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RESEARCH NOTE

Record of color aberration in the Humboldt Penguin *Spheniscus humboldti* in the Biobío Region and a review of unusual coloration in Chilean wildlife

Primer reporte de aberración del color en el pingüino de Humboldt *Spheniscus humboldti* en la Región del Biobío y una revisión de la coloración inusual en la fauna silvestre chilena

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Abstract.- Anomalies in skin or plumage pigmentation have been recorded across various vertebrate species, albeit infrequently. Factors such as pollution and genetics are indicated as the causes. This study reports for the first time, a case of color aberration (albinism or Brown) in a juvenile Humboldt penguin *Spheniscus humboldti* individual on the Hualpén Peninsula, Chile, along with an update of the literature comprising 25 reported cases of these anomalies in the Chilean wildlife.

Key words: Albinism, pigmentary anomalies, vertebrates, Biobío Region

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INTRODUCTION

One of the morphological abnormalities present in vertebrates is skin, feathers and hair depigmentation (van Grouw 2006, Acevedo & Aguayo 2008). To date, seven types of color aberrations have been described, all of which are associated with defects in melanocyte function. Defects in the development of melanocytes give rise to leucism and progressive greying. Defects in melanin synthesis result in albinism, the Brown phenomenon, and Ino. Defects in melanin deposition in feathers lead to dilution, while defects in the type of melanin produced result in melanism (van Grouw 2021). Among these anomalies, leucism and albinism have been the most reported (Lepschi 1990, van Grouw 2021, Camacho *et al*. 2022). Albinism is classified as a hereditary pathology, which is transmitted through a recessive trait (McCormac 2001, van Grouw 2006). The differences between leucism and albinism lie in the fact that in the former, individuals are distinguished by hypopigmentation, resulting in total or partial loss of coloration. Pink beak and normal-colored feet, or beak and feet with normal color depending on the area of the skin where cells are missing (McCormac 2001, Carello 2021, van Grouw 2021). Albinism is expressed as the total absence of pigments in the skin, feathers, legs, beak, and eyes. The soft parts (eyes and skin) typically exhibit a pale pink or red coloration (McCormac 2001, van Grouw 2006).

Albinism is an anomaly with few individuals reported within a population (1/10,000 individuals); however, in some taxonomic groups of birds, it tends to be more prevalent than in others (McCormac 2001, McCardle 2012). Although albinism is more common than leucism, particularly in mammals, the likelihood of reporting albino individuals is lower than that of leucistic ones, as the former tend to have a shorter lifespan. Moreover, many of these records have been misdiagnosed and are often confused with other color aberrations (McCardle 2012, van Grouw 2021). Examples of albino species have been documented in vertebrates across various regions of the globe (McCardle 2012). Particularly in South America, there are records in mammals (Martínez-Coronel *et al*. 2013, Pelaez-Tapia *et al*. 2021), birds (Puig *et al*. 2017), and some undiagnosed abnormalities in fish (Nugra *et al*. 2018). Among vertebrates, birds have been categorized as the taxonomic group with the highest number of individuals exhibiting this phenomenon, with families Fringillidae (passerines), Phasianidae (pheasants), and Anatidae (ducks) being the most recurrent (McCardle 2012, Carello 2021).

In Chile, reports of chromatic abnormalities are most common in Passeriformes (Fuentes & González-Acuña 2011), but they have also been documented in marine vertebrates such as otariids, petrels, and two penguin species (Aguayo & Torres 1967, Aguayo 1978, Cárdenas & Yáñez 1983, Acevedo & Aguayo 2008, Fuentes & González-Acuña 2011, Novoa & Casanova 2020). Generally, the sighting and reporting of these individuals tend to be isolated cases, from land at a great distance or using a vessel that sometimes hinders close and accurate observation difficult to establish the type of abnormality.

Although the pigmentation anomaly presented below is not well understood, this study reports for the first time the occurrence of a color aberration in the Humboldt penguin (*Spheniscus humboldti*) in central-southern Chile, along with an update of the published literature on abnormal colorations in wild vertebrates (marine mammals, land and seabirds) in Chile.

Materials and methods

During fieldwork aboard a vessel around the Hualpén Peninsula, Biobío Region (36.758°S-73.204°W; 36.803°S-73.180°W) on July 11, 2023, at the Punta Hualpén Lighthouse, a specimen of Humboldt penguin (*Spheniscus humboldti*) was sighted. It was identified as such due to the extensive pinkish bare area from the lorum, orbital ring, passing through the corner of the beak to the chin (Couve *et al*. 2016). This individual was alone, preening in the water, and the vessel approached to approximately 2-3 m from the animal for about 10 min to observe it carefully. The specimen was photographed, and phenotypic characteristics of its plumage and extremities were observed.

Regarding the literature review on pigment abnormalities in Chilean wildlife, a search was conducted on the Web of Science (WoS), Latindex and Scopus platforms using keywords such as “albinism,” “colour aberration” “leucism,” “vertebrates,” “birds,” “Chile” to compile all publications that included formal reports and the total number of wild vertebrates recorded with some type of pigmentary abnormality in Chile.

Results and discussion

Penguin sighting

The individual, at a juvenile developmental stage, did not exhibit the typical pigmentation of juvenile *S. humboldti* individuals, which is characterized by a head of gray coloration, as well as both sides of the face and throat, with a mixture of gray and white (Couve *et al*. 2016). Another characteristic of juveniles is that the beak is black with gray and white spots. The dorsal plumage is dark gray, the flippers are black on the upper part and white with black and gray spots on the lower part. The legs typically present a grayish-black color (Couve *et al*. 2016). In contrast, the observed specimen displayed characteristics indicative of being an albino or Brown individual, with an atypical white-yellowish coloration of the feathers around the head, face, throat, back, and the entire abdomen (Fig. 1A, B).

The beak was light brown with white lines, and both the orbital ring and the eye were red-brown in color (Fig. 1C). The flippers displayed a light brown color with dark spots on both sides, and the legs were pale pink with dark spots (Fig. 1D). The total length of the individual was estimated to be around 50 cm. The site of the sighting has been revisited nine times (monthly from August 2023 to April 2024); however, the animal has not been sighted again, despite the observation and classification of at least two caves that would serve as breeding habitat for the Humboldt penguin on the Hualpén Peninsula, where other juvenile individuals have been sighted.

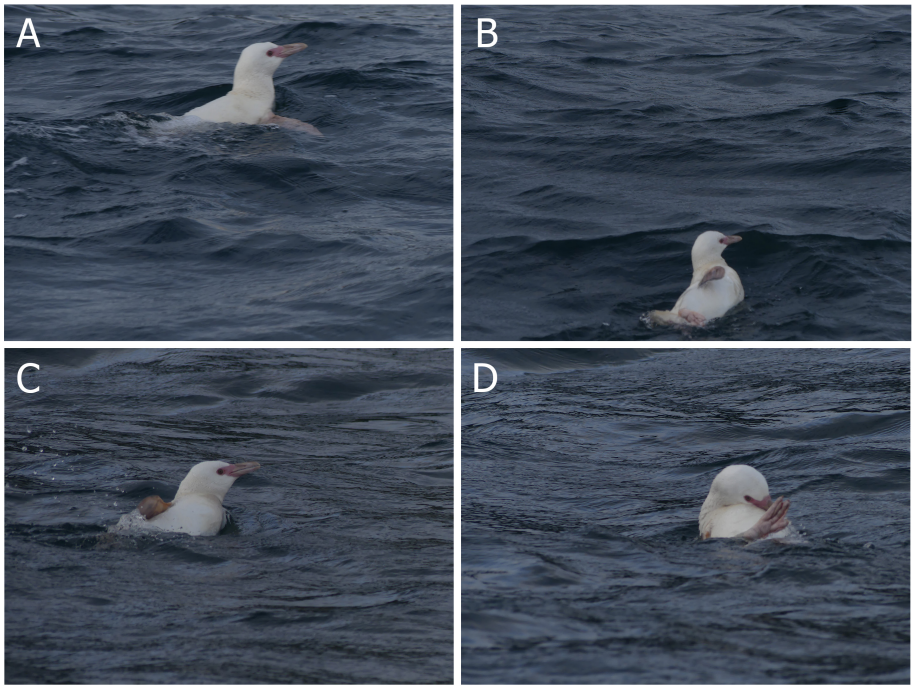

Figure 1. Photographic record of a Humboldt penguin (*Spheniscus humboldti*) with a pigmentation anomaly observed on the Hualpén Peninsula, Biobío Region, Chile. A) dorsal plumage, B) entire body, C) bill, right eye, D) hind limb. Photo credit: Sara M. Rodríguez / Registro fotográfico de un ejemplar de pingüino de Humboldt (*Spheniscus humboldti*) con pigmentación anómala en la Península de Hualpén, Región del Biobío, Chile. A) plumaje dorsal, B) vista del cuerpo completo, C) detalle del pico y del ojo derecho, D) extremidad posterior. Crédito fotográfico: Sara M. Rodríguez

Literature review

Regarding wildlife recorded in Chile with some pigmentation anomaly, the bibliographic search yielded 10 formal publications, the oldest being from 1967 and the most recent a record from 2020. The report included 14 species of birds and two species of marine mammals (Table 1). The most recurrent records involve juvenile Antarctic fur seals (*Arctocephalus gazella*), reported seven times across different islands in the South Shetland Islands, Antarctica (Table 1). For birds, the most frequently reported species are the Austral thrush (*Turdus falcklandii*), recorded on three occasions across different regions, and the house sparrow (*Passer domesticus*), recorded twice in different regions of Chile (Table 1). Additionally, five marine vertebrates species were recorded: i) the South American sea lion (*Otaria flavescens*) corresponding to a population from the Strait of Magellan; ii) the neotropic cormorant (*Phalacrocorax brasilianus*) from the Biobío Region; iii-iv) the Magellanic (*Spheniscus magellanicus*) and gentoo (*Pygoscelis papua*) penguins, both from the Magellanic Region, v) the southern giant petrel (*Macronectes giganteus*) was reported in the Aysén Region (Table 1).

This occurrence of color anomaly in the Humboldt penguin represents the first formally recorded case in this species. Previously, albinism has been reported in three other bird species in Chile between 2004 to 2023 (González-Acuña 2004, Kusch & Donoso 2017), establishing a significant milestone in the study of avian genetic aberrations. In the case of albinism, it has only been documented for the eared dove (*Zenaida auriculata*) in Chillán and the Magellanic horned owl (*Bubo magellanicus*) for Tierra del Fuego (González-Acuña 2004, Kusch & Donoso 2017). The remaining 11 bird species and the two otariid species (refer to Table 1) have been diagnosed as leucistic, indicating varying degrees of depigmentation or color abnormalities, while retaining the typical coloration of normal individuals in their soft tissues. Most of these aberrations have been misdiagnosed, confusing albinism with leucism, Brown mutations, or simply 'dilution' (van Grouw 2021). Nevertheless, the Brown mutation is probably the most common heritable color aberration in birds, but its significance, and even its existence, has often been overlooked, misclassified as other anomalies (McCormac 2001, McCardle 2012, van Grouw 2021).

Table 1. Published records of vertebrates in Chile, including terrestrial and marine birds, as well as marine mammals, with abnormal coloration, ordered by the most recent date of record / Registros publicados de vertebrados en Chile, incluyendo aves terrestres y marinas, así como mamíferos marinos, con coloración anormal, ordenados según la fecha más reciente del registro

Species	Date	Site	References
Spheniscus humboldti (n= 1)	July 11, 2023	Faro Hualpén, Talcahuano	This study
Macronectes giganteus (n= 1)	June 2019	Isla Larga, Región de Aysén	Novoa & Casanova 2020
Bubo magellanicus (n= 1)	February 2017	Isla Grande de Tierra del Fuego	Kusch & Donoso 2017
Curaeus curaeus (n= 1)	December 2012-2013	Coquimbo, Región de Coquimbo	Chávez-Villavicencio 2014
Passer domesticus (n= 1)	March 2010	Iquique, Región de Tarapacá	Fuentes & González-Acuña 2011
Passer domesticus (n= 1)	–	Quinchamalí, Concepción	Fuentes & González-Acuña 2011
Phrygilus gayi (n= 1)	December 2010	Farellones, Región Metropolitana	Fuentes & González-Acuña 2011
Turdus falcklandii (n= 1)	March 2009	Las Condes, Región Metropolitana	Fuentes & González-Acuña 2011
Turdus falcklandii (n= 1)	November 2011	Rari, Región del Maule	Fuentes & González-Acuña 2011
Turdus falcklandii (n= 1)	–	La Pampa, Región de Los Lagos	Fuentes & González-Acuña 2011
Sturnella loyca (n= 1)	May 2009	Santo Domingo, Región de Valparaíso	Fuentes & González-Acuña 2011
Athene cunicularia (n= 1)	2010	Universidad de Concepción, Chillán	Fuentes & González-Acuña 2011
Phalacrocorax brasilianus (n= 1)	November 2011	Isla Quiriquina, Región del Biobío	Fuentes & González-Acuña 2011
Zonotrichia capensis (n= 1)	2010	Ranquilco, Región del Biobío	Fuentes & González-Acuña 2011
Spheniscus magellanicus (n= 1)	March 2011	Isla Magdalena, Región de Magallanes y de la Antártica Chilena	Fuentes & González-Acuña 2011
Pygsocelis papua (n= 1)	January 2011	Base Gabriel González Videla, A Península Antárctica	Fuentes & González-Acuña 2011
Otaria flavescens (n= 1)	February 2007	Francisco Coloane, Estrecho de Magallanes	Acevedo & Aguayo 2008
Vultur gryphus (n= 1)	September 2006	Santiago, Región Metropolitana	Pavez 2008
Zenaida auriculata (n= 1)	August 2003	Puente de Ala, Chillán	González-Acuña 2004
Arctocephalus gazella (n= 2)	1981-1982	Livingston Island, South Shetland Islands	Cárdenas & Yáñez 1983
Arctocephalus gazella (n= 1)	1981-1982	King George Island, South Shetland Islands	Cárdenas & Yáñez 1983
Arctocephalus gazella (n= 1)	1972-1973	Snow Island, South Shetland Islands	Aguayo 1978
Arctocephalus gazella (n= 1)	1972-1973	Low Island, South Shetland Islands	Aguayo 1978
Arctocephalus gazella (n= 1)	1965-1967	Cabo Belsham, Elephant Island, South Shetland Islands	Aguayo & Torres 1967
Arctocephalus gazella (n= 1)	1965-1967	Cabo Valentine, Elephant Island, South Shetland Islands	Aguayo & Torres 1967

(–) not indicated

Reports of vertebrate's color anomalies such as leucism or depigmentation have been deemed scarce; this study confirms 26 individuals in 11 regions of Chile that have been reported with leucism or some form of color aberration. Although these pigment anomalies can produce similar colouration and complicate the field identification of leucism and/or albinism, albinism is even rarer (McCormac 2001, van Grouw 2006). Some examples include otariids individuals, though not all correctly reported, that have been recorded with abnormalities in fur coloration. On several occasions, leucism has been considered a form of albinism, as specific observation of red eye or skin coloration is challenging to discern (McCormac 2001, Acevedo & Aguayo 2008, Carello *et al*. 2021). Although reports are typically sporadic, re-sampling the same individuals is nearly impossible (Aguayo 1978, Acevedo & Aguayo 2008). One reason is that albino specimens do not usually reach adulthood, as they manifest diminished visual acuity, rendering them vulnerable to predators (van Grouw 2006, Dharmarathne & Wijesinghe 2020). Furthermore, other studies have shown that individuals with these abnormalities alter their behavior and become isolated, which raises the hypothesis that these anomalies could pose potential issues for these individuals, such as changes in intraspecific interactions, including ostracism (Slavík *et al*. 2015). In this study, the

discoloured individual was observed alone in the water. Humboldt penguins typically travel in groups, and during multiple visits to the site we consistently recorded group formations, except on the occasion when the discoloured penguin was sighted. Group living in this species is probably an adaptive strategy to facilitate prey capture and provide protection against potential predators (Siegfried *et al*. 2016).

The causes of these color anomalies are primarily associated with factors related to the development of melanin pigmentation and genetic factors, which in turn are influenced by environmental factors and geographic isolation (Puig *et al*. 2017, Nugra *et al*. 2018, Dharmarathne & Wijesinghe 2020). For example, environmental pollution, which can have physiological effects on individuals, can induce genetic alterations and chromatic anomalies (Harney *et al*. 2022). Moreover, environmental pollution can cause habitat loss or fragmentation, promote genetic isolation and increase the likelihood of hypopigmentation and conditions such as albinism in individuals (Puig *et al*. 2017, Carello 2021). An example of this is the rise of albino and leucistic individuals in guanacos (*Lama guanicoe*) populations in Mendoza, Argentina. The expansion of urbanization, new roads, and mining activities have resulted to the continued isolation of these populations (Puig *et al*. 2017). In this regard, the Hualpén Peninsula, where the discoloured Humboldt penguin was sighted, has been exposed to environmental pollution for decades due to a petrochemical complex. This has led to the deposition and persistence of heavy metals, including mercury, in the waters, sediments, and soils of the Lenga Estuary, which drains into Lenga Beach on the peninsula (Yáñez 2002). Therefore, it cannot be ruled out that factors arising from industrial activities in this area contribute to habitat degradation or loss, leading to population isolation, and thereby promoting an increase of individuals with pigmentary anomalies. Conversely, albinism or brown colouration may be more frequent in small populations because inbreeding tends to increase under geographic isolation. When subpopulations become spatially segregated, gene flow can be reduced, promoting inbreeding and, consequently, the expression of chromatic anomalies in some individuals (Carello 2021). An example of this would be the frequent reports of hypopigmentation in Antarctic fur seals in the South Shetland Islands during the years 1965-1982 (Aguayo 1978, Cárdenas & Yáñez 1983, Acevedo & Aguayo 2008), indicating that in isolated communities, limited genetic diversity increases the probability that two carriers of the recessive gene for albinism will mate and thus transmit this condition to their offspring (Novoa & Casanova 2020, Carello 2021). Therefore, the rise in polluting activities could induce environmental stress in individuals, isolate populations, and promote inbreeding, thereby increasing genetic mutations and the prevalence of color aberrations in the population.

Evidence of reports on wildlife with these types of abnormalities has been increasing in recent years (Novoa & Casanova 2020). This increase could be related to the growing number of field observers and the advance of photography, which facilitates the documentation of these individuals. Moreover, given this rise in reports, it becomes important to maintain a constant record of species with these abnormalities inhabiting the wild, in order to better understand the underlying causes of these pigmentary anomalies. For instance, because variation in animal colouration has been considered an environmental indicator, repeated sightings of individuals with these anomalies could provide clues for studies of population genetics and biogeography, including analyses of spatiotemporal trends in the occurrence (or birth rate) of affected individuals (Gong *et al*. 2021). In conclusion, this life history note represents the third record of plumage color abnormalities for individuals of the family Spheniscidae and probably the first instance of Brown mutation for the species *S. humboldti* in Chile.

Statements

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Data availability

The data are available upon request from the corresponding author (SR).

Conflicts of interest

The authors declare no conflicts of interest.

Use of AI

No artificial intelligence tools were used in this work.

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