza, Argentina, un residente informó de la presencia de una hembra de *D. albiventris*. El animal fue capturado utilizando una trampa Tomahawk y anestesiado para un examen clínico detallado, que reveló leucismo y mala condición corporal. Se estudiaron medidas morfométricas, parámetros reproductivos y observaciones clínicas y ecológicas para investigar posibles vínculos con la anomalía de color. Las deficiencias nutricionales en entornos urbanos podrían estar asociadas a la coloración inusual.
Palabras clave: deficiencias nutricionales, hipopigmentación, leucismo, medidas morfométricas, marsupiales sinantrópicos

Observations of wild animals with unusual coloration patterns have been reported by naturalists since the 18th century (Edwards 1758). Hypopigmentation is one of the most frequently recorded anomalous fur color patterns in mammals (Caro 2005;

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Abreu et al. 2013). Although the exact causes and consequences of chromatic disorders are still unclear (Kreling 2023), emerging evidence suggests the affected animals could serve as bioindicators of wildlife health in urban-sylvatic environments (Cuxim-Koyoc et al. 2020; Cotts et al. 2023). Anomalous pigmentation can have a genetic basis and may be more prevalent in anthropic environments due to increased exposure to toxins and pollutants, which can elevate mutation rates (Dubrova 2019). Urban sprawl and its consequent habitat fragmentation, population declines, reduced gene flow and inbreeding are also factors associated with the occurrence of chromatic disorders (Koneru & Caro 2022; Kreling 2023).

Albinism, leucism, and xanthochromism have been reported in opossums (Didelphidae) from disturbed environments (Abreu et al. 2013; Cuxim-Koyoc et al. 2020; Ortiz Hoyos et al. 2020; Vanstreels et al. 2021; Cotts et al. 2023). Albino opossums are completely white due to a failure in the synthesis of melanin, the essential pigment for coloring (Cuxim-Koyoc et al. 2020). Xanthochromism manifests as an increased concentration of yellow pigments in tissues (e.g., pheomelanin) (Cotts et al. 2023), whereas leucism involves a reduction in melanin production or impaired distribution of melanocytes (melanin-producing cells) in the skin layers. Leucistic opossums are white or partially whitish, with dark pigmentation in their eyes and/or extremities (Abreu et al. 2013). In addition to genetic mutations, leucism may also be caused by nutritional deficiencies (Britton & Davidowitz 2023) and progressive graying (Izquierdo et al. 2018).

The white-eared opossum *Didelphis albiventris* Lund, 1840 is the largest marsupial in Argentina. Only one haplogroup is present in the country, with low levels of genetic differentiation among populations (Chemisquy et al. 2021). In fact, Chemisquy et al. (2023) identified two independent evolutionary lineages of *D. albiventris* that may warrant splitting it into two species, with the populations distributed in Argentina, Bolivia, Paraguay, Uruguay, and southern Brazil being *D. leucotis* and the remainder corresponding to *D. albiventris*. Thanks to its opportunistic behavior as a synanthropic omnivore, this species is able to take advantage of the multiple refuges and food provided by urban and peri-urban environments (Cáceres 2000). As a consequence, *D. albiventris* has significantly extended its range across the southern and western regions of the country over the last 150 years, following the expansion of urbanization and agriculture (Pastrán-López et al. 2022). At the national level, the species is listed as Least Concern (Chemisquy & Martin 2019). There is only one documented newspaper report of albinism in a white-eared opossum from Argentina (El Litoral 2023).

The objective of this note is to present the first case of a color anomaly in *D. albiventris* in an urbanized area of Mendoza, in central-western Argentina, and to discuss possible associations between its color alteration, and its nutritional and health status.

The opossum was reported by a neighbor to the local government wildlife officials in November 2022. The animal was in an urbanized neighborhood of Godoy Cruz, in the metropolitan area of Mendoza, Argentina (latitude -32.952284; longitude -68.842294; Fig. 1). Our working group had not documented the presence of

D. albiventris in this area previous to this record. Godoy Cruz department, spanning 107 km^2, is completely urbanized (Dalla Torre & Ghilardi 2021). In spite of the arid climate, this area follows a forested city model with exotic implanted trees, sustained by an irrigation system consisting of channels, trenches, and irrigation ditches (Arboit 2017). The animal was captured with a Tomahawk trap and anesthetized for a thorough clinical examination. Ketamine (7 mg/kg), midazolam (0.2 mg/kg), and dexmedetomidine (0.02 mg/kg) were administered via intramuscular injection, followed by reversal with atipamezole (0.04 mg/kg) after 30 minutes. During examination, the animal was sexed, its age category determined following Schweigmann et al. (1999), weighed with a spring scale, and the following external measurements (in mm) were taken with a dial caliper and a measure tape: total length, snout-base of tail (ToL); head length, snout-base of skull (HL); tail length (TL); hand length, without claws (HDL); hindfoot length, without claws (HFL); ear length (EL); forearm length, corresponding to the radius bone (FL); and leg length, corresponding to the tibia bone (LL). The morphometric measurements and body mass were statistically compared to those of other adult females previously captured in peri-urban and rural areas of Mendoza city (Morales 2023) and plotted in a pairplot using the software R (R Development Core Team 2021). Finally, the animal was maintained for two weeks to observe its behavior to assess whether it had been illegally kept as a pet. Its reactions were evaluated in response to human presence, different vocal tones, attempts to handle it manually, and efforts to offer food directly to its mouth. Animals accustomed to human contact often lose their fear and may not display typical defensive behaviors, such as aggressive vocalizations with an open mouth to reveal intimidating dentition (Hunsaker & Shupe 1977). It was then released in a rural area in collaboration with wildlife officials.

The specimen identified as DA59 was a female, an adult of category V (I:5/5, C:1/1, PM:3/3, M:4/4) x 2). Its coat was hirsute with an atypical coloration pattern, characterized by predominantly white fur on its dorsal side, including the head. Black pigmentation was observed on the nasal septum, eye contour, labial commissure, extremities, and base of the tail (Fig. 2). Its abdominal region exhibited a yellowish-brown hue, with an empty marsupial pouch showing non-lactating small teats (defined as pre-lactating by Guilhon et al. 2019). Although the animal had smaller body measurements than the other females, no statistically significant differences were found, probably due to the small sample size (Table 1). In the pairplot, both the scatterplots and the density plots on the diagonal show that the red dot/line corresponding to the leucistic animal appears to deviate from the general data pattern. However, no statistical outliers were identified (Fig. 3). During the clinical examination, no tail ulceration was observed which is a typical lesion seen in individuals kept in captivity (Fowler 2001). Both ears had small cuts along their edges. Palpation of the maxillae, mandibles, and long bones revealed no deformities. Additionally, no dental or gingival issues were detected.

In Argentina, *D. albiventris* typically has a long, thick coat, with hairs that are yellowish-white at their base and transition to black towards the tips. There is variation amongst individuals, with some being distinctly dark. They are somewhat paler ven-

trally. The head is mostly white with a black medial stripe and black patches around the eyes. The ears are whitish with a black base, the legs black, and the tail has a black base with a white distal half (Teta & de Tommaso 2009). The anomalous coloration of the opossum from Mendoza, with a predominantly white dorsal coat but black pigmentation in both eyes and extremities, suggests leucism.

According to Van Grouw (2013), leucism can be explained by three different, not mutually exclusive, mechanisms: nutritional alterations, heritable mutations, and progressive graying. In other species, these factors have been shown to be influenced by anthropogenic causes, with individuals exhibiting leucism being more frequently found in urban than in non-urban habitats (Izquierdo et al. 2018). The clinical examination revealed that the leucistic animal had a poor body and coat condition, suggesting a possible history of nutritional deficiencies. Its limbs and tail were shorter than those recorded in adult opossums from nearby peri-urban areas. While these differences were not statistically significant, they were very close to the established p-value threshold (Table 1). Nutritional deficiencies may contribute to leucism in synanthropic wildlife, as urban areas typically offer diets that are low in nutrients and high in carbohydrates that can limit melanin production (Britton & Davidowitz 2023). The reduction in food intake as well as in certain components of the diet can result in insufficient quantities of amino acids that are necessary to produce melanin, such as tyrosine, causing a lightening or whitening of the pelage (Britton & Davidowitz 2023). The diet of *D. albiventris* in Mendoza is not well understood; future longitudinal studies, as well as the comparison of the diet between urban and peri-urban or rural individuals, will be key to understanding its role in the appearance of nutritional deficits and anomalous fur color patterns.

A notable observation was that no signs indicated that the leucistic animal, an adult (V) found in November, had ever carried young in its pouch. In Argentina, female *D. albiventris* start breeding at the end of August (Carusi et al. 2009). They are able to reproduce during the same season in which they are born because they are partially semelparous (Astúa & Geise 2006). Although the presence of young has been reported in the pouch of an adult albino specimen of *D. virginiana* (Cuxim-Koyoc et al. 2020), in other species the loss of pigmentation has been reported to negatively affect mate choice, fitness, and reproductive success (Caro 2005). The lack of evidence of reproductive activity in the leucistic opossum could therefore be related to its fur color.

Although the presence of *D. albiventris* in fully urbanized areas is frequent in other provinces of Argentina and in other countries (Chemisquy & Martin 2019), in Mendoza, this species' distribution appears to be associated with peri-urban and rural areas. Males and females of all ages have been documented in a diverse landscape with agricultural crops and rich biodiversity (Morales 2023). In this context, finding an opossum in a fully urbanized area of Mendoza was an unusual occurrence. The urban neighborhood where this individual was captured had a predominance of concrete and only low vegetation cover (Arboit 2017). The peri-urban area closest to the capture site of the leucistic opossum is about 3000 meters away; its presence may therefore be due to its natural dispersal toward urban areas.

However, according to Cáceres et al. (2022), most *Didelphis* do not disperse or migrate from the area where they usually forage, mate, and rear their offspring. An alternative explanation of the origin of the leucistic opossum is that the animal was captured in another area and brought to this urban site, e.g., to be illegally kept as a pet. A clinical examination and the observation of its behavior ruled out this possibility. The animal manifested aggression and nocturnal habits, behaviors that tend to change in opossums kept in captivity (Hernandez et al. 2019). Furthermore, captive opossums often suffer from ulcerations of the tail due to a combination of low humidity shelters and inadequate ambient temperature (Fowler 2001). Dental disease is another common ailment in captive omnivorous marsupials fed sugary or excessively moist diets, resulting in plaque build-up, gingivitis, and potential dental problems (Fowler 2001). Lack of calcium in the diet can cause metabolic bone disease, also known as "cage paralysis". This disease manifests as osteomalacia with fractures or fibrous osteodystrophy, especially of the maxillae and mandibles (Fowler 2001; Hernandez et al. 2019). None of these symptoms were, however, observed in this individual, thus reinforcing the hypothesis that it dispersed on its own toward the urban site. Assuming dispersal through disturbed environments and considering that opossums live approximately up to 2.5 years (Cáceres 2000), the leucistic animal may have been exposed to poor nutrition and a reduced chance of mating.

The occurrence of color alterations in marsupials of the genus *Didelphis* has been rarely documented in the scientific literature. Our report provides a new record of hypopigmentation in *D. albiventris* within an urban area of Mendoza, Argentina, setting a precedent for further studies in the region. Urban environments offer a unique opportunity to study such cases. This is particularly true for nocturnal animals such as opossums, as the risk of predation of leucistic or albino individuals is much higher in non-urban environments due to the lack of camouflage (Caro 2005). In recent years, records of hypopigmentation in wild animals have increased thanks to the use of camera traps (Ortiz Hoyos et al. 2020) as well as to citizen photographic documentation (Abreu et al. 2013; Cosentino & Gibbs 2022). These tools are important technological resources for understanding the frequency of these anomalies in synanthropic animals, and the factors that could promote their occurrence. Although the causes of chromatic disorders are varied and often not mutually exclusive (Kreling 2023), our findings highlight the importance of integrating thorough clinical examinations with detailed field observations.

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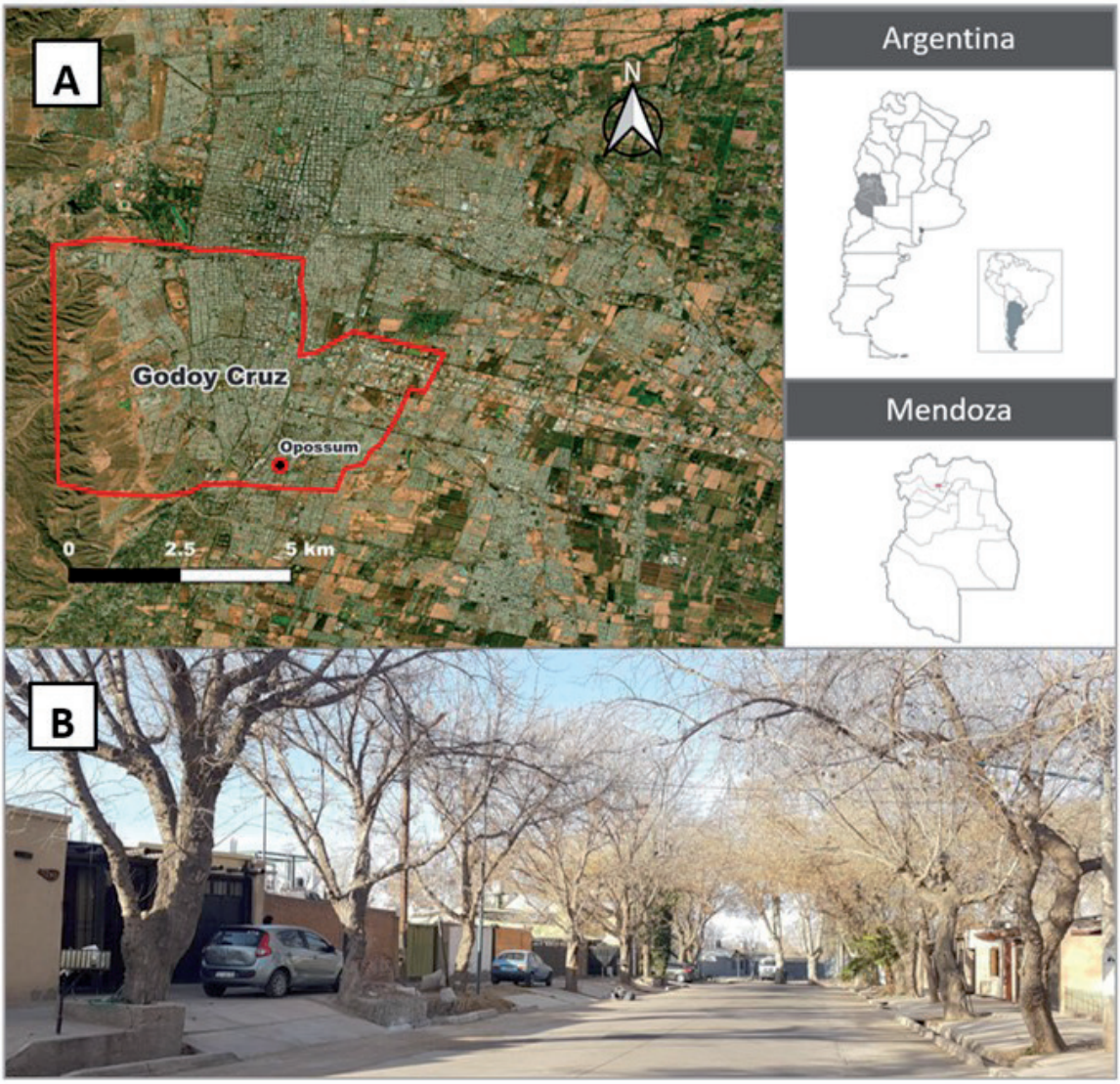

Figure 1. A) Satellite image showing the location of the leucistic opossum in Godoy Cruz, Mendoza, Argentina; B) neighborhood where the individual of *Didelphis albiventris* was captured.

Figure 2. A) Captured specimen of *Didelphis albiventris* (DA 59); B) anesthetized opossum (lateral view); C) opossum in enclosure during the observation period.

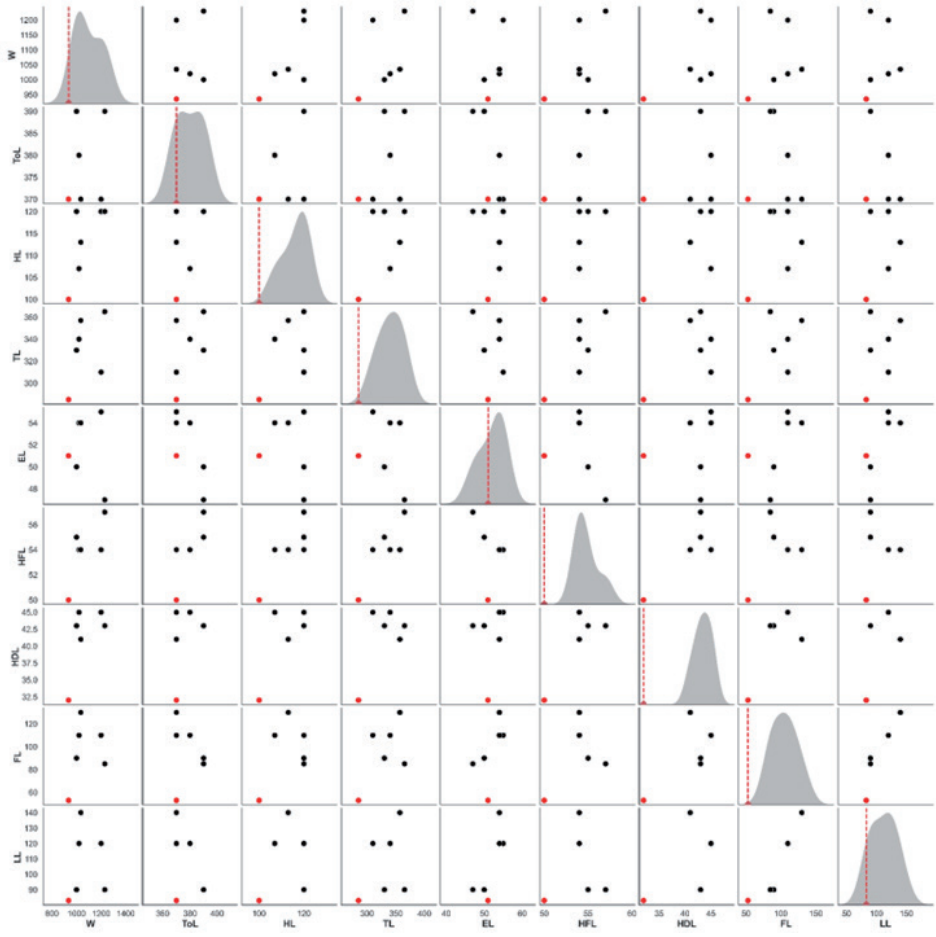

Figure 3. Pairplot graph with morphometric measurements of *Didelphis albiventris* from the Mendoza Metropolitan Area. Red dot and line indicate the leucistic animal.

Table 1. Morphometric measurements and weight of *Didelphis albiventris* from Godoy Cruz, Mendoza Metropolitan Area, Argentina. ToL: total length; HL: head length; TL: tail length; EL: ear length; HFL: hindfoot length, without claws; HDL: hand length, without claws; FL: forearm length; LL: leg length.

Didelphis albiventris	Weight (gr)	ToL (mm)	HL (mm)	TL (mm)	EL (mm)	HFL (mm)	HDL (mm)	FL (mm)	LL (mm)
DA59*	935	370	100	285	51	50	32	53	83
DA11	1000	390	120	330	50	55	43	90	90
DA20	1200	370	120	310	55	54	45	110	120
DA21	1020	380	107	340	50	54	45	110	120
DA26	1230	390	120	365	47	57	43	85	90
DA56	1035	370	113	357	54	54	41	130	140
Wilcoxon-Mann-Whitney (p value)	V: 15; 0.059	V:6; 0.173	V:15; 0.054	V:15; 0.059	V:9.5; 0.683	V:15; 0.054	V:15; 0.056	V:15; 0.057	V:15; 0.056

$p<0.05$

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