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Leucism and albinism in the rear-fanged snakes *Tachymenis chilensis chilensis* (Schlegel, 1837) and *Tachymenis chilensis coronellina* Werner, 1898 (Serpentes, Dipsadidae)

Felix A. Urra[1,2], Alejandro Zúñiga[3,4], Nel Melero[5], Nibaldo Reyes[6], Yarela Herrera[1,2,7], Alejandro Bruno Miranda-Calle[2,8,9], Juan Carlos Ortiz[7]

1 *Programa de Farmacología Molecular y Clínica, Instituto de Ciencias Biomédicas (ICBM), Facultad de Medicina, Universidad de Chile, Santiago, Chile*
2 *Network for Snake Venom Research and Drug Discovery, Santiago, Chile*
3 *Departamento de Ciencias Químicas y Biológicas, Universidad Bernardo O´Higgins, Santiago, Chile*
4 *Instituto de Ciencias Naturales, Universidad de Las Américas, Santiago, Chile*
5 *C/ Del Río Dela 3,32, 33570 Panes, Asturias, Spain*
6 *Mundo Reptil, Marina Grande 613 Maipú, Santiago, Chile*
7 *Departamento de Zoología, Facultad de Ciencias naturales y Oceanográficas, Universidad de Concepción, Casilla 160-C, Concepcion, Chile*
8 *Colección Boliviana de Fauna, Instituto de Ecología, Universidad Mayor de San Andrés, c. 27 de Cota Cota, La Paz 10077, Bolivia*
9 *Red de Investigadores en Herpetología, La Paz, Bolivia*

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Corresponding author: Félix A. Urra (felixurraf@u.uchile.cl)

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Abstract

Herein, we report the first observation of two different coloration patterns in Chilean snakes. Based on the alteration of wild coloration patterns, a juvenile specimen of *Tachymenis chilensis coronellina* Werner, 1898 was diagnosed with albinism and a juvenile specimen of *Tachymenis chilensis chilensis* (Schlegel, 1837) was diagnosed with leucism. The existence of color variations in wild snake populations and the implications of these for fitness are discussed.

Key Words

phenotype, reptiles, short-tailed snake, skin coloration, South American snakes

Snake species have evolved numerous coloration patterns with functions that aid in thermoregulation, camouflage, warning, and mimicry (Bechtel 1978, Krecsák 2008). However, inherited color defects, such as albinism and leucism, are well documented in many species of snakes (Bechtel 1991).

Leucistic animals present eyes normally pigmented, usually black, or blue (Wareham 2005) whereas the skin has either reduced coloration or lacks it entirely (Sage 1962, Bechtel 1995). Leucistic snakes have a diminished number of iridophores and probably an exceptionally low number of melanophores and xanthophores or none at all (Bechtel 1991), and lack eumelanin and phaeomelanin (Bechtel 1995, Van Grouw 2006). On the other hand, albinism is generally defined as the absence of the black and brown pigmentation usually provided by melanophore cells, but the other two types, xanthophores, and iridophores are functional, which results in

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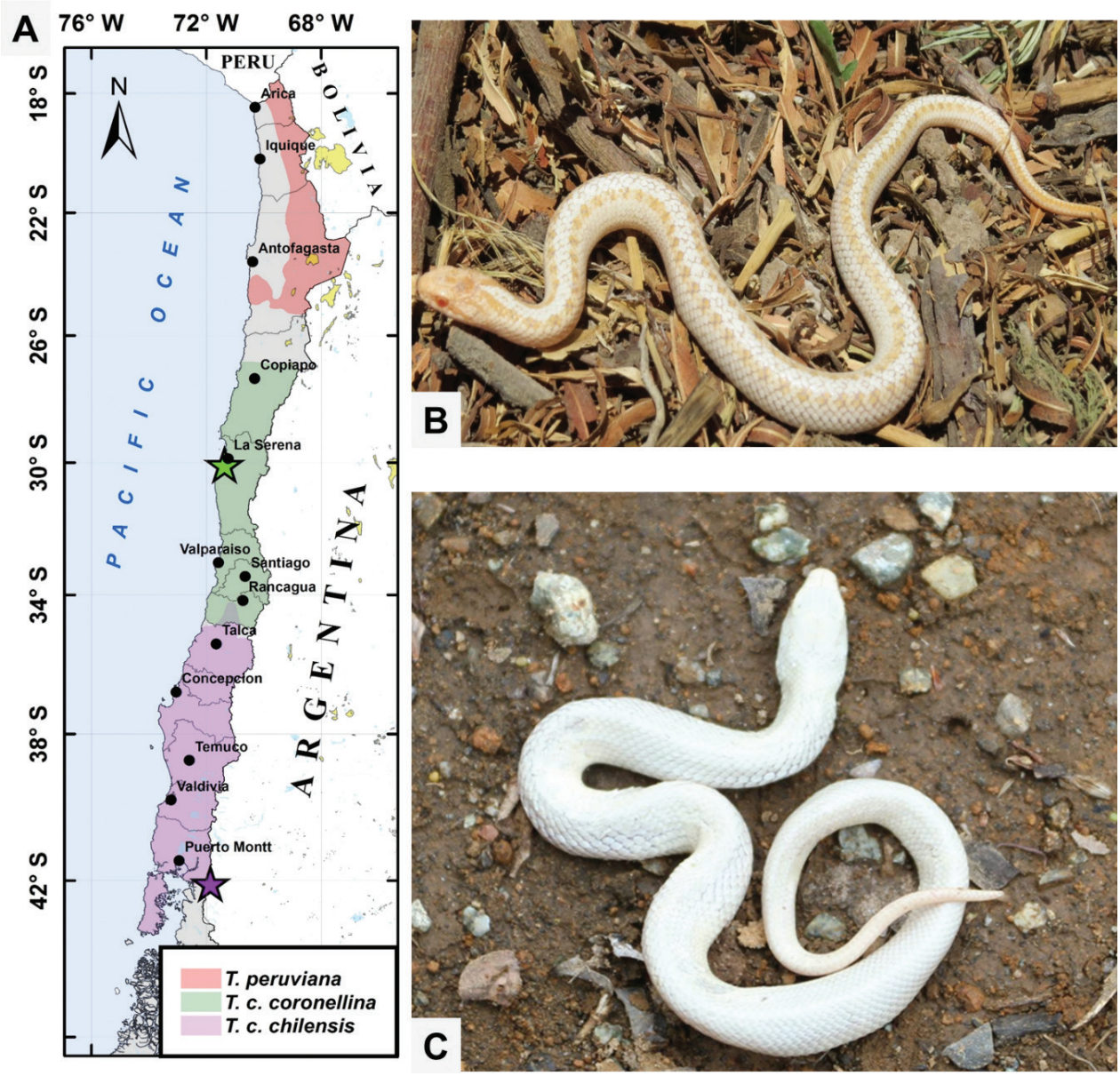

Figure 1. A. Distribution of *Tachymenis* species in Chile based in Valenzuela-Dellarossa et al. (2010). The location of the specimens with albinism and leucism are represented in green and purple stars, respectively. Map was done using ARCGIS v10.7 (ESRI) software; **B.** *T. c. coronellina* with albinism; **C.** *T. c. chilensis* with leucism.

skin with a pattern of yellow, orange, and red pigments, and red eyes (Bechtel 1991). Nevertheless, albinism relies on defects to several biochemical pathways caused by different genetic defects and producing partial and total albinism (Bechtel 1991, 1995). Although there are numerous reports of total albinism, partial albinism, and leucism in snakes worldwide, some of them require detailed revision if the diagnoses were incorrectly made. Recently, Devkota et al. (2020) showed a list of snake species with leucism, which were verified with a photograph or description that specifically mentioned the coloration of the eyes. Remarkably, leucism has also been confused with albinism in snakes (e.g., Sazima and Di-Bernardo 1991, Vyas 2009, Thombre and Dhande Abhishek 2015).

The genus *Tachymenis* is distributed through Peru, Bolivia, Argentina, and Chile, with six species currently recognized. In Chile, *Tachymenis* comprises *T. peruviana* Wiegmann, 1834 and *T. chilensis* (Schlegel, 1837), the latter species containing two subspecies *T. c. coronellina* Werner, 1898 and *T. c. chilensis* (Schlegel, 1837), *fide* Ruiz de Gamboa 2020. *Tachymenis c. coronellina* is distributed from San Fernando in the south to Antofagasta in the north (Valenzuela-Dellarossa et al. 2010). *Tachymenis c. chilensis* is a small snake distributed from Monte Lorenzo and Toquihua (O´Higgins Region) to Chiloé Island, further south in the Los Lagos Region of Chile (Ortiz 1973, Simonetti 2001, Valenzuela-Dellarossa et al. 2010) (Fig. 1A). In Argentina, *T. c. chilensis* is recorded from Neuquén, Chubut and Río Negro provinces (Cei

1986, Avila et al. 2012, Giraudo et al. 2012, Nenda et al. 2017), where it inhabits riverbanks with rocks and forests of *Nothofagus* and *Araucaria* (Giraudo et al. 2012). *T. chilensis* exhibits considerable variability of color and dorsal pattern, including reduction of the dorsal lines and melanism in the Chilean southern populations (Hellmich 1937, Donoso-Barros 1966, Flores 2018); however, no formal studies on color variations and their relevance to geographic distribution or natural history have been conducted. Herein, we describe the first observations of leucism and albinism in specimens of *Tachymenis chilensis*.

In November 2018, in the vicinity of Totoralillo (30°03'54"S, 71°22'10"W), a specimen of *Tachymenis chilensis coronellina* with abnormal coloration was found between low bushes near an old and abandoned house at 13.21 h (GMT-4). The specimen was measured and photographed (Fig. 1B and Table 1). This snake exhibited a dorsal pattern of white and yellow and possessed red eyes, so it was diagnosed as albino.

Table 1. Morphometric data of neonates of *T. c. coronellina* with normal coloration and albinism. Data (in mm) are shown as mean ± standard deviation (SD). Abbreviations: N.C. = not collected, N.D. = not determined, F = female, M = male.

Phenotype/voucher MZUC	Sex	HL	HW	HH	TL
Normal/MZUC11512	F	7.00	3.30	2.60	117
Normal /MZUC44959	F	6.51	2.32	2.96	110
Normal /MZUC44953	M	6.48	2.68	2.59	131
Normal /MZUC44954	M	5.59	3.31	2.38	117
Albino/N.C.	N.D.	5.81	3.57	2.38	143
Mean ± SD		**6.28 ± 0.57**	**3.04 ± 0.52**	**2.58 ± 0.24**	**123.60 ± 13.24**

In February 2014, during fieldwork in the vicinity of Segundo Corral, Los Lagos Region, Chile (42°04'33"S, 71°51'49"W), an abnormally patterned specimen *Tachymenis chilensis chilensis* was found crossing a path between *Nothofagus* and *Drymis* forests at 12.00 h (GMT-4). The specimen was measured and photographed (Fig. 1C and Table 2) and released where it was found. This snake lacked any dorsal patterning, being fully white while its eyes were gray with black vertical pupils. Leucism was diagnosed based on these characteristics.

Table 2. Morphometric data of neonates of *T. c. chilensis* with normal coloration and leucism. Data (in mm) are shown as mean ± standard deviation (SD). Abbreviations: N.C. = not collected, N.D. = not determined.

Phenotype/voucher MZUC	Sex	HL	HW	HH	TL
Normal /MZUC 45031	N.D.	8.15	2.89	4.22	161
Normal /MZUC 45032	N.D.	7.73	2.77	3.94	160
Normal /MZUC 45033	N.D.	8.05	2.86	4.16	157
Normal /MZUC 45036	N.D.	7.88	2.88	3.97	151
Leucistic/N.C.	N.D.	8.25	3.00	4.27	158
Mean ± SD		**8.01 ± 0.20**	**2.88 ± 0.08**	**4.11 ± 0.15**	**157.4 ± 3.91**

To compare the morphological characteristics and coloration of *T. chilensis* specimens, we reviewed 361 specimens of *Tachymenis c. coronellina* and *T. c. chilensis* deposited between 1947 until 2020 in Museo Nacional de Historia Natural de Chile (MNHNC; 39 specimens), Colección de Flora y Fauna Profesor Patricio Sánchez Reyes of Pontificia Universidad Católica de Chile (SSUC; 3 specimens), Museo de Zoología of Universidad de Concepción (MZUC; 316 specimens), and Museo Regional de Historia Natural de Concepción (MHNC; 3 specimens). Measurements of head length (HL), head width (HW), head high (HH), and total length (TL) were taken with a hardened stainless steel digital Vernier caliper (0.01 mm precision). These morphological data were obtained only for neonates from herpetological collections to be used for comparisons with specimens reported in this study with leucism and albinism (Table 1 and 2).

Substantial differences in dorsal patterning and coloration were observed during the review of the specimens of *T. chilensis* included in the four Chilean herpetological collections. Specimens of *T. chilensis* exhibited yellow or gray coloration with dorsal black stripes, which can be separated or in contact with the following stripe (Fig. 2A, B). Some specimens had an extension of black coloration of dorsal stripe on their yellow background, predominating the black as dorsal and ventral coloration (Fig. 2C). This suggests a pseudo-melanistic phenotype in which occurs an unusual enlargement of the pattern of dark spots of the animal as has been reported for other snakes (Fernández-Guiberteau et al. 2015). Melanism, which is due to excessive dark pigmentation of the integument by mutations, also has been observed (Fig. 2D) as previously described by Donoso-Barros (1966). None of the museum voucher specimens exhibited leucism or albinism. Taking into consideration the current dearth of studies about the abundance of leucism and albinism in Chilean snakes, we calculated the prevalence and incidence of these phenotypes using the specimens collected over 73 years of fieldwork plus our two observations. We determine a low prevalence (0.27%, i.e. 1 specimen observed with albinism or leucism in 363 specimens) and low incidence (1.37%, i.e. 1 specimen identified with albinism or leucism in 73 years of fieldwork) for these alterations in coloration in *T. chilensis*.

The reproductive biology of Chilean snake species is poorly known (Donoso-Barros and Rubio 1962, Cabeza et al. 2019). To determine if the specimens with leucism and albinism observed may be neonates, we studied two series of neonates collected from females of *T. c. coronellina* and *T. c. chilensis*, during January 1961 Polpaico, Metropolitan Region, and March 1971 in Laraquete, BioBio Region, respectively. All neonates exhibited the normal phenotype comprised of a gray or brown background with black vertebral lines or stripes (Fig. 2E–G, arrowheads). No differences in coloration or pattern were found between neonates and adults with normal phenotype. On the other hand, morphological measurements of neonates of *T. c. coronellina* and *T. c. chilensis*, and the specimens with albinism and leucism described in this work exhibited similar size and length to the normal phenotype (Table 1 and 2), suggesting that the specimens with abnormal coloration were of early

Figure 2. Variations of the coloration in *Tachymenis c. coronellina* and *T. ch. chilensis*. **A–C.** Variations in black stripes in *T. c. coronellina* (MZUC 25351, SSUC-Re 440, SSUC-Re 023); **D.** Total melanism in *T. c. chilensis* (FMNH 3871); **E, F.** Neonates of *Tachymenis c. coronellina*. The red arrowheads show dorsal pattern (MZUC11512, MZUC44953); **G.** Dorsal view (MZUC45033) of neonate of *Tachymenis c. chilensis*.

ontogenetic age. In this report, we described the first cases of both albinism and leucism in the genus *Tachymenis*. Our review of 73 years of collection in the field shows that adults and neonates exhibit normal phenotype with variations in the extension of dorsal stripes, and some specimens acquiring more black coloration as previously described (Donoso-Barros 1966). In contrast, with reports that in some populations of Japanese *Elaphe climacophora*, where albino and leucistic adults are common (Fukada 1978, Iwanishi et al. 2018), leucism and albinism have apparently low prevalence and incidence for *T. chilensis*. Notably, the implications of these rare phenotypes on metabolism and thermoregulation in these specimens as well as their fitness in the environment remain largely unknown. Further studies are required to understand the relevance of these abnormalities of coloration and their implications for the natural history of *Tachymenis* species.

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