

Defensive behaviors of *Leptodactylus rhodomystax* (Anura: Leptodactylidae) from northern Brazil

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ABSTRACT

The study of defensive behaviors in anurans can lead to new hypotheses for a better understanding of prey-predator interactions. Herein, based on field observations, we described for the first time defensive behaviors of *Leptodactylus rhodomystax*. The studied individual displayed stretching limbs posture and evidenced hidden aposematism. Hidden aposematism was occasionally described to occur with stretching limbs posture. Our observations suggest that synergistic defense mechanisms in anurans may be more common than currently known.

Key Words: Amphibians; Defense; Predators; Leaf-litter.

Anurans are a common prey for several vertebrate and invertebrate taxa (Duellman and Trueb 1994; Rubbo *et al.*, 2003). Predator-prey interactions have been important in the evolution of many anti-predator mechanisms in these animals, such as toxic and distasteful skin secretions, cryptic and aposematic colouration, and a variety of postures (Dreher *et al.*, 2015; Rebouças *et al.*, 2019; Ferreira *et al.*, 2019). These anti-predator mechanisms act in different life history stages and phases of predation, avoiding or interrupting a predation attempt. On the other hand, predators may evolve strategies to overcome some anuran defences (Brodie and Brodie 1999; Greenbaum, 2004).

Recently, the anti-predatory mechanisms of anurans were arranged in a classification system (Ferreira *et al.*, 2019), showing geographic, taxonomic, and evolutionary patterns. Some of these behaviors have been recognized in previous studies as being effective in reducing predator attacks (Johnson and Brodie 1975; Dreher *et al.*, 2015; Gally *et al.*, 2014). Among them, death feigning and escape behaviors are the most commonly reported (Toledo *et al.*, 2010;

2011). However, there are some defensive postures in anurans that are still poorly understood in terms of their influence on predator-prey interactions. One of these is the stretching limbs posture, which is characterized by full or partial extension of the fore or hind limbs (Ferreira *et al.*, 2019). Several authors have suggested that this behavior is displayed only by forest-floor species in order to mimic fallen leaves, and thus confuse visual predators (Sazima, 1978; Bertoluci *et al.*, 2007; Toledo *et al.*, 2011; Mângia and Santana 2013; Mira-Mendes *et al.*, 2016; Ferreira *et al.*, 2019). With the aim to increase the knowledge of anuran defensive mechanisms, we report here the occurrence of stretching limbs posture with hidden aposematism in *Leptodactylus rhodomystax* Boulenger, 1884.

The Leptodactylidae is one of the most widely distributed anuran families in the Americas, comprising species of large, medium, and small-sized frogs that occupy a wide range of environments, including lowland dense rainforests and open habitats (de Sá *et al.*, 2014; Barrio-Amorós *et al.*, 2019). *Leptodactylus rhodomystax* is a nocturnal terrestrial

frog of moderate size (SVL 58.5–91.4 mm in adult females and 59.0–89.6 mm in adult males), and a member of the *L. pentadactylus* group; it dwells in Amazonian Bolivia, Brazil, Colombia, Ecuador, French Guiana, Peru, and Suriname (de Sá *et al.*, 2014; Barrio-Amorós *et al.*, 2019).

On 8 July 2019, during faunal inventories and monitoring at Reserva de Desenvolvimento Sustentável do Rio Iratapuru (0.5627°S, 52.5775°W; datum: WGS84; 66 m a.s.l), located in the municipality of Laranjal do Jari, state of Amapá, Brazil, one of us (VAMBF) observed a male of *L. rhodomystax* on the leaf-litter, at about 19:30 h, accommodated it in a plastic bag, and transported it to the nearby laboratory to obtain measurements and photographs. The specimen could be confidently identified by its morphological traits, as described by de Sá *et al.* (2014). During the photographic session, we observed that the individual (male, SVL = 62.5 mm) displayed extension of the hindlimbs when touched, while exposing a contrasting conspicuously colored area of the thighs and post-femoral regions (Fig. 1). It maintained this posture for about 5 min. After these observations, the individual was released at the original place of encounter. According to Ferreira *et al.* (2019), the behavior displayed by the individual in our study could be classified as stretching limbs posture with hidden aposematism. These authors

indicate that the stretching limbs posture was recorded in 39 species belonging to seven different families. However, this is likely an underestimation. Our record corresponds to the second occurrence of this behavior in the genus *Leptodactylus*, and the first formal description of a defensive behavior in *L. rhodomystax*. We think that in *L. rhodomystax*, the stretching limbs posture may mimic fallen leaves or a dead frog, in addition to the synergism by hidden aposematism. This species inhabits both leaf-litter areas (e.g., in forest floor and swamps within tropical rainforest), but also non-forested habitats (de Sá *et al.*, 2014), in which mimicking a dead frog with scarce leaf-litter around would be alternatively advantageous. Hind limbs of dead frogs may become stiff for a time under rigor mortis similarly to the stretching limb posture (Borteiro *et al.*, 2018). Therefore, both defensive mechanisms would act as warning signals (Ferreira *et al.*, 2019). Hidden aposematism is common in some leptodactylids and phyllomedusids, and its exhibition is commonly related to the postures of rear elevation, unken reflex, death feigning, and escape behavior; usually, the hidden aposematism occurs at the axila, underside of the body, tongue, thighs, or post-femoral region (Ferreira *et al.*, 2019).

As pointed by Sazima (1978), stretching limbs posture may have convergently evolved among unrelated leaf-litter anuran groups. However, this defensive posture can also occur in forest-dwelling and arboreal species, which are distributed in open and flooded areas with scarce leaf-litter (e.g., Mângia and Santana 2013, Rocha and López-Baucells, 2014; Figueiredo-de-Andrade and Silveira 2018; Ferrante *et al.*, 2020). In addition, this behavior has also been described in open grasslands (referred to as “death feigning”, Kolenc *et al.*, 2009). As suggested by Mângia and Santana (2013), phylogenetic mapping of this behavior would help to understand its appearance in Neobatrachia during recent anuran diversification. In this sense we encourage field researchers to further record defensive behaviors in still poorly known anurans.

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Figure 1. (A) Usual posture of *Leptodactylus rhodomystax*. (B) Postero-lateral and (C) posterior view of stretching limbs posture evidencing hidden aposematism.

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