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Defensive behaviour in *Aplastodiscus leucopygius* (Cruz and Peixoto, 1985) (Anura: Hylidae)

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Abstract. Defensive behaviour in amphibians is diverse, exhibiting a variety of postures and strategies to avoid a predation event. Over the course of fieldwork conducted in southern Minas Gerais, Brazil, we recorded defensive behaviours for *Aplastodiscus leucopygius*, a forest-associated species. Herein we report on these behaviours and discuss them in relation to defensive behaviours recorded for other closely related species in the genus *Aplastodiscus*. We report on three general defensive behaviours for *A. leucopygius* for the first time and two new behaviours for the genus *Aplastodiscus*.

Keywords. Anurans, amphibians, Brazil, behaviour, Atlantic Forest

Defensive behaviours comprise an important mechanism through which amphibians can protect themselves against predators. Among amphibians there is a diverse spectrum of defensive behaviours (Wells, 2007), where a species can adopt one or more such behaviours over the course of a given threat event (Angulo et al., 2007, Toledo et al., 2010). Defensive behaviours have been reported for the genus *Aplastodiscus* (Toledo et al. 2010), although we have not found any such behaviours reported for the species *Aplastodiscus leucopygius* (Cruz & Peixoto, 1985 "1984"). This species is restricted to the Atlantic Forest domain, being distributed in the states of Paraná, eastern São Paulo, Rio de Janeiro, and southern and eastern Minas Gerais, Brazil (Rocha et al., 2010). Herein we report on different forms of visual defensive behaviour exhibited by *A. leucopygius* over the course of fieldwork. We conducted observations in three different municipalities in the state of Minas Gerais, Brazil: Lambari (observations conducted by M. Sacramento in February 2008 at Parque Estadual Nova Baden [PENB]), Alfenas and Areado (observations conducted by L. Ferrante from January to February 2012 at five forest fragments of semideciduous Atlantic Forest) (Table 1).

The study sites were forest fragments of varying sizes characterized by the presence of water bodies that have their source of origin within these fragments; males were found calling in choruses around these water bodies, in vegetation varying from 1.5-5 m from the ground. We conducted all observations at night between 19:30 and 00:30 hours, totalling up to 15 days of sampling, with air temperatures varying between 18.6°C and 27.4°C and relative humidity of the air varying from 66% to 89%. All observed individuals were calling males.

We carried out visual observations of defensive behaviour from the moment we detected an individual (through Visual Encounter Surveys; Crump and Scott, 1994), over the course of manual capture, and then shortly after its release. We noted individual reactions after release (escaping [Flight] or remaining at the site

Table 1. Sampling localities for *Aplastodiscus leucopygius* detailing geographical coordinates, elevation and number of individuals observed. Legend: PENB (Parque Estadual Nova Baden, municipality of Lambari); F1, F2, F3, F4 and F5 (Forest fragments, municipalities of Alfenas and Areado, split by locality).

Localities	*Latitude*	*Longitude*	*Elevation (m asl)*	*Individuals (n)*
PENB	21°56'35"S	45°19'02''W	900	01
F1 – Alfenas	21°33'5.24"S	45°57'12.20"W	830	06
F2 – Alfenas	21°28'36.38"S	45°55'33.58"W	850	12
F3 – Alfenas	21°23'55.31"S	46°14'0.80"W	860	08
F4 – Areado	21°33'41.37"S	45°56'12.98"W	882	03
F5 – Areado	21°24'41.64"S	45°19'1.19"W	860	01

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of release [No flight]). We observed a total of 31 adult males.

We recorded all potential predators observed in the field. We found a juvenile *Bothropoides jararaca* (Wied, 1824) with a body length of about 15 cm, a snake which often includes treefrogs in its diet (Sazima, 1991), and the spider *Phoneutria nigriventer* (Keyserling, 1891), which has been reported to consume anurans (Menin, 2005; Toledo, 2005).

Our observations suggest three possible behaviours displayed during handling which we consider defensive in nature given the context in which they were produced. We term and describe these behaviours based on the apparent physical changes experienced (or not) by the individuals: 1) "Lung inflation" (comparable to "Inflation of the body" *sensu* Wells (2007) and "Puffing up the body" *sensu* Toledo et al. (2011)); 2) "Contraction" (an "immobility response" as per Wells (2007) and inclusive of the terms "Crouching" and "Shrinking" used in Toledo et al. (2011)), and 3) "No apparent reaction". As the substrate appears to play an important role in the extent of body contraction and inflation (Fig. 1e), and in view of the difficulty associated with determining the exact level of contraction of the body (because of the wide breadth of behaviours that rely on varying degrees of contraction), we have opted to use the term "Contraction" to refer to a general contraction of the body (see e.g. Fig. 1f), irrespective of the substrate where the individual is found, as we consider the behaviour to involve the same basic physical response.

There were two instances where we observed concurrent defensive behaviours in the same "predation" event. In Parque Estadual Nova Baden, we found one male (SVL=36.84 mm) calling on a bush leaf at ca 1.5 m above muddy ground and adjacent to a small stream at 19:30 hours. Upon capture, this individual adopted an immobile posture, bending the body slightly, keeping its eyes closed and its limbs close to the body (Fig. 1a). As we handled it, however, it inflated its lungs, and maintained this posture even after we moved it for photographic record (Fig. 1b). This male maintained this position for about 25 seconds, returning gradually to its initial state (Fig. 1c), until it could rearrange its posture so that it could jump away (Fig. 1d). Similarly, a second male presented both "Lung inflation" and "Contraction" simultaneously on a leaf in the same "predation" event in Alfenas on 18 January 2012 (Fig. 1f).

On one occasion we observed an attempted predation event by the spider *Phoneutria nigriventer* (Keyserling, 1891) in the municipality of Alfenas. Over the course of this event we observed a male *A. leucopygius* adopting a defensive behaviour without human interference. As the spider began to approach the male, which was facing away from the spider, the male began to inflate its lungs, giving the impression of an increased body size, which appeared to cause the spider to stop, allowing the male to jump to a different tree branch and away from the spider.

For individuals observed in the Alfenas and Areado forest fragments we found that "Lung inflation" was the most common behaviour (38.71%), followed closely by "No apparent reaction" (32.26%), "Contraction" (22.58%) and lastly by "Concurrent behaviours" (6.45%). Of the post-release behaviours, "No flight" (67.74%) was more frequent than "Flight" (32.26%). The frequencies of defensive behaviours observed are summarised in Figure 2.

"Lung inflation", consisting of filling the lung cavities with air and resulting in an apparent increase in body size, is a common defensive response among anurans and has also been reported for a closely related species, *Aplastodiscus arildae* (as "Puffing up the body", see Appendix 1 in Toledo et al. (2011)), which also displays an immobile posture behaviour that has been termed "Shrinking" by Toledo et al. (2010).

Among the 15 recognized species of *Aplastodiscus* (Frost, 2014), six (40%) have had reports of defensive behaviour. All of these six species present at least two different forms of defensive behaviours ("Body raising" and "Body tilting", see Appendix 1 of Toledo et al. (2011)). We present the first record and spectrum of defensive behaviours for *Aplastodiscus leucopygius* and also report on two other general behavioural displays for the genus ("Lung inflation" and "Contraction"). It is not yet known to what extent these defensive behaviours may contain phylogenetic signal.

As Wells (2007) points out, the primary literature on amphibian defensive behaviour is largely descriptive; a result, perhaps, of the mostly opportunistic nature of these observations in the field. However, a departure from this approach was presented by Marchisin and Anderson (1978), who conducted experiments involving forced encounters between anuran species and sympatric snakes. These authors reported both "Contraction" ("crouch" sensu the authors) and "Lung inflation" ("body inflation" sensu the authors) behaviours occurring synergistically in ten of the 14 anuran species tested.

Our observations support the hypothesis that anuran defensive behaviours are variable and can change within a given "predation" event (as also reported

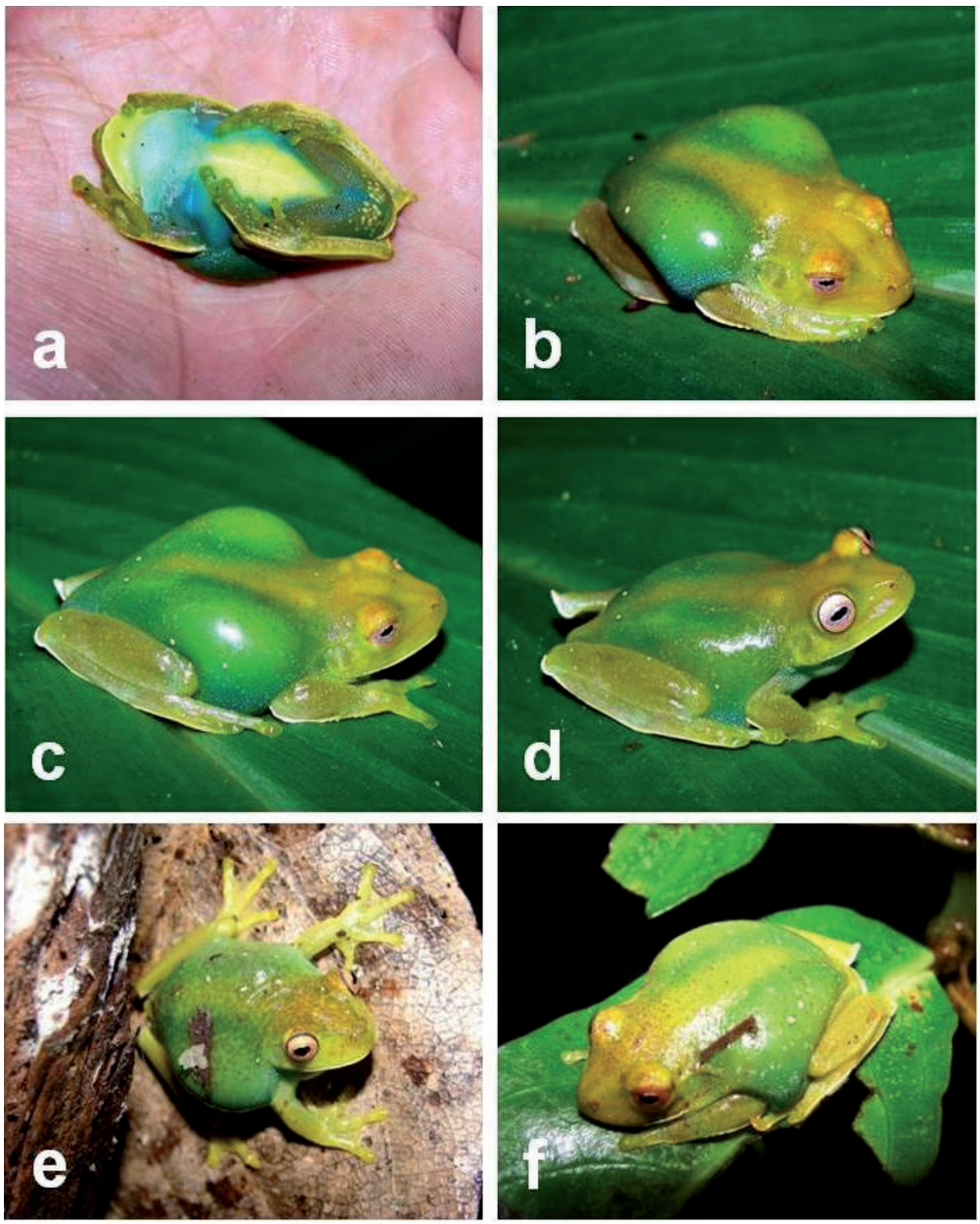

Figure 1. Potential defensive behaviours displayed by *A. leucopygius* in PENB (a: Ventral view of "Contraction" display; b: "Lung inflation" and "Contraction"; c: "Lung inflation"; d: Ready to take flight) and in the other five localities (e: "Lung inflation"; and f: "Lung inflation" and "Contraction"). Photos: a-d (M. Sacramento); e-f (L. Ferrante).

by Menin & Rodrigues, 2007), and can also occur synergistically as reported by Toledo et al. (2011), including the behaviours of "Contraction" (inclusive of Toledo et al.'s (2011) "Crouching") and "Lung inflation", which are here reported to occur within the same event. This suggests that such behaviours could be different components of more complex behaviours (e.g. see Lang et al., 1977), or that they could exhibit a degree of plasticity. Both possibilities have so far been largely unexplored in defensive behaviour research.

Systematic experimental approaches to defensive strategies could potentially shed some light on the

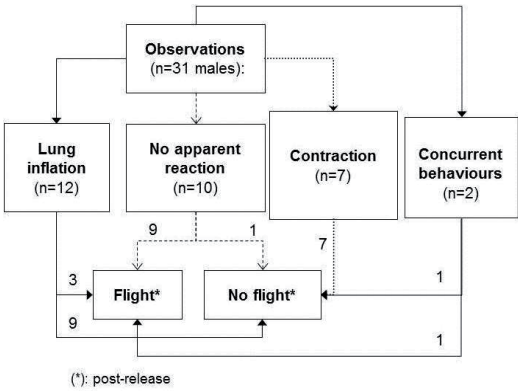

Figure 2. Ethogram of potential visual defensive behaviours displayed by *A. leucopygius* individuals during handling. (*) indicates reactions after release.

effectiveness of some behaviours over others, on the potential presence and effectiveness of plasticity, or the composition of suites of defensive behaviour in predation events, and determine whether there are associations between these and the frequencies of behaviours observed in the field. The ability to change behaviours in response to specific conditions (e.g. predator type, predator response) could potentially result in improved fitness for the individual(s) that exhibit these behavioural suites.

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