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The tadpole of *Adelphobates galactonotus* (Steindachner, 1864) (Amphibia, Anura, Dendrobatidae)

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The systematics of the dart-poison frogs, family Dendrobatidae, experienced several taxonomic rearrangements over time (e.g., Grant *et al*. 2006, 2017; Brown *et al*. 2011). Currently, this family comprises 194 described species organized in three sub-families and 15 genera (Frost 2018). Among them, the genus *Adelphobates* Grant, Frost, Caldwell, Gagliardo, Haddad, Kok, Means, Noonan, Schargel, & Wheeler, 2006, comprises three species, all distributed in Central and lower Amazon drainage of Peru and Brazil, and possibly in northeast of Bolivia (Grant *et al*. 2006; Frost 2018). *Adelphobates galactonotus* (Steindachner 1864) is an endemic Brazilian frog, and can be found throughout Pará, Maranhão, Mato Grosso and Tocantins states (Hoogmoed & Avila-Pires 2012), related to Amazon forest formations and also in transitional areas between the Cerrado and the Amazon forest (Valdujo *et al*. 2012). Despite this species is classified as Least Concern (Rodrigues *et al.* 2010), several threats are known. First, its geographic distribution coincides with the so-called Amazonian Deforestation Arc, which comprehends the southeastern portion of the Amazonian Forest that has been rapidly converted into pasture and crop areas or being flooded due to the construction of hydroelectric power plants (Hoogmoed & Avila-Pires 2012). Also, this species is present in Appendix II of CITES as a target for illegal trade, and their commercial exploitation should be controlled to avoid that this species become seriously endangered in the near future (see a case study in Paula *et al*. 2012). These threats are of deeper concern because despite *A. galactonotus* has been described since more than 150 years (Steindachner 1864), its tadpole remains unknown. Without a better understanding of the natural history of *A. galactonotus*, attempts of conservation strategies and population management are inefficient. In an effort to fill the knowledge gaps about this species natural history, we present a detailed description of the external morphology of the *A. galactonotus* tadpole.

Tadpoles of *A. galactonotus* were collected in an ombrophilous Forest fragment, in a highly fragmented landscape (i.e. pastures, highways and urban zone), during February 2015 at Araguaína municipality (48°12'32'' O, 07°13'04'' S), Tocantins State, Brazil. Tadpoles were unintentionally captured in pitfall traps with drift-fences, positioned to survey anuran movements. After heavy rains, the traps were filled with water and the adults of *A. galactonotus* used it as a developmental site for tadpoles. The tadpoles collected were anesthetized and killed in water containing dissolved lidocaine and preserved in a 10% formalin solution. To allow specific identification, we have also raised some tadpoles in laboratory until the metamorphosis.

We describe external morphology based on five tadpoles between Gosner (1960) stages 31–37 housed in the tadpole collection of the Zoological Collection of Federal University of Goiás, Goiânia, Goiás State, Brazil (ZUFG 2508). The following measures were taken: total length (TL), tail length (TAL), body length (BL), body height (BH), body width (BW), eye diameter (ED), nostril diameter (ND), interorbital distance (IOD), internarial distance (IND), nostril-eye distance (NED), eye-snout distance (ESD), dorsal fin height (DFH), ventral fin height (VFH), tail muscle height (TMH), spiracle length (SL), spiracle width (SW), vent tube length (VTL) and vent tube width (VTW). The measurements in millimeters were obtained using a stereomicroscope (Leica M80) with a millimetric ocular, with exception of the body length, body width, total length and tail length which were obtained with a digital caliper to the nearest 0.1 mm. The morphological terminology and measurements follows Altig & McDiarmid (1999).

External morphology. Body depressed, rounded in dorsal view and globular in lateral view. Snout rounded in dorsal and lateral views (Fig. 1A, B). Eyes small (ED/BH = 0.09–0.11mm), dorsally positioned, and directed

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anterolaterally. Nares small (ND/BH = 0.01–0.03mm), oval, dorsally positioned, and directed anterolaterally (Fig. 1D). Spiracle lateroventral, deeper than longer, directed posterodorsally, opening at the end of the middle third of the body; inner wall fused to the body, with distal portion free and longer than the external wall. Vent tube medial, with medial opening, fused to the ventral fin; type S gut (*sensu* Sanchez 2013). Caudal musculature robust, higher than the fins, not reaching tail tip. Dorsal and ventral fins are low, parallel to the longitudinal axis of the tail muscle, with dorsal fin originating at the body-tail junction.

Oral disc anteroventral, laterally emarginate; row of elongated marginal papillae uniseriate ventrally and alternated laterally, with wide dorsal gap (Fig. 1E); papillae are absent at the emarginations. Submarginal papillae absent. Tooth row formula 2(2)/3(1), with A-1 and A-2 of the same width, and P-3 slightly shorter than P-1 and P-2. Jaw sheaths wide, darkly colored, with conical serration. Upper and lower jaw sheaths with similar width. Upper sheath ''U'' shaped with lateral processes short and without serrations; lower sheath ''V'' shaped. Lateral lines not visible.

Coloration. In live, the body is blackish, the tail musculature and fins are slightly lighter than the body and pigmented. In preservative, the color fainted, and gray becomes clear with the presence of small dark spots scattered throughout the body. The caudal musculature becomes brownish gray. It is possible to observe the appearance of golden yellow spots on the dorsal region at Stage 43.

Measurements [in mm, expressed as mean ± SD (range)]. TL: 38.17±2.70 (34.11– 41.74); BL: 14.57±0.67 (13.47–15.19); TAL: 23.88±1.71 (21.18–25.90); BW: 8.50±1.16 (6.60–9.70); BH: 3.65±0.52 (3.18–4.50); ED: 0.40±0.03 (0.37–0.43); ND: 0.10±0.02 (0.06–0.12); IOD: 2.57±0.20 (2.25–2.75); IND: 1.17±0.27 (0.68–1.37); NED: 0.82±0.06 (0.75–0.93); ESD: 1.89±0.26 (1.56–2.25); DFH: 0.82±0.12 (0.62–0.93); VFH: 0.72±0.03 (0.68–0.75); TMH: 1.82±0.19 (1.56–2.00); SL: 0.39±0.08 (0.31–0.50); SW: 0.53±0.12 (0.37–0.68); VTL: 0.63±0.12 (0.43–0.75); VTW: 0.85±0.12 (0.68–1.00).

Comparison with other tadpoles of the genus. Caldwell & Myers (1990) described the tadpoles of *A. castaneoticus* and *A. quinquevittatus*, which they considered to be morphologically similar. The figures provided in the article (Fig. 5A,B) allowed us to differentiate *A. galactonotus* from these by the snout shape in lateral view (rounded in *A. galactonotus*, truncated in *A. castaneoticus*, and sloped in *A. quinquevittatus*). *Adelphobates galactonotus* can be distinguished from *A. castaneoticus* also by the lateral emargination of the oral disc. While the disc is weakly emarginated in *A. castaneoticus*, in *A. galactonotus* the emargination of the oral disc is always perceived, even when the oral disc is fully opened. Furthermore, marginal papillae are absent in emarginations of *A. galactonotus*, but present in those of the other species (as seen in illustrations).Whether this is a diagnostic or an intraspecifically variable feature should be revisited with larger sampling. Finally, *A. galactonotus* tadpoles are larger than those of *A. castaneoticus* (TL = 29.56 at Stage 39).

Larval morphology represents a valuable source of evidence to test phylogenetic hypothesis and to understand anuran evolution (e.g., Haas 2003; Frost *et al*. 2006). Regarding dendrobatoids, it played an important role in the evolution of different lineages (e.g., Silverstone 1975; Myers & Daly 1980); for instance, Grant *et al*. (2006) recognized several larval synapomorphies for the genus *Silverstoneia*. Recently Grant *et al*. (2017) revisited the phylogenetic systematics of the Dendrobatoidea and their relatives. They employed different phenotypic characters, including several characters from larval morphology, plus DNA sequences in a total evidence analysis. They recovered several larval synapomorphies for different clades, including *Adelphobates.* The long, S-type gut occurs in all three species of the genus, and represents a reversion from the basal state in the clade joining all Dendrobatini but *Minyobates*. It is noteworthy that this character-state is unknown to several taxa and it was observed in other Dendrobatini as well (e.g., *Dendrobates truncatus*). On the other hand, Grant *et al*. (2017) recovered as synapomorphies for Dendrobatini the U-shaped upper jaw and the absence of projections on the nostril margin. While the first feature is shared by all three *Adelphobates* species, only *A. galactonotus* and *A. castaneoticus* lack nostril ornamentation (Caldwell & Myers 1990; Sánchez 2013; this work).

As Sánchez (2013) pointed, few tadpoles have been described based on free-living larvae and there is evidence in the literature suggesting that back-riding tadpoles and free-living tadpoles may present different morphology and character-states (see Castillo-Trenn 2004; Anganoy-Criollo 2013). The lack of data for tadpoles in the free-living semaphoront (sensu Hennig 1966) may represent a major constraint in the usage of larval morphology in the systematics of dart-poison frogs (Sánchez 2013). We suggest that future studies include ontogenetic variation and focus on free-living larvae.

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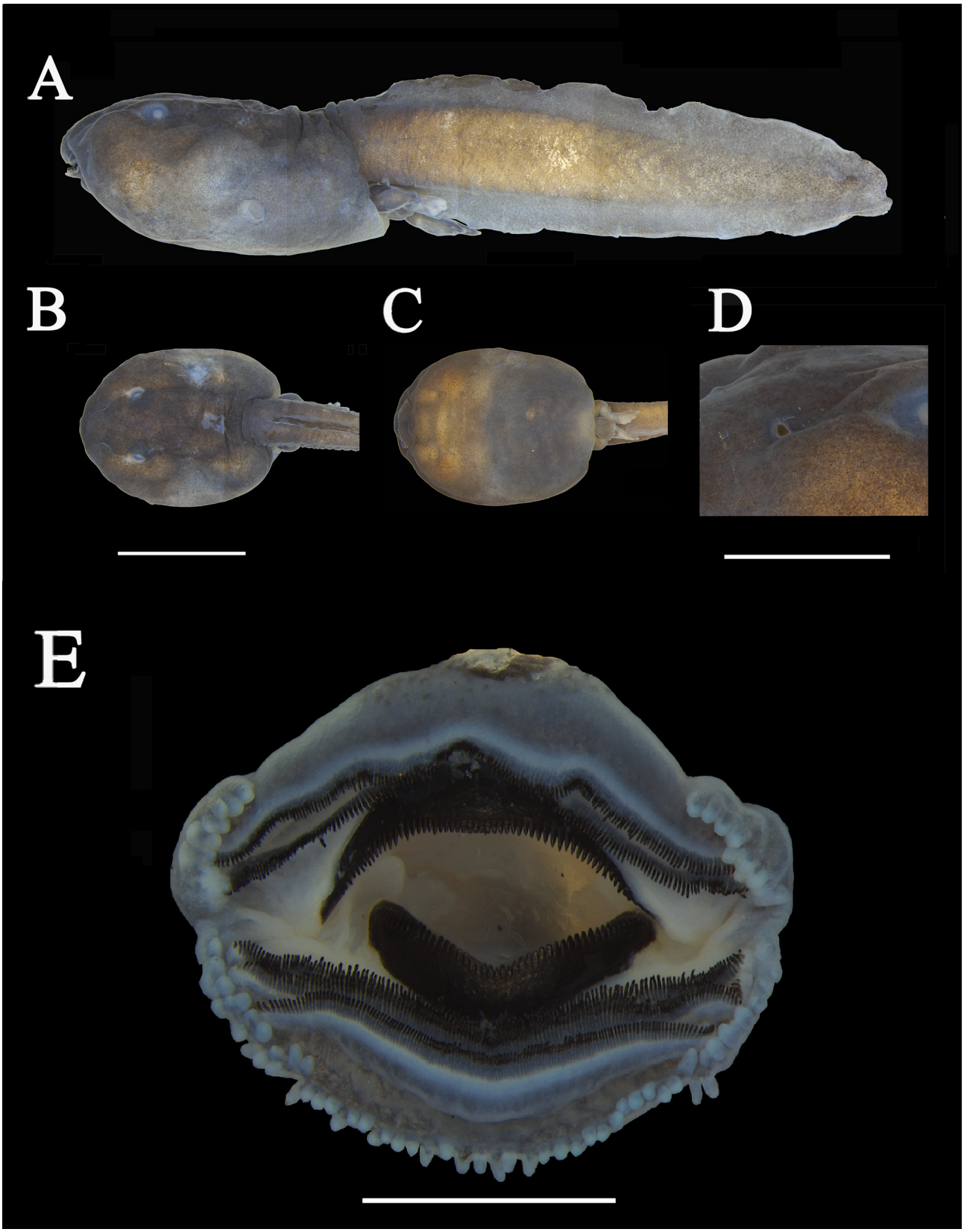

FIGURE 1. Tadpole of *Adelphobates galactonotus* at Stage 37 (Gosner 1960): (A) lateral, (B) dorsal, and (C) ventral views (scale 10 mm), (D) left nostril in lateral view (scale 2 mm), (E) oral disc (scale 2 mm).

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