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Short Communication

Limb malformations in *Leptodactylus rhodomystax* (Anura: Leptodactylidae) in the Brazilian Amazon

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Amphibians are among the most threatened vertebrate groups in the world, with 40.7% of species facing some level of extinction risk (Luedtke *et al.* 2023, Toledo *et al.* 2023). The decline in amphibian populations is primarily linked to global climate change, which alters habitats and ecological niches of these species (Luedtke *et al.* 2023). Other factors, such as land use changes, overexploitation, human interference, pollution, and deforestation are interconnected with the loss and degradation of habitats (Stuart *et al.* 2004, Luedtke *et al.* 2023, Toledo *et al.* 2023).

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From this perspective, amphibians, which inhabit both aquatic and terrestrial ecosystems throughout their life cycle, are vulnerable to a wide range of biotic and abiotic factors, including water pollution, exposure to toxic chemicals, ultraviolet radiation, parasitic infections, and genetic alterations (Alford and Richards 1999, Ankley *et al.* 2002, Prati *et al.* 2002, Johnson *et al.* 2012, Bessa-Silva *et al.* 2016). Consequently, these factors can lead to morphological anomalies that affect the structure and development of these vertebrates (Henle *et al.* 2017, Souza *et al.* 2021). Such anomalies can range from limb and eye malformations, organ duplications, and other morphological variations (Henle *et al.* 2017, Ajibola and Omoshehin 2024).

Studies on morphological anomalies in anuran amphibians within the Amazon Rainforest are relatively recent and have documented malformations across various families, including Brachycephalidae, Bufonidae, Hylidae, Hylodidae, Leptodactylidae, Microhylidae, and Odontophrynidae (Pedroso-Santos *et al.* 2020, Souza *et al.* 2021, Mônico *et al.* 2023). In this study, we report four types of morphological limb malformations in individuals of *Leptodactylus rhodomystax* Boulenger, 1884 from the Brazilian Amazon.

During taxonomic work with specimens of *L. rhodomystax* deposited in the herpetological collection of the Museu Paraense Emílio Goeldi, we identified three individuals exhibiting morphological limb malformations. We captured images of these specimens and described the malformations using the terminology adopted by Meteyer (2000) and Henle *et al.* (2017).

The first specimen (MPEG25877 ♂; SVL: 61.89 mm; Figure 1A–B), collected in March 2008 at UHE Belo Monte, Vitória do Xingú municipality, Pará state (03°07'01.14" S, 51°47'35.51" W; WGS 84), exhibited tibial-fibular ectromelia in the right hind limb (Figure 1A–B). This condition was characterized by an incomplete limb with the absence of the lower part of the leg. Due to the lack of radiographs, we could not confirm whether the metatarsal and phalangeal bones were fused in the terminal part of the affected limb.

The second specimen (MPEG36537 ♂; SVL: 66.65 mm; Figure 1C–D), collected in May 2012 at Feijó municipality, Acre state (08°08'35.82" S, 70°20'36.43" W; WGS 84), exhibited a combination of ectrodactyly, brachydactyly, and syndactyly. These conditions were characterized by the absence of the fourth digit, shortening of the third digit, and fusion of the second and third digits of the left forelimb, respectively.

The third specimen (MPEG29190 ♂; SVL: 71.82 mm; Figure 1E), collected in February 2006 at Parque Ecológico do Gunma, Santa Bárbara do Pará municipality, Pará state (01°13'02.24" S, 48°17'40.07" W; WGS 84), exhibited ectrodactyly, characterized by the complete absence of the second digit of the left forelimb (Figure 1E).

Limb malformations are among the most frequently reported anomalies in anurans (Correia *et al.* 2018, Ascoli-Morrete *et al.* 2019, Souza *et al.* 2021, Gobel *et al.* 2022, Baroni *et al.* 2024). Although the etiology of these malformations remains unclear, studies suggest that the affected regions may be directly associated with specific teratogenic factors (Gardiner and Hoppe 1999, Lannoo 2009). Some authors propose potential connections between trematode infections, UV-B radiation, and exposure to agricultural chemical contaminants with the occurrence of limb abnormalities (Gardiner and Hoppe 1999, Spolyarich *et al.* 2011, Johnson *et al.* 2012). Furthermore, species with terrestrial and semiaquatic habits, such as those in the genus *Leptodactylus,* may exhibit a higher prevalence of malformations affecting locomotor limbs compared to arboreal species (Peltzer *et al.* 2011, Agostini *et al.* 2013, Gobel *et al.* 2022). These authors suggest that such results may be linked to varying survival rates of abnormal individuals in different microhabitats. The malformations found in terrestrial species may not significantly impact survival rates (Baroni *et al.* 2024); in fact, all individuals analyzed in this study are adults. Nevertheless, these malformations may negatively influence the reproductive success of these animals, emphasizing the need for further studies on this topic (Baroni *et al.* 2024). The impact of these anomalies may differ in arboreal species, given their greater reliance on specific motor skills for locomotion and survival in these habitats (Goodman and Johnson 2011, Agostini *et al.* 2013).

Records of morphological anomalies in Brazilian anurans are frequently reported for the family Hylidae, followed by the family Leptodactylidae (Souza *et al.* 2021). For the genus *Leptodactylus,* anomalies have been described in various species, including *L. fuscus* (Schneider, 1799) (Borges *et al.* 2019), *L. latinasus* Jiménez de la Espada, 1875 (Gobel *et al.* 2022), *L. latrans* (Steffen, 1815) (Carezzano *et al.* 2016), *L. longirostris* Boulenger, 1882

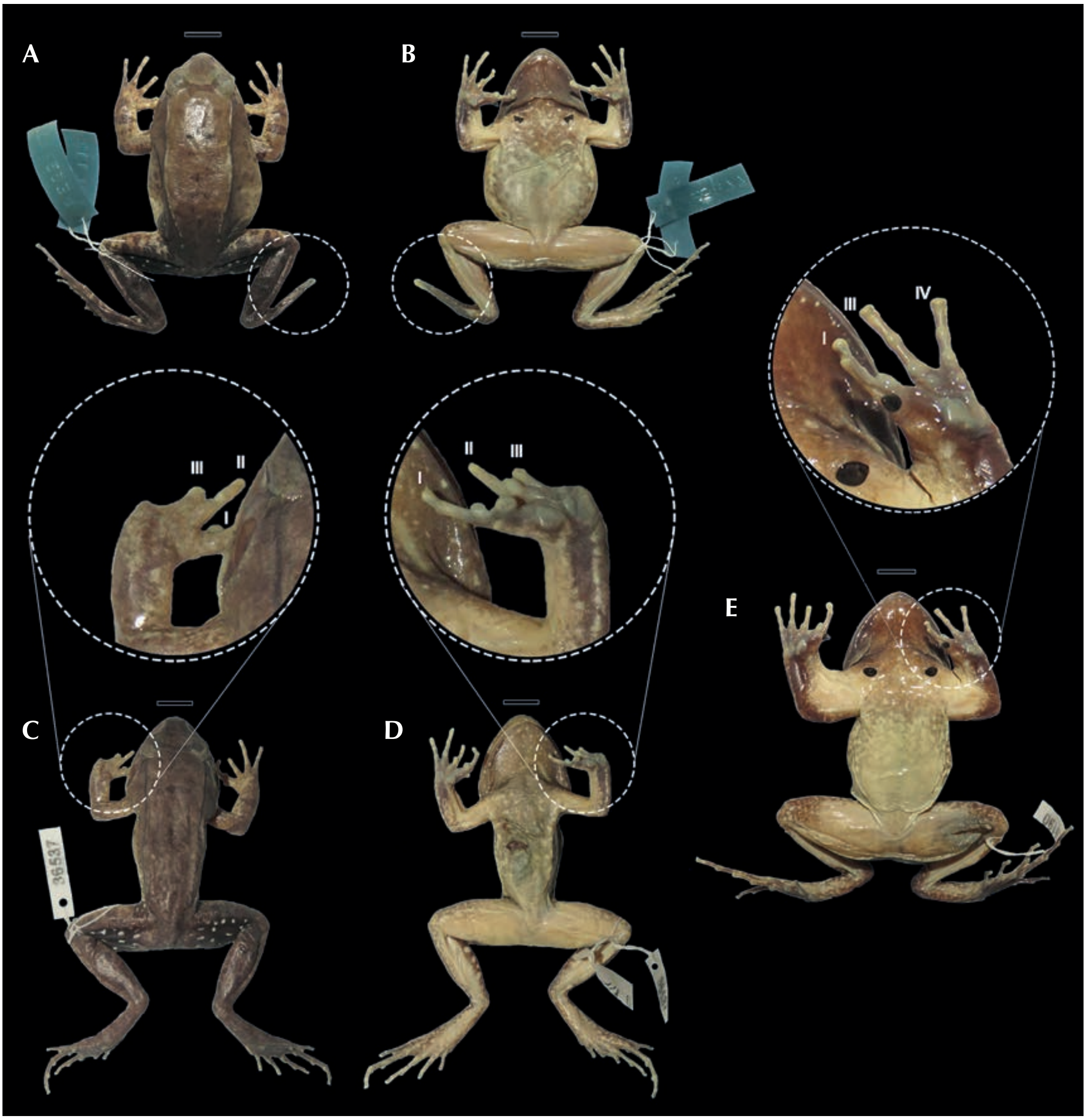

Figure 1. Limb malformations in *Leptodactylus rhodomystax* from the Brazilian Amazon. Specimen MPEG25877 showing tibial-fibular ectromelia in the right hind limb, with dorsal (**A**) and ventral (**B**) views. Specimen MPEG36537 exhibiting ectrodactyly, brachydactyly, and syndactyly in the left forelimb, with dorsal (**C**) and ventral (**D**) views. (**E**) Specimen MPEG29190 displays ectrodactyly of the second digit of the left forelimb. Scale bar = 10 mm.

(Pedroso-Santos *et al.* 2020), *L. luctator* (Hudson, 1892) (Gobel *et al.* 2022), *L. mystaceus* (Spix, 1824) (Pedroso-Santos *et al.* 2020), *L. mystacinus* (Burmeister, 1861) (Ascoli-Morrete *et al.* 2019), *L. petersii* (Steindachner, 1864) (Pedroso-Santos *et al.* 2020), *L. podicipinus* (Cope, 1862) (Pedroso-Santos *et al.* 2020), *L. troglodytes* Lutz, 1926 (Santos and Silva 2010), and *L. vastus* Lutz, 1930 (Braga *et al.* 2013). Among the main types of morphological malformations are those associated with locomotor limbs, such as brachydactyly, ectrodactyly, and ectromelia (Souza *et al.* 2021, Gobel *et al.* 2022), which are consistent with our findings for *L. rhodomystax.* It is important to mention that the high prevalence of limb malformations may be related to the limitations of methods that analyze only external morphology. The application of complementary techniques, such as radiography, becomes crucial for a more comprehensive understanding of the anomalies present in the internal morphology of these organisms (Peltzer *et al.* 2011, Baroni *et al.* 2024).

Although the causes of the malformations in the examined specimens were not identified, these reports represent the first record of morphological malformations in *L. rhodomystax.* They provide new insights into the occurrence of such anomalies among Amazonian amphibians and contribute to a better understanding of potential geographic and taxonomic patterns of this phenomenon.

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