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Chromatic variation in populations of *Xenodon merremi* (Serpentes: Dipsadidae) in Paraguay

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Abstract. *Xenodon merremi* is a polychromatic species distributed in South America. Among its wide range of color patterns, the most common pattern resembles a pitviper of the genus *Bothrops*. In this work is recorded the different patterns found in Paraguayan populations of *X. merremi*. Four patterns can be observed: marked pattern, slightly marked pattern, smooth, and banded pattern. The marked pattern is the most common pattern (mimetic with pitvipers), and all juveniles bear this coloration. Only adults show variation in their coloration.

Keywords. *Xenodon merremi*, Paraguay, chromatic variation.

Xenodon merremi is a colubrid snake widely distributed from Ecuador and the Guianas, to northern and central Argentina, and Uruguay (Cerreira et al., 2005; Tipton, 2005). Throughout its distribution, *X. merremi* occurs in both natural and anthropogenic areas (Cabrera, 2004; Scrocchi et al., 2006) and feeds largely on toads (Carreira, 2002).

Several works have made reference to the variable polychromatic coloration of *X. merremi* (under the genus *Waglerophis*) even in local areas (Giraudo, 2001; Cabrera, 2004; Scrocchi et al., 2006). The typical coloration of *X. merremi* is a pattern with semicircular brownish lateral marks with wavy edges and skirted by white thin margins, this pattern being mimetic with pitvipers of the genus *Bothrops* (Giraudo, 2001; Cabrera, 2004; Carreira et al., 2005; Scrocchi et al., 2006). Additionally, Brodie and Brodie (2004) also pointed out that the species can show coloration mimetic of coral snakes (see plate 1338 in Campbell and Lamar, 2004).

Included in the range of variation reported in *X. merremi* are specimens with black marks (not brownish); specimens with the body completely yellowish, brown, or even almost completely blackish; as well as a specimen with partial albinism (Scrocchi et al., 2006). Giraudo (2001) identified six different patterns: A (uniformly immaculate), B (with rings on the back), C (with small semicircular marks on the sides, with a vertebral stripe),

D (the typical pattern with smooth marks), E (the typical pattern with clear center marks), and F (with one undulated stripe on each side). Giraudo (2001) stated that there is no concordance between coloration variation and distribution, but there is an ontogenetic pattern: juveniles are always marked with patterns D or E), whilst adults are variable. Ontogenetic changes were also recorded by Norman (1994).

In this work is presented a summary of the coloration patterns recorded in Paraguay, together with the frequency of each pattern.

Paraguay with an area of 406,752 km^2 is located in the center of South America, and divided approximately in half by the Paraguay River. Western Paraguay (commonly referred to as "The Chaco") makes up 60% of the territory, whereas the remaining 40% is represented by the eastern or Oriental Region. Biogeographically, Paraguay is divided into seven ecoregions (Fig. 1). *X. merremi* is distributed almost throughout the whole country.

For this study, a sample of 60 Paraguayan specimens (18 juveniles and 42 adults, Appendix 1) preserved in the Museo Nacional de Historia Natural del Paraguay (MNHNP) was analysed. Specimens shorter than 25 cm were considered juveniles.

Four different patterns were recognized in this sample: marked (normal pattern), slightly marked, smooth, and banded. All juveniles analysed were of the normal marked pattern, only adults exhibited variation. There follows a brief definition of each of the observed patterns, with comments on their frequency in the sample.

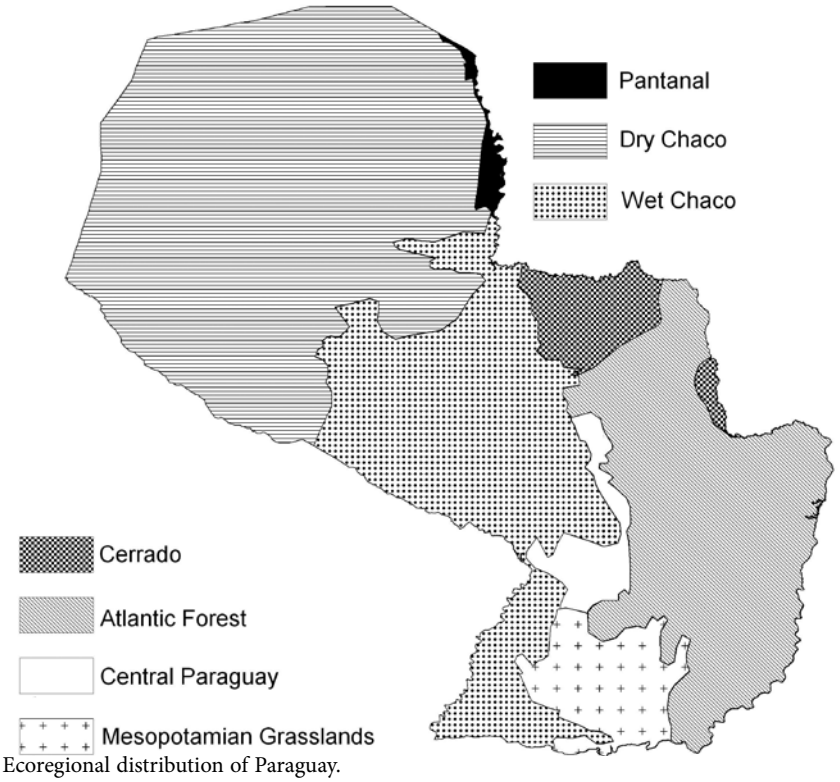

Fig. 1. Ecoregional distribution of Paraguay.

Marked pattern: this is the "typical" pattern of the species, with series of marks on the sides (Fig. 2A). Marks can reach the vertebral zone, joining with its couple of the other side. Although different color patterns were observed, all are here grouped as "marked" individuals. All juveniles were shown to exhibit this pattern in addition to 22 of the adults (52.4% of the adults in the sample).

No difference was observed between specimens from the western and Oriental Regions (Fig. 3A).

Slightly marked pattern: "slightly-marked" individuals tend to lose the body markings (Fig. 2B), though typically traces of marks remain near the vertebral zone. Eleven adults bore this pattern corresponding to 26.2% of the sample. No juveniles in the sample exhibited this pattern. Specimens with "slightly marked pattern" are present in a wide variety of environments, and have been recorded from all the Paraguayan ecoregions except for the Pantanal (Fig. 3B).

Smooth: specimens with smooth coloration, lack contrasting pattern (Fig. 2C) and are usually uniformly yellowish or brownish. Six adults were recorded with this coloration, representing 14.3% of the adults examined.

Specimens with smooth coloration were collected from the Dry Chaco and Wet Chaco, and were recorded in the Oriental Region only in the Departments of Central and Ñeembucú, where the predominant habitat is similar to that of wet Chaco (Fig. 3C).

Fig. 2. Body color patterns of Paraguayan populations of *Xenodon merremi*. **A:** marked pattern, **B:** slightly marked pattern, **C:** smooth coloration, and **D:** banded pattern.

Banded pattern: the "banded pattern" consists of a series of black bands or rings along the body, against a grey background (Fig. 2D). Specimen MNHNP 2601 additionally shows vertebral constriction in some bands, and is quite similar in shape to the typical "marked" pattern. Only three adults in the sample showed this pattern, corresponding to 7.1% of the total adults.

The three specimens were collected from three widely-dispersed localities: Cerro Corá National Park (Cerrado ecoregion, Departamento Amambay), Colonia Walter Insfrán (Alto Paraná Atlantic Forest ecoregion, Departamento Caaguazú), and the surroundings of Loma Plata (Dry Chaco ecoregion, Departamento Boquerón) (Fig. 3D).

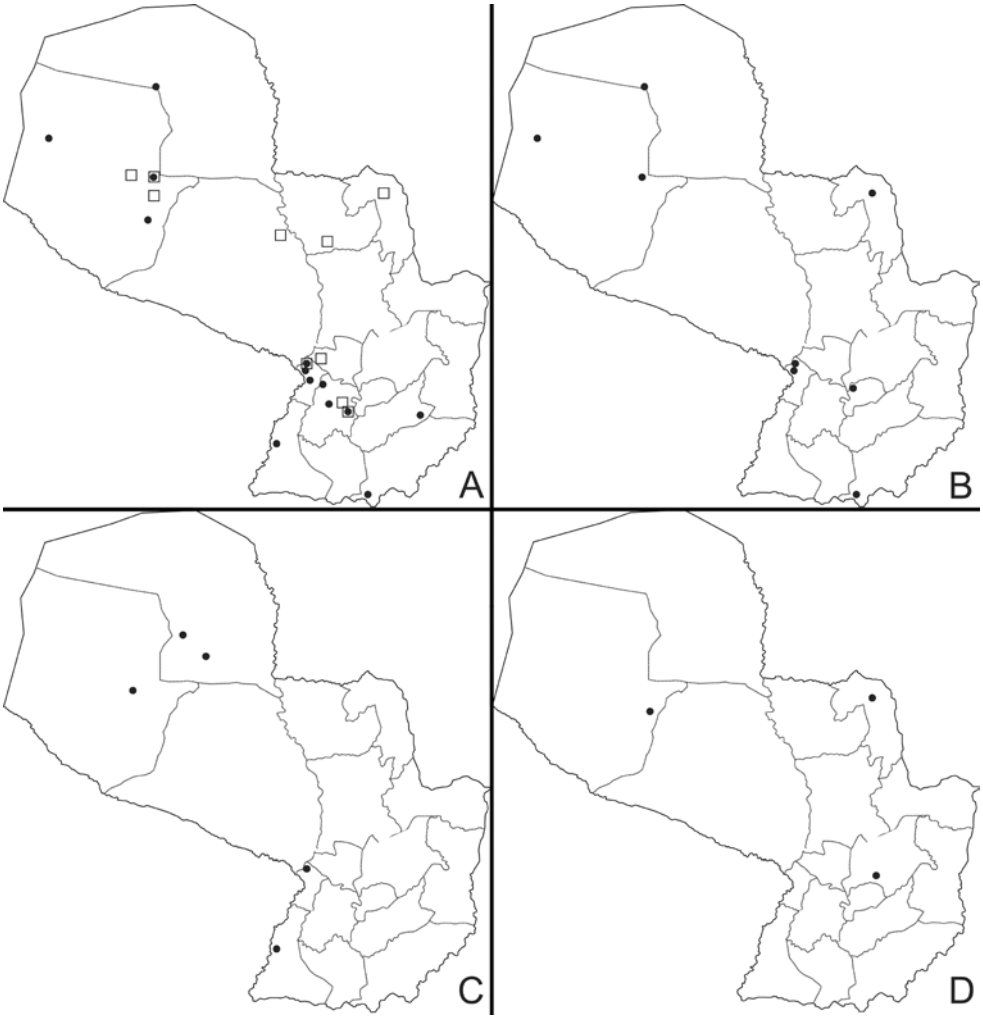

Fig. 3. Distribution of examined specimens, according to the color pattern. Black dots are adults, and open squares are juveniles. Note that there are juveniles only in "A". **A:** marked pattern, **B:** slightly marked pattern, **C:** smooth coloration, and **D:** banded pattern.

Table 1. Patterns frequencies in each ecoregion. PA (Pantanal), DC (Dry Chaco), WC (Wet Chaco), CE (Cerrado), AF (Alto Paraná Atlantic Forest), CP (Central Paraguay), MG (Mesopotamian Grasslands). There are 12 additional sampled specimens without specific locality data.

	PA	DC	WC	CE	AF	CP	MG	Total
Pattern A	0	8	3	1	7	10	3	32
Pattern B	0	3	0	1	2	2	0	8
Pattern C	0	3	1	0	0	1	0	5
Pattern D	0	1	0	1	1	0	0	3
Total	0	15	4	3	10	13	3	48

Results show that like other previous works (Norman, 1994; Giraudo, 2001), juvenile coloration is always consisting in well defined marks, whereas adults can show different patterns of coloration. This results confirms that coloration probably change ontogenetically in this species.

The commonest adult pattern in the Paraguayan sample was the marked pattern, which accounted for 52.7% of the adult specimens. Giraudo (2001) defined two different kinds of "normal" patterns, to differentiate them from the other marked patterns. Nevertheless, in Paraguay, the marked specimens only exhibit the normal marked coloration (Fig. 2A), and not the wide range described by Giraudo (2001, Fig. 42). These findings suggest that more than half of all Paraguayan specimens retain juvenile coloration into adulthood.

In the Dry Chaco, it is possible to find all the different patterns. Probably also in the Wet Chaco; but examined specimens with banded pattern was not presents in the Wet Chaco. An important fact is that in the Cerrado, occur three of the four different patterns, being absent only the smooth coloration. In the Table 1, is presented a list of number of individuals of each color pattern in each ecoregion. Any specimen came from Pantanal.

More sampling effort is required to get a clearer picture of the distributional patterns of the different color types. Given the small sample size the current observed distribution of the pattern types in Paraguay may be a result of different sampling efforts in different locations. Bearing this mind it should be noted that the smooth type could yet prove to have a wider distribution in Paraguay than it currently appears.

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APPENDIX 1

Examined specimens

A. Marked pattern (including juveniles): Paraguay (MNHNP 2611, 9256, 9429, 9431, 9432, 9516, 9554, 9583). Alto Paraguay: Fortín Madrejón (MNHNP 2657). Amambay: Parque Nacional Cerro Corá (MNHNP 2660). Boquerón: 15.6 km S of Filadelfia (MNHNP 10033); 26 km N of Filadelfia (MNHNP 9736); Parque Nacional Teniente Enciso (MNHNP 6524); Filadelfia (MNHNP 2610, 8495); Neuland (MNHNP 9992); Route IX, Km 519 (MNHNP 6825). Caazapá: Parabel (MNHNP 8808). Central: Asunción (MNHNP 3180, 6520); Guarambaré (MNHNP 2664); Luque (MNHNP 6288-90); San Lorenzo (MNHNP 7461, 9939). Concepción: Horqueta (MNHNP 2609). Cordillera: Altos (MNHNP 10309). Itapúa: Isla Yacyretá (MNHNP 9568). Misiones: Yabebyry (MNHNP 3779-80). Ñeembucú: Estancia Yacaré (MNHNP 4556, 6679). Paraguari: Acahay (MNHNP 3540); Coronel C. Barrientos (MNHNP 3781); Parque Nacional Ybycui (MNHNP 2661-3); Yaguarón (MNHNP 2658). Presidente Hayes: Estancia Bella Vista (MNHNP 10610).

B. Slightly marked pattern: Paraguay (MNHNP 9456, 9593, 9594). Alto Paraguay: Fortín Madrejón (MNHNP 2679). Amambay: Parque Nacional Cerro Corá (MNHNP 9193). Boquerón: Parque Nacional Teniente Enciso (MNHNP 2656); Filadelfia (MNHNP 3839); Central: Luque (MNHNP 6286); San Lorenzo (MNHNP 9172). Guairá: 13 km W of Villarrica (MNHNP 6518). Itapúa: Coast of the Paraná (MNHNP 4213).

C. Smooth coloration: Paraguay (MNHNP 9566). Alto Paraguay: Estancia Tres Marías (MNHNP 9197); Laguna León (MNHNP 11041). Boquerón: Route IX, Km 508 (MNHNP 2655); Central: San Lorenzo (MNHNP 7053). Ñeembucú: Estancia Yacaré (MNHNP 4585).

D. Banded pattern: Amambay: Parque Nacional Cerro Corá (MNHNP 2659). Boquerón: 9 km S of Loma Plata (MNHNP 9996). Caaguazú: Colonia Walter Insfrán (MNHNP 2601).