Journal of Herpetology, Vol. 44, No. 3, pp. 480–483, 2010
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Tadpole of *Rhinella jimi* (Anura: Bufonidae) with Comments on the Tadpoles of Species of the *Rhinella marina* Group

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ABSTRACT.—Here we describe the tadpoles of *Rhinella jimi*. *Rhinella jimi* tadpoles are benthic and exotrophic and display aggregative behavior. These tadpoles can be distinguished from other members of the *Rhinella marina* group by the combination of the following characters: spiracle with external tube opening on midbody; snout sloped in lateral view; eyes and nostrils proportionally larger than in *Rhinella schneideri*. Finally, we reviewed the information available on the other described tadpoles of the *R. marina* species group and compare them with the tadpole of *R. jimi*.

The genus *Rhinella* Fitzinger is currently composed of 77 species distributed in North, Central, and South America (Frost, 2009). The *Rhinella marina* species group (sensu Martin, 1972) is composed of 10 species: *Rhinella achavali*, *Rhinella arenarum*, *Rhinella cerradensis*, *Rhinella icterica*, *Rhinella jimi*, *Rhinella marina*, *Rhinella poeppigii*, *Rhinella rubescens*, *Rhinella schneideri*, and *Rhinella veredas* (Maciel et al., 2007). All species of this group occur in Brazil, except *R. poeppigii*, which occurs on the Andes slopes of Ecuador, Peru, and Bolivia (Frost, 2009). *Rhinella jimi*, distributed in northeastern Brazil, is closely related to *R. schneideri* from which it is distinguished by the combination of the following characters: presence of forearm gland; an external gland on feet; and gland conglomerates on both sides of the cloaca (Stevaux, 2002).

The tadpoles of *R. arenanum*, *R. cerradensis*, *R. icterica*, *R. marina*, *R. rubescens*, and *R. schneideri* have already been described (Kenny, 1969; Cei, 1980; Ford and Scott, 1996; Eterovick and Sazima, 1999; Rossa-Feres and Nomura, 2005; Maciel et al., 2007). No information is available about the tadpoles of *R. achavali*, *R. jimi*, *R. poeppigii*, or *R. veredas* (Maneyro et al., 2004; Kwet et al., 2006; Brandão et al., 2007). Here we describe the tadpole of *R. jimi* and compare it to the described tadpoles of the *R. marina* species group.

MATERIAL AND METHODS

Tadpoles were collected between 24 and 31 January 2009 by L. F. Toledo and R. Ribeiro in Fernando de Noronha, Pernambuco, Brazil (3°50′S, 32°25′W; sea level). *Rhinella jimi* is the only species of *Rhinella* present in Fernando de Noronha (Toledo and Ribeiro, 2010). All tadpoles were preserved in 10% formalin and deposited in the amphibian collection of the ''Prof. Adão José Cardoso'' Zoology Museum (ZUEC), Universidade Estadual de Campinas, Campinas, São Paulo, Brazil. Collecting permit (17242-1) was provided by Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio).

Tadpole description is based on 20 specimens (ZUEC 14806) in Stages 28 and 29 sensu Gosner (1960). Fifteen measurements were taken on the preserved tadpoles following the terminology of Altig et al. (1998), Altig and McDiarmid (1999), and Altig (2007): body length; body height; body width; tail length; maximum tail height; tail muscle height; tail muscle width; total length; oral disc width; internarial distance; interorbital distance; eye diameter; nostril diameter; eye–nostril distance; and nostril–snout distance. Measurements were taken using a digital caliper (0.01 mm of precision).

Five tadpoles of *R. schneideri* (ZUEC 15777; collected by M. Martins in 1973 in Campinas, São Paulo, Brazil) in Stages 27–29 were analyzed to make comparisons with the tadpoles of *R. jimi*. Student's *t*-test was used to compare eye and nostril diameters between the species.

RESULTS

Description of the Tadpole.—Measurements of larvae in Stages 28 and 29 are provided in Table 1. Body depressed (body height/body width = 0.83), oval in dorsal and ventral views, elliptical in lateral view; body length about 44% (41–50%) of total length. Snout oval in dorsal view and sloped in lateral view. Nostrils large, nearly oval, located dorsally, with the opening dorsolaterally directed, with a small projection on the rim; nearer the eyes than the snout (eye–nostril distance/nostril–snout distance = 0.85). Small dorsal eyes (eye diameter/body width = 0.18) dorsolaterally oriented. Interorbital distance about twice the internarial distance. Spiracle single and sinistral, opening located near midbody, directed posteriorly. Inner (or centripetal) wall totally fused to the body wall and longer than the external wall. Medial vent tube, attached to ventral fin, with opening oriented posteriorly. Bicolored tail musculature; dorsal fin about same height as ventral fin. Dorsal fin originates near the tail/body junction and ventral fin begins anterior to vent tube. Oral disc anteroventral, laterally emarginated. Triangular marginal papillae with wide dorsal and ventral gaps, a single row of marginal papillae begins on each side of dorsal gap and ends on each side of ventral gap, few scattered

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TABLE 1. Mean measurements, standard deviations, and range (in millimeters) of 20 *Rhinella jimi* tadpoles in Stages 28 and 29 of Gosner (1960).

Characteristic	Mean ± SD	Range
Body length (BL)	7.77 ± 0.48	6.72–8.66
Body height (BH)	4.46 ± 0.34	3.36–5.07
Body width (BW)	5.36 ± 0.38	4.26–6.01
Tail length (TAL)	9.78 ± 0.64	8.77–10.99
Maximum tail height (MTH)	3.93 ± 0.17	3.59–4.20
Tail muscle height (TMH)	1.50 ± 0.13	1.30–1.73
Tail muscle width (TMW)	1.19 ± 0.10	0.96–1.34
Total length (TL)	17.57 ± 1.04	15.40–19.05
Oral disc width (ODW)	2.26 ± 0.17	2.05–2.72
Internarial distance (IND)	1.11 ± 0.07	1.00–1.29
Interorbital distance (IOD)	2.31 ± 0.14	1.95–2.57
Eye diameter (ED)	0.98 ± 0.07	0.84–1.16
Nostril diameter (ND)	0.51 ± 0.05	0.43–0.62
Eye–nostril distance (END)	1.17 ± 0.08	1.00–1.38
Nostril–snout distance (NSD)	1.37 ± 0.11	1.18–1.56

submarginal papillae are located near the teeth rows laterally in the oral disc. Two anterior rows of labial teeth, the second one with a wide medial gap; three posterior rows of labial teeth, the first one with a small gap in one of the individuals analyzed; labial tooth row formula (LTRF) 2(2)/3[1]. Narrow jaw sheaths with triangular serration; lower jaw sheath U-shaped and upper jaw sheath arch-shaped with long lateral processes. Dark brown coloration in preservative, with translucent nonpigmented fins; the internal organs are visible in ventral view. A tadpole at stage 28 is illustrated in Figure 1.

Natural History Notes.—*Rhinella jimi* tadpole is exotrophic and benthic (sensu Altig and Johnston, 1989). Tadpoles were always observed along pond edges and were active during the day but never at night. They inhabit lentic water bodies and form dense aggregations. These aggregations may be classified as stationary according to Beiswenger (1975). These tadpoles remain on the water surface exposed to the sun, but sometimes they can dive down to a depth of 50 cm and hide in sandy ground or under dead leaves. They also dive when approached. No feeding was observed.

Comparisons with Other Species.—Some characteristics of the tadpoles of the described species of *R. marina* species group are presented in Table 2. Tadpoles of *R. jimi* are similar to tadpoles of the other species of the *R. marina* group. *Rhinella jimi* is distinguished from *R. schneideri* by having proportionally (diameter/body length) larger eyes and nostrils ($t_{23} = 5.41$, $P < 0.001$; $t_{23} = 9.00$, $P < 0.001$, respectively). The analyzed specimens differed also in eye orientation, with the eyes of *R. jimi* tadpoles more dorsally oriented than in *R. schneideri*. However, eye orientation can be modified during development of tadpoles; hence, this difference may be merely a result of differences in developmental traits among the observed individuals.

TABLE 2. Characteristics of the described tadpoles of the species of *Rhinella marina* group. LTRF: Labial tooth row formula; BL: body length; TL: total length. Stages are presented according to Gosner (1960).

Species	Stage	LTRF	BL/TL	TL	Spiracle position	Locality	Reference
R. arenarum	37	2(2)/3	Less than 50%	30	Posterior	–	Cei, 1980
R. cerradensis	40	2(2)/3(1)	45%	20.08	On midbody	Brasília (Brazil)	Maciel et al., 2007
R. icterica	37	2(2)/3(1)	–	35	Posterior	–	Cei, 1980
R. jimi	28 and 29	2(2)/3[1]	44%	17.6	On midbody	Fernando de Noronha (Brazil)	This study
R. marina	29[a]	2(2)/3	40%	23	Posterior[a]	Trinidad	Kenny, 1969
R. marina	33–36	2(2)/3	42%	22.4	Posterior[a]	Jalisco (Mexico)	Ford and Scott, 1996
R. rubescens	25	2(2)/3(1)	43%	23.7	On midbody	Serra do Cipó (Brazil)	Eterovick and Sazima, 1999
R. schneideri	37	2(2)/3(1)	Slightly more than 50%	35	On midbody	Argentina	Cei, 1980
R. schneideri	36–38	2(2)/3	–	24.3	Posterior	Nova Itapirema (Brazil)	Rossa-Feres and Nomura, 2005

[a] Information inferred from the pictures presented in the original articles.

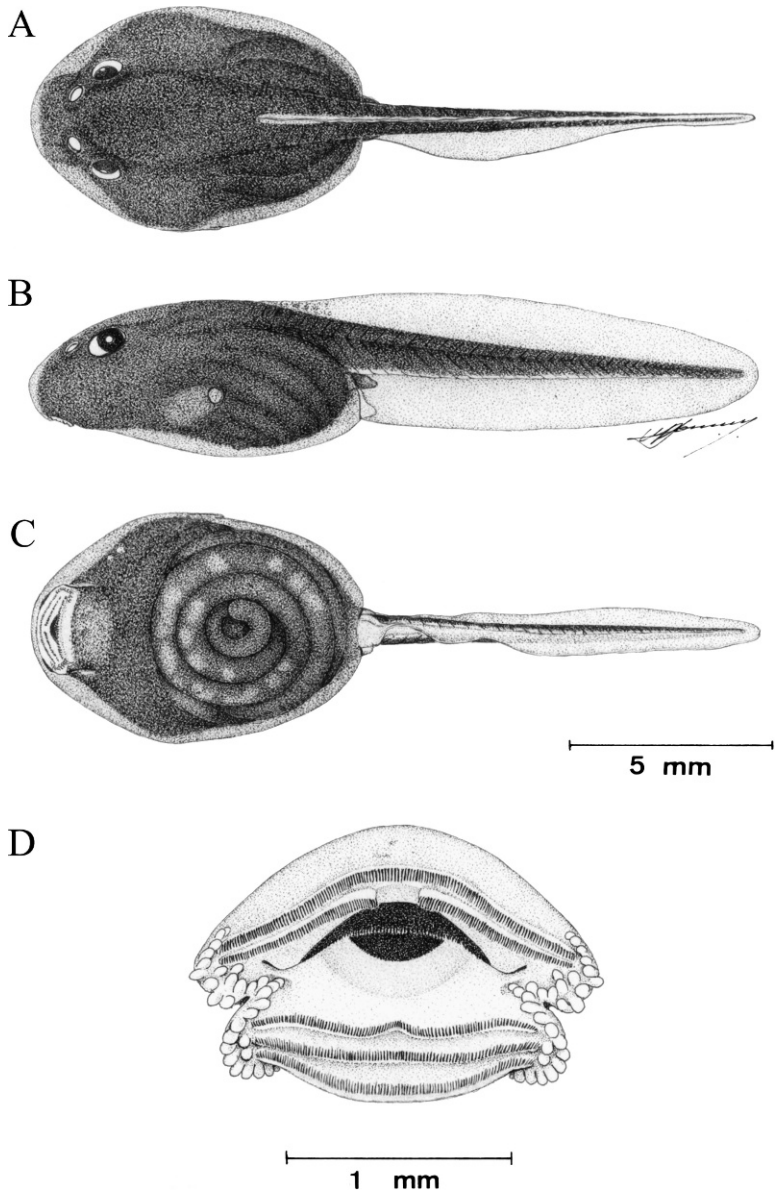

FIG. 1. Tadpole of *Rhinella jimi*, Stage 28: (A) dorsal, (B) lateral, and (C) ventral views. (D) Oral disc.

DISCUSSION

Tadpoles of the *R. marina* group are very similar in shape and general characters. Eterovick and Sazima (1999) suggested that *R. rubescens* is more similar to *R. schneideri* and that *R. arenarum* is more similar to *R. icterica* based on body proportions and spiracle position. According to Maciel et al. (2007), the tadpoles of *R. cerradensis* resemble *R. rubescens* and *R. schneideri* in body proportions and spiracle position. *Rhinella jimi* tadpoles also resemble *R. rubescens*, *R. schneideri*, and *R. cerradensis* in spiracle position.

Based on available data on the spiracle position, it is possible to form two groups of species: the first composed of *R. arenarum*, *R. icterica*, and *R. marina* with the spiracle opening located posteriorly (Kenny, 1969; Cei, 1980; Ford and Scott, 1996); and the second composed of *R. rubescens*, *R. cerradensis*, and *R. jimi* with the spiracle positioned midbody (Eterovick and Sazima, 1999; Maciel et al., 2007). *Rhinella schneideri* seems to have variable spiracle position among the different populations studied by Rossa-Feres and Nomura (2005) (with posterior spiracle) and by Cei (1980) (with midbody spiracle). *Rhinella cerradensis* tadpoles can be distinguished from other tadpoles of the *R. marina* group by the absence of an external tube in the spiracle (Maciel et al., 2007). According to Eterovick and Sazima (1999), *R. rubescens* can be diagnosed by its snout being slightly truncated in

lateral view. Therefore, *R. jimi* tadpole can be diagnosed by the spiracle with external tube opening on midbody, the snout sloped in lateral view, and the eyes and nostrils proportionally larger than in *R. schneideri*.

Because we lack a complete or well-accepted phylogeny of the genus (or at least of the *R. marina* species group), we are not able to link the morphological similarities/dissimilarities observed to evolutinary relationships. However, the tadpoles of *R. jimi* were morphologically more similar to those of *R. schneideri* (than compared to the other species of the group) just as observed for postmetamorphic individuals (Stevaux, 2002). Therefore, our study corroborates this hypothesized close relationship.

Acknowledgments.—We thank R. S. Ribeiro for helping in fieldwork and G. Smith and an anonymous reviewer for suggestions in the manuscript. LFT thanks Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for financial support. JT thanks Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and FAPESP for a graduate scholarship. We thank ICMBio for logistical support and for providing collecting permit (17242-1).

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Accepted: 4 February 2010.