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Knowledge gaps and bibliographical revision about descriptions of free-swimming anuran larvae from Brazil

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Abstract. Research on tadpole morphology has grown rapidly in recent decades, but many larval anurans remain unknown. We made a literature survey of all studies that describe free-swiming larvae of anuran species occurring in Brazil in order to identify major gaps and provide a searchable bibliographical source about these descriptions. We found that 61.25% of tadpoles of species with free-swiming larvae have already been described. We hope that this paper will foster future tadpole descriptions by providing easy access to the literature.

Key words: literature survey, tadpoles, Anura, herpetology.

Introduction

Traditionally, most studies on anurans have focused on variation and characteristics of the post-metamorphic stage with a few studies dealing with tadpole morphology and ecology (Larson & De Sá 1998). On the other hand, research on tadpoles is increasing rapidly in the last decades (see McDiarmid & Altig 1999) and many unusual larval features have been reported (e.g., Natale et al. 2011). Even so, tadpoles of most tropical anuran species remain unknown. This fact is even more worrisome because amphibians have been declining or even disappearing from the planet at an alarming rate (Stuart et al. 2004). Information on every anuran life stage, from eggs to adults, is paramount to derive proper conservation and management plans. Nonetheless, difficulties in tadpole identification are a major obstacle in anuran surveys and in the development of conservation and management programs. Trying to balance studies between adults and tadpoles is extremely important because: i) the use of larval characters in taxonomic studies can assist in solving phylogenetic issues among species and genera (Larson and De Sá 1998; Frost et al. 2006) and even at the ordinal level (Haas 2003); ii) tadpoles are appropriate models in a broad range of ecological approaches, such as ecotoxicology (Relyea 2005), competitive and predatory interactions (Morin 1983, 1986), food webs (Wilbur 1997), and community structure (Wilbur 1987); and iii) most tadpoles remain at the breeding sites longer than the adults (Altig & McDiarmid 1999). Therefore, these factors make tadpoles a critical component in any anuran survey (Shaffer et al. 1994, Skelly & Richardson 2010, Silva 2010).

The current estimate of amphibian species in the world is about 6,921 (AmphibiaWeb 2012), but this number is constantly changing, as new species are being discovered either/or becoming extinct. Brazil harbors the greatest species richness of amphibians in the world, with about 877 species (SBH 2010). Among these, 849 are anurans, of which 738 have free-swimming larvae that inhabit a wide variety of habitats (e.g., bromeliads, streams, and ponds; Haddad and Prado 2005).

During a workshop held in 2004, researchers estimated that about 40% of the tadpoles had not been described yet (Andrade et al. 2007). Our goal here is to review the literature about tadpoles of Brazilian species in order to identify major knowledge gaps. In addition, we provide an on-line and fully searchable database that might be helpful for

South American herpetologists, who will have an easy access to the literature about Brazilian free-swimming larvae, including internal oral features and chondrocranial morphology.

Materials and methods

We conducted a literature survey on Internet databases, such as Google scholar, Scielo, Web of Science, and major herpetological journals dealing with descriptions of tadpoles from Brazil. Taxa with direct development (*sensu* Haddad and Prado 2005) were obviously not included (e.g., Brachycephalidae, Craugastoridae, Eleutherodactylidae, some Hemiphractidae, Strabomantidae, and some Microhylidae). Our survey is also based on interviews with other expert herpetologists who have been working with Brazilian tadpoles (see Acknowledgements section). We also included larvae of species that were described with little information a long time ago (e.g., *Ceratophrys aurita*, *Dendropsophus berthalutzae*) and need further detailed descriptions. We did not evaluate the quality of the works or provide further comments. This literature survey did not include exotic species (e.g., *Lithobates catesbianus*). We followed the taxonomy as given in Frost (2011).

Results and discussion

We found that approximately 61.25% of tadpoles of Brazilian anurans with aquatic free-swimming larvae have been described so far. The family Allophrynidae is composed by a single species (Frost 2011), whose tadpole has not been described. The family Bufonidae has the least percentage of known tadpoles, since only 31 out of 67 (46.3%) species have been described (Fig. 1). The only family in which 100% of tadpoles were described is Ranidae, but this family has only one species in Brazil. The families with larger number of tadpoles described in Brazil are: Ceratophrydae (80% of 5 species), Leptodactylidae (70.7% of 75), Pipidae (66.7% of 3), Hylidae (64.5% of 341), Leiuperidae (69.6% of 56), Aromobatidae (60% of 20), Microhylidae (52.8% of 36), Hylodidae (54.8% of 42), Centrolenidae (50% of 8), Dendrobratidae (50% of 18), Cycloramphidae (53.8% of 65), and Bufonidae (46.3% of 67 – Fig. 2).

Most Brazilian tadpoles have been described after 1960 (Fig. 2). The 1920s pioneer studies dealing with tadpole morphology published in Brazil (Lutz 1926, 1930, Miranda-Ribeiro 1920, 1923, 1926) only included a picture or a line drawning of larvae in most cases, along with data about size and place where they were found, but no further morphological characteristics. Conversely, recent descriptions often provide more detailed descriptions about external morphology, including internal oral features, and the chondrocranium, which makes it easier to compare and identify tadpoles found in different regions of the country. However, geographical variation in tadpole morphology is scarcely studied in Brazil. An atypical example is the recently described tadpole of *Elachistocleis cesarii* from Rio Grande do Norte, North-

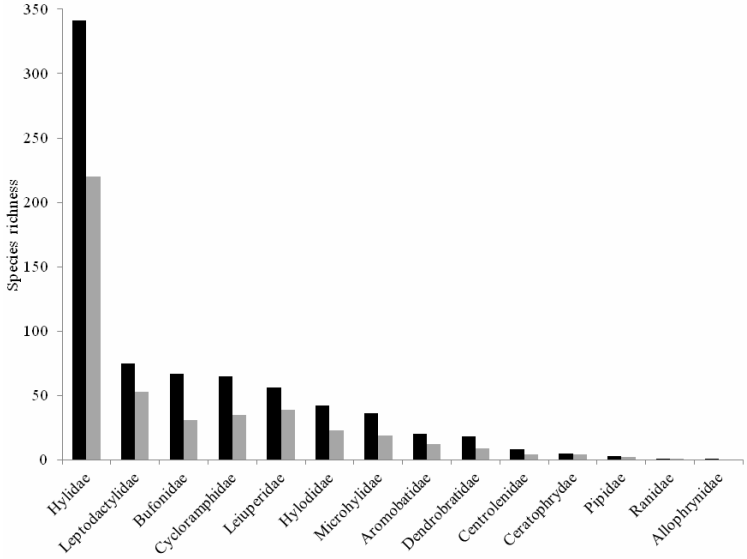

Figure 1. Distribution of the richness of Brazilian anurans with free-swimming larvae (black bars) and the number of tadpoles described per family (gray bars).

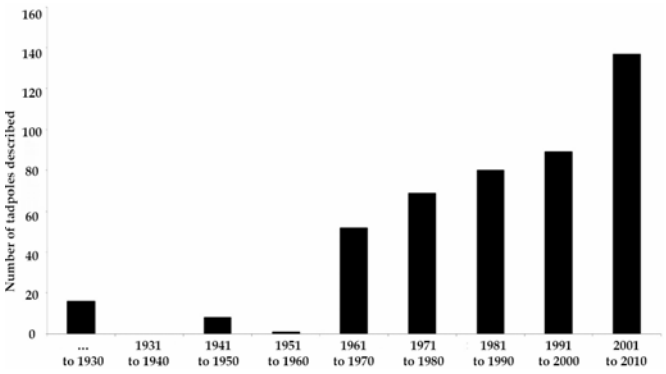

Figure 2. Number of tadpole descriptions within recent decades.

eastern Brazil (Magalhães et al. 2012), which had been previously described as *Elachistocleis* sp. in Rossa-Feres and Nomura (2006) from Northwestern São Paulo, Southeastern Brazil (see Provete et al. 2011 for species identification). Apparently there are striking external morphological differences between the two populations (see Magalhães et al. 2012).

We recommend that along with the external morphological descriptions, authors should also describe eggs in detail and the morphology and coloration of hatchlings. Finally, despite the increase in the number of tadpole descriptions in the recent decades, the number of tadpoles described in Brazil is smaller than in Europe and North America, for example.

As a result of this study, we assembled the list of bibliographical references about Brazilian tadpoles, which is available on-line at http://goo.gl/opquI. The user can now search the databse directly and copy the reference. The database is maintained and continuously updated by DBP.

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