

Records of morphological abnormalities of anuran limbs from Paraguay

Brogan L. Pett¹, Joseph Sarvary¹, Harry-Pym Davis¹, Paul Smith^{1,2}, Karina Atkinson¹

¹ Para La Tierra, Centro IDEAL, Pilar, Dpto. Ñeembucu, Paraguay.

² FAUNA Paraguay, Encarnación, Paraguay.

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ABSTRACT

Morphological abnormalities in anurans are known to be globally widespread. Here, we report on six individual anuran morphological abnormalities from four Paraguayan departments. We briefly discuss potential causal agents and highlight the need for further research into this topic in Paraguay.

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Morphological abnormalities in anurans first appeared in scientific literature nearly 300 years ago (Ouellet, 2000), and are now reported across the world (Ankley *et al.*, 2004; Garcia-Munoz *et al.*, 2010; Spolyarich *et al.*, 2011). Morphological abnormalities are a natural phenomenon in amphibian populations, with rates above 5% considered high and a likely indicator of environmental degradation (Lanoo, 2008). Malformation of the limbs can have a negative impact on individual fitness as they may impair mobility, increase risk of predation, and decrease foraging efficiency (Blaustein and Johnson, 2003). Several causal agents have been proposed, with four main theories: increases in chemical pollutants (Peltzer *et al.*, 2011; Hedge and Krishnamurthy, 2014), parasitic infection (Johnson *et al.*, 1999), increased UV-B radiation (Spolyarich *et al.*, 2011), and predators (Johnson and Bowerman, 2010).

Reports exist in South America from Argentina (Attademo *et al.*, 2005; Peltzer *et al.* 2011, Agostini *et al.*, 2013), Brazil (dos Santos *et al.*, 2017; Silva- Soares and Mónico, 2017, Ascoli- Morrete *et al.* 2019), Uruguay (Prigione and Langone, 1985) and Paraguay (Brouard and Smith, 2014), but are still scarce in comparison to temperate regions (see detailed revision in Lanoo, 2008).

In this study, we reported morphological abnormalities of the limbs on six anuran species, *Scinax fuscovarius* (Lutz, 1925), *Rhinella dypticha* (Cope, 1862), *Rhinella major* (Muller and Hellmich, 1936), *Leptodactylus latrans* (Linnaeus, 1758), *Physalaemus santafecinus* Barrio, 1965, and *Elachistocleis haroi*

Pereyra *et al.*, 2013. The examinations were based on external observation under a stereoscope. Individuals were collected from Paraguayan departments: Itapúa, Ñeembucú, Presidente Hayes and Boquerón. All individuals were euthanized according to Simmons (2002) and deposited in the Colección Científica de Para La Tierra (CZPLT) registered by the Ministerio del Ambiente y Desarrollo Sostenible (MADES). Our classification of abnormalities followed Johnson *et al.* (2001) and Lanoo, (2008); (Table 1).

Scinax fuscovarius (Hylidae, Scinaxinae): An individual (CZPLT-H 1474) was recorded on the 18th of January 2019 at an urban site located at 7.5km west of Encarnación (-27°10'32.88" S; -55°33'25.92" W). The individual exhibited ectrodactyly of at least two digits and syndactyly on the remaining digits on its left forelimb.

Table 1. Classification and description of morphological abnormalities observed in this paper, adapted from Johnson *et al.* (2001) and Lanoo (2008).

Condition	Description
Amelia	Absence of one or more limbs
Brachydactyly	Abnormal shortness of one or more digits
Ectrodactyly	Complete absence of one or more digits
Ectromelia	Complete absence of one or more bones
Hemimelia	Partial or complete absence of distal portion of long bones
Syndactyly	Partial or complete fusion of one or more digits

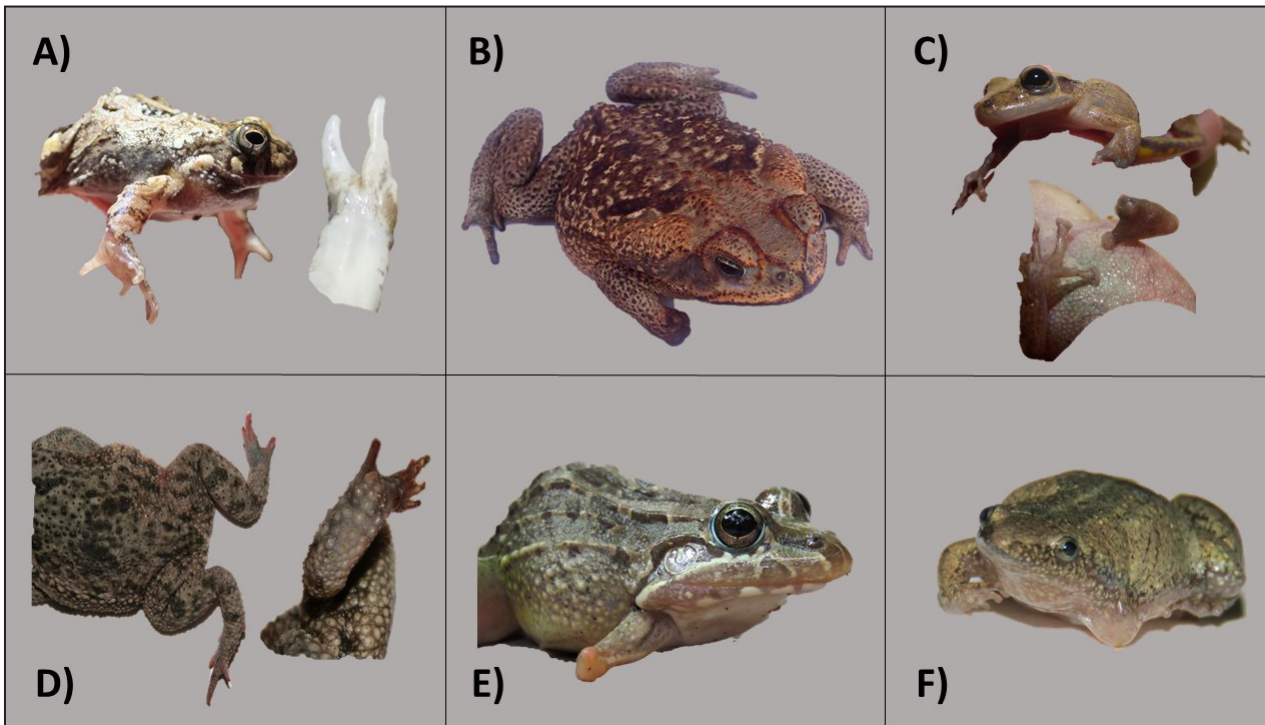


Figure 1. Photographs of individual anurans with morphological abnormalities, A) *Physalaemus santafecinus* (ectrodactyly on left forelimb), B) *Rhinella dypticha* (ectromelia on right forelimb), C) *Scinax fuscovarius* (ectrodactyly and syndactyly of digits on the left forelimb), D) *Rhinella major* (ectrodactyly and brachydactyly on right hindlimb), E) *Leptodactylus latrans* (amelia and hemimelia on right forelimb), F) *Elachistocleis haroi* (amelia of left forelimb). Photographs taken by: A, E, F (BLP, co- author), B (Lia Nydes), C (PS, co- author), D (JS, co- author).

Rhinella dypticha (Bufonidae): An individual (CZPLT-H 1420) of *R. dypticha* was recorded on the 21st of January 2019, at Estancia Santa Ana (-26°51'7.92" S; -58°2'32.28" W) in Ñeembucú department. The individual exhibited ectromelia on its right forelimb, with the distal portion completely missing and forming a smooth black stump.

Rhinella major (Bufonidae): An individual of *R. major* (CZPLT-H 1391) was recorded on the 12th of January 2019, at a pond near Parador Pirahú hotel (-23°39'24.12" S; -58°41'36.24" W) in Presidente Hayes department). The individual exhibited ectrodactyly and brachydactyly on its hind right foot, with a missing digit II and stunted and deformed digits III and IV (Fig. 1).

Leptodactylus latrans (Leptodactylidae): An individual of *L. latrans* (CZPLT-H 1459) was recorded on the 23rd of March, at Estancia Santa Ana (-26°51'1.8" S; -58°2'5.64" W) from Ñeembucú department. The individual exhibited amelia and hemimelia on the right forelimb.

Physalaemus santafecinus, (Leptodactylidae, Leiuperinae): An individual (CZPLT-H 1342) was recorded on the 5th of December 2018, at Regimiento de Caballería N°2 Coronel Felipe Toledo

(-26°50'42.72" S; -58°18'18.72" W) in Ñeembucú department. The individual exhibited ectrodactyly on its left forelimb, missing two digits (digits II and III).

Elachistocleis haroi (Microhylidae): An individual (CZPLT-H 1371) was recorded on the 13th of January 2019 from a swamp near Fortin Toledo (-22°12'42.48" S; -60°12'6.84" W, Boquerón department). The individual exhibited an amelia of its left forelimb.

These are the first records of morphological abnormalities for *R. major*, *E. haroi* and *P. santafecinus*, and these records increase the number of morphological abnormalities from Paraguayan departments from one to five (Fig. 2). The only previously published records were of *Elachistocleis bicolor* and *Euphemphix nattereri* in San Pedro department, where Brouard and Smith (2014) noted that abnormality rates were generally low. Several causes may be responsible for the abnormalities (discussed previously), some may be genuine deformities (Meyer, 2000), however, abnormalities observed for *R. dypticha* and *E. haroi* appear to have been produced by a mechanical injury, or trauma due to predation event (Ballengée and Sessions, 2009; Johnson and Bowerman, 2010; Bionda *et al.* 2012).

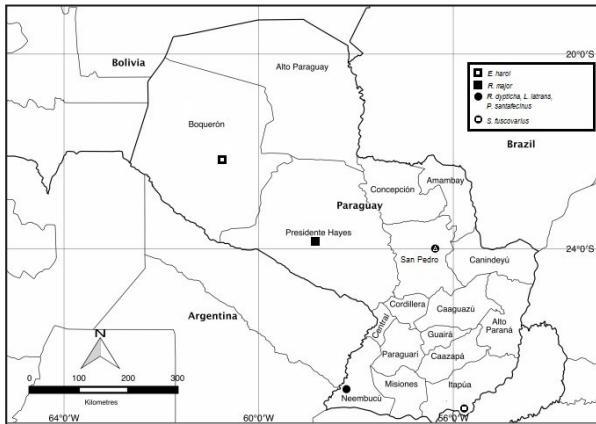


Figure 2. Geographical localities of morphological abnormalities recorded in this paper. Solid black circle: Estancia Santa Ana (*R. dypticha*, *L. latrans*), Base Militar (*P. santafecinus*). Black ring: Encarnación (*S. fuscovarius*). Black square: Parador Pirahú (*R. major*). Black square ring: Fortín Toledo (*E. haroi*). Black circle with white triangle inset: the 2014 morphological abnormality records from San Pedro Department are shown (Brouard and Smith, 2014).

Amphibians are exceptional bioindicator taxa (Davic and Welsh, 2004; DeGarady and Halbrook, 2006) and Paraguay is undergoing rapid land- use change (Aide *et al.*, 2012). Future research in Paraguay should examine relationships between land use change and levels of abnormality prevalence and severity. Evaluation of historical museum records would also prove useful in comparing abnormality rates over time.

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