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SHORT NOTE

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Anomalies in amphibians from the eastern Amazon region

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INTRODUCTION

Over the years, a broad range of morphological abnormalities (anomalies) have been documented from the anurans of both wild and urban populations (Ouellet, 2000; Blaustein & Johnson, 2003; Bionda et al., 2012). These anomalies have been recorded as a consequence of factors related to changes in the environment, such as exposure to UV-radiation and environmental pollutants (Cohen, 2001; Lannoo, 2009; Lunde & Johnson, 2012; Agostini et al., 2013) and parasitic infection (Kiesecker, 2002). Anomalies include incomplete or missing digits and limbs, additional digits and limbs, and body deformations, in which limb malformations seems to be the most prevalent (Gardiner & Hoppe, 1999; Blaustein & Johnson, 2003). Records have come from isolated individuals and from populations, and in the latter case they normally occur in about only 5 % of the population (Read, 1997). Thus the rate of occurrence may be considered abnormally high when the value in a population exceeds this mark (Piha et al., 2006; Peltzer et al., 2011; Bionda et al., 2012).

In this study we report anomalies in several anuran species from Amapá state, eastern Amazonia, Brazil, consider an endemic zone for the herpetofauna in the Guiana Shield (Silva et al., 2005), and reinforce the importance of the monitoring and conservation of the habitats for anuran populations in these areas.

MATERIALS AND METHODS

We sampled anurans during fieldwork conducted in the municipalities of Macapá (0° 00'29.9" S, 51° 05'43.1" W), Santana (0° 02'09.2" N, 51° 09'38.8" W) and Serra do Navio (0° 54'50.0" N, 52° 59'59.2" W), all in the State of Amapá, Brazil. Samples were collected between July 2017 to June 2018, with active visual and auditory searches along transects (Crump & Scott Jr., 1994; Heyer et al., 1994) during the night (from 17:00 h to 21:00 h), in temporary lentic water bodies surrounded by arboreal vegetation, wetlands and urban areas. The total search effort amounted to 900 person hours.

Abnormal individuals were examined for malformations which were then identified with reference to a recent publications on the subject (Lannoo, 2009; Peltzer et al., 2011; Henle et al., 2017; Meteyer, 2000), although for terminology and traits we have followed Henle et al. (2017) (see Table 1).

Specimens with anomalies were collected under permit (authorisation #48102-2) from the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), killed with 5 % lidocaine, fixed in 10 % formalin and transferred to 70 % ethanol (Heyer et al., 1994). They have been deposited in the Herpetological Collection of the Universidade Federal do Amapá (CECC).

Table 1. Terminology of anuran anomalies and traits adopted in our study, according to Henle et al. (2017)

Type of anomaly	Traits
Amely	Missing limb
Anophthalmy	Missing eye
Brachydactyly	Presence of short toe, but the metatarsal bones remain present, with the number phalanges reduced
Ectrodactyly	Completely missing digit, including metatar-sal bone
Ectromely	Missing limb segments
Ocular anomaly of the eye	Anomalous pigmentation of iris
Polydactyly	Extra digit, including metatarsal bone
Polymely	Duplication of a complete limb or parts thereof
Syndactyly	Fused digits
Schizodactyly	Forked digits

RESULTS

A total of 255 adult anurans were observed, of which 20 had one or more morphological abnormality. These are listed in Table 2 and illustrated in Figure 1. Between habitat types, 97 individuals were recorded in primary forest, of which 6 (6.2 %) had anomalies; 77 individuals were recorded in urban areas, of which 9 (11.7 %) had anomalies; and, 81 individuals were reported in floodplain areas, of which

Table 2. Anuran species reported in our study with anomalies, Amapá State, Brazil

Species	Type of abnormalities	Localities	Voucher specimens (CECC)
Bufonidae			
Rhinella cf. *margaritifera*	Brachydactyly	0° 54'39.0" N 52° 00'42.1" W	2465
Rhinella cf. *margaritifera*	Brachydactyly + Syndactyly	0° 54'38.7" N 52° 00'41.9" W	1275
Rhinella cf. *margaritifera*	Schizodactyly	0° 54'38.8" N 52° 00'41.1" W	1218
Rhinella marina	Ectrodactyly	0° 54'28.9" N 52° 00'51.0" W	1416
Rhinella marina	Ectromely	0° 54'28.8" N 52° 00'50.9" W	1417
Rhinella marina	Brachydactyly + Polydactyly	0° 54'28.5" N 52° 0 0'51.2" W	1418
Rhinella marina	Polydactyly	0° 54'28.4" N 52° 00'51.1" W	2696
Rhinella marina	Ectrodactyly	0° 54'28.2" N 52° 00'51.2" W	2697
Rhinella marina	Brachydactyly + Ectrodactyly	0° 54'28.0" N 52° 00'51.4"W	2698
Dendrobatidae			
Ranitomeya amazonica	Syndactyly	0° 54'45.9" N 52° 00'32.7" W	2699
Hylidae			
Boana boans	Colour anomaly of the eye	0° 54'36.5" N 52° 00'37.5" W	0836
Lysapsus bolivianus	Ectromely	0° 02'09.0" S 51° 09'33.0" W	0696
Scinax cf. *ruber*	Colour anomaly of the eye	0° 02'06.8" S 51° 09'31.5" W	2390
Sphaenorhynchus lacteus	*Amelia* + Colour anomaly of the eye	0° 02'06.8" S 51° 09'31.5" W	0436
Leptodactylidae			
Adenomera hylaedactyla	Ectromely	0° 53'55.1" N 52° 00'05.4" W	0839
Leptodactylus longirostris	Ectromely	0° 54'29.8" N 52° 00'50.1" W	1516
Leptodactylus mystaceus	Anophthalmy	0° 54'23.8" N 52° 00'26.3" W	0368
Leptodactylus cf. *podicipinus*	Polymely	0° 00'30.8" S 51° 05'43.9" W	2628
Leptodactylus petersii	Brachydactyly	0° 02'08.5" S, 51° 09'31.4" W	2403
Leptodactylus sp.	Amely	0° 02'09.4" S 51° 09'32.5" W	2633

with 5 (6.2 %) had anomalies. The species most frequently showing anomalies was *Rhinella marina* (Bufonidae) (n = 6). We identified 10 types of anomalies and their frequencies were as follows: Brachydactyly (25 %; n = 5); Ectromely (20 %; n = 4); Ectrodactyly (15 %; n = 3); Ocular anomaly (15 %; n = 3); Syndactyly (10 %; n = 2); Amely (10 %; n = 2); Polydactyly (10 %; n = 2); Anophthalmy (5 %; n = 1); Polymely (5 %; n = 1); and Schizodactyly (5 %; n = 1). Individuals of the species *Sphaenorhynchus lacteus*, *Rhinella* cf. *margaritifera*, and *R. marina* presented more than one type of abnormality (Table 2).

DISCUSSION

Globally, most accounts of morphological abnormalities in anurans have been reported in species of Bufonidae (e.g., García-Muñoz et al., 2010; Bionda et al., 2012; Correia et al., 2018) and Ranidae (e.g., Haas et al., 2017). For Brazil, there are also reports mentioning other families but with apparently lower frequencies of anomalies, in particular Leptodactylidae (Sousa & Costa-Campos, 2016; Santos el al., 2017), Hylidae (Sousa & Costa-Campos, 2017; Ramalho et al., 2017; Silva-Soares & Mônico, 2017) and Aromobatidae (Santana et al., 2020).

Figure 1. Examples of morphological abnormalities shown by anuran species in this study - Colour anomaly of the eye: **A.** *Boana boans*, **B.** *Scinax* cf. *ruber* and **C.** *Sphaenorhyncus lacteus*; Anophthalmy: **D.** *Leptodactylus mystaceus*; Polymely: **E.** *Leptodactylus* cf. *podicipinus*; Brachydactyly: **F.** *Rhinella* cf. *margaritifera*; Ectromely: **G.** *Rhinella marina*; Polydactyly: **H.** *Rhinella marina*; Ectromely: **I.** *Adenomera hylaedactyla* and **J.** *Lysapsus bolivianus*; Amely: **K.** *Sphaenorhyncus lacteus*

In the literature, brachydactyly has been cited in several cases (e.g., Bionda et al., 2012; Sousa & Costa-Campos, 2016; Oliveira-Souza et al., 2020), being the most common in semi-aquatic and terrestrial species (Agostini et al., 2013), and in our study was observed in the genera *Leptodactylus* and *Rhinella* (Table 2). In addition, it is of interest to note the anomalies of *Leptodactylus* sp., *L.* cf. *podicipinus* (Fig. 1E) and *Sphaenorhynchus lacteus* (Fig. 1K). Previously, in these cases duplication of a complete limb or parts thereof (polymely), and missing limb (amely) have been cited as malformations caused by the trematode *Ribeiroia* (Kiesecker, 2002; Stopper et al., 2002; Schotthoefer et al., 2003; Johnson et al., 2012). However, there is no evidence of the presence of this parasite in Amapá state.

During this study, the urban areas provided the greatest number of specimens with anomalies although differences between habitat types were small. The urban areas of Amapá state have a historical record of environmental impacts. For example, in the 1990s an environmental accident in the port area of the municipality of Santana caused the pollution of the water table and surface waters with arsenic, barium and manganese in several areas of the region, in which heavy metals from mining tailings were responsible for a biological imbalance (Casara, 2003; Muniz & Oliveira-Filho, 2006); this area is located 3.5 km from the floodplain area and 4 km from the urban area sampled in our study. Also, there are reports of environmental impacts of Serra do Navio mining in and around the Parque Natural Municipal do Cancão (protected conservation unit sampled in our study), resulting in contamination with chemical residues, including arsenic, deforestation and pollution of streams (Drummond, 2000; Queiroz et al., 2008), which might be considered exogenous factors affecting the frog populations (Santana et al., 2020). Future ecotoxicological studies of anuran populations are needed to establish the actual causes of morphological anomalies, especially in areas with a history of environmental impacts.

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