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Tadpole diversity of Bolivia's lowland anuran communities: molecular identification, morphological characterisation, and ecological assignment

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Abstract

The last decades have witnessed a rapid increase in our knowledge about amphibian diversity, and a growing number of studies have focused on anuran larval stages. Tadpoles can provide key information for conservation issues and the understanding of amphibian evolution. Moreover, research in tadpoles has the potential to advance species delimitation in the diverse and still understudied Neotropical amphibian fauna. In this study we present morphological tadpole characterisations of 41 lowland species illustrated by detailed imagery (mainly of live specimens). The larvae were identified via captive breeding and genetically using recently published DNA barcodes of adult Bolivian frogs. Tadpoles of three species (*Rhinella mirandaribeiroi*, *Dendropsophus melanargyreus*, and *D. salli*) are described for the first time. The descriptions of 38 tadpoles are at least new for Bolivia (due to the divergent status of many of the Bolivian lineages, further studies are needed to clarify their taxonomy). In addition, we provide information on tadpole habitats, which—combined with morphological data—reveal ecomorphological guilds that further illustrate Bolivia's lowlands tadpole diversity.

Keywords: Bolivia's lowlands; ecomorphological guilds; tadpoles; tadpole microhabitats; tadpole morphology

Introduction

Tadpoles, the premetamorphic life stage of many frogs and toads, play a key role in anuran biology, and are the focus of various aspects of anuran research (McDiarmid & Altig 1999). The usually aquatic larval stage and the corresponding adults are exposed to notably different selective regimes due to the biphasic life cycle of anurans (e.g., Haas & Das 2011). Among terrestrial vertebrates, this unique free-living larval stage is considered a particularly suitable indicator of adaptive radiation processes in the evolutionary context of lineage diversification (Bossuyt & Milinkovitch 2000; Roelants *et al.* 2011). Under the conditions of current climate change, anuran larvae are of interest, as numerous effects of varying abiotic factors (e.g., temperature, availability of water, ultraviolet radiation) can be observed in tadpoles and tadpole communities (Reading 2002; Blaustein *et al.* 2003; Blaustein *et al*. 2010). Furthermore, extended amplitudes in temperature are correlated with chytrid fungus infection in tadpoles (Hamilton *et al.* 2012), as the latter host and transport the pathogen on their external keratinous mouthparts (Marantelli *et al.* 2004; Wake & Vredenburg 2008; Venesky *et al.* 2011). Given that larvae usually occupy different habitats than the adults, tadpoles are also important to conservation issues such as the global decline of amphibians that is attributed to habitat alteration (Becker *et al.* 2007). Properly characterising anuran larvae can assist with distinguishing species and inferring phylogenetic relationships (Eterovick & Sazima 2000; Vences *et al.* 2010a).

All these factors underline the importance of tadpole research and at the same time may demonstrate that anuran larvae are, to a certain extent, the “Achilles’ heel” of amphibians. Therefore, it is even more surprising that in the past, research on tadpoles has received less attention than that of adult amphibians (McDiarmid & Altig 1999). Misidentifications can lead to error cascades and seriously affect studies in other disciplines, e.g., ecology, physiology, behaviour (Bortolus 2008). Recently, several studies on tadpole identification have been conducted using molecular tools alongside morphological data, notably in Madagascar (Thomas *et al*. 2005; Raharivololoniainaa *et al.* 2006; Randrianiaina *et al*. 2012). Studies of this kind are still underrepresented in the Neotropics (but see e.g., Schulze & Jansen 2012, Kolenc *et al.* 2013) In Brazil, for example, taxonomic studies on amphibians have been increasing substantially, yielding a current total of about 946 described frog species (Segalla *et al*. 2013), but larvae are only known of about 60% of the species (Provete *et al.* 2012). In Bolivia, even less is known about the tadpoles of native species and only about 30% have been described, partly even from bordering countries. A recent study, however, revealed that hidden diversity exists on a regional level in the country’s eastern lowlands (Jansen *et al*. 2011).