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A review of Northern Peruvian glassfrogs (Centrolenidae), with the description of four new remarkable species

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Abstract

Peru is well known for amphibian diversity and endemism, yet there have been relatively few field studies of glassfrog (Centrolenidae) diversity in this country. Research in Colombia and Ecuador indicates that centrolenid diversity is higher in the northern Andes. However, part of this trend appears to be due to sampling effort. We conducted fieldwork throughout northern Peru, and based on phylogenetic analysis of DNA sequences, combined with bioacoustic and morphological analyses of new and available material we now recognize 33 species from the country (versus 30 species prior to this work). Field surveys led to the discovery of four remarkable species: *Centrolene charapita* **new species** is a large, ornamented glassfrog that appears to be sister to *Ce. geckoideum*; *Chimerella corleone* **new species** represents the second-known member of the genus *Chimerella*; *Cochranella guayasamini* **new species** is the second-known member of the genus with humeral spines; and *Hyalinobatrachium anachoretus* **new species** occurs in the cloud forest of the east-Andean versant in Peru. In addition to the new species described here, we provide new country records, new localities including range extensions of up to 875 km, information on diagnostic characters and phylogenetic relationships, call and larval descriptions, and observations on natural history for several Peruvian centrolenids. Our results also revealed several taxonomic problems concerning species of the genus *Rulyrana*, and we conclude that *R. croceopodes* and *R. tangarana* are junior synonyms of *R. saxiscandens*. By implication of our phylogenetic analyses, we recognize the following new combinations: *Espadarana audax* **new combination**, *Espadarana durrelorum* **new combination**, and *Espadarana fernandoi* **new combination**.

Key words: Amphibians, Bioacoustics, Biodiversity, Integrative taxonomy, New species, Phylogenetics, Peru

Introduction

Peru is one of 17 “mega-diverse” countries, boasting the third-highest country total of amphibian species with 555 at the time of this writing (AmphibiaWeb 2014). Stream-breeding frogs of the Neotropical family Centrolenidae reach their highest diversity in the tropical Andes (Ruiz-Carranza & Lynch 1991). Species numbers in this group have nearly tripled since 1977, increasing from 55 to 153 in the last 36 years (Duellman 1976; Frost 2014). While the advent of molecular tools has led to an increase in known diversity of some Neotropical groups of frogs (e.g., Dendrobatidae, see Brown *et al.* 2008; Twomey & Brown 2008), the increase in known numbers of glassfrogs has largely been due to discoveries of undocumented species in the field (e.g., Ruiz-Carranza & Lynch 1989; 1991a, b, c, d; 1995a, b, c; 1996; 1997; 1998; Torres-Gastello *et al.* 2007; Catenazzi *et al.* 2012; Guayasamin 2013).

Compared to the Andean countries of Ecuador and Colombia, Peruvian glassfrogs have received little taxonomic attention. It has been over 22 years since the last major field work was conducted on the centrolenid frogs in Peru. Field work done in 1989 resulted in the description of eight new species by Duellman and Schulte (1993), nearly doubling the number of Peruvian centrolenids known at the time. Since then, only four species have been described from Peru, a sharp contrast to 22 new centrolenids described from Colombia and 14 from Ecuador during this same period (Fig. 1). While glassfrog diversity appears to diminish in all directions away from the northern Andes of Colombia, we suspect that part of the discrepancy in known diversity, particularly between Ecuador and Peru, is due to differences in taxonomic effort. Indeed, both Colombia and Ecuador have witnessed sudden increases in their numbers of known centrolenid species, largely due to work of local taxonomists (e.g., Lynch & Duellman 1973; Ruiz-Carranza & Lynch 1997; Guayasamin *et al.* 2006; Cisneros-Heredia & McDiarmid 2007). In comparison, Peru has had no resident centrolenid taxonomists, and the accumulation of species has been consequently gradual rather than punctuated (Fig. 1).

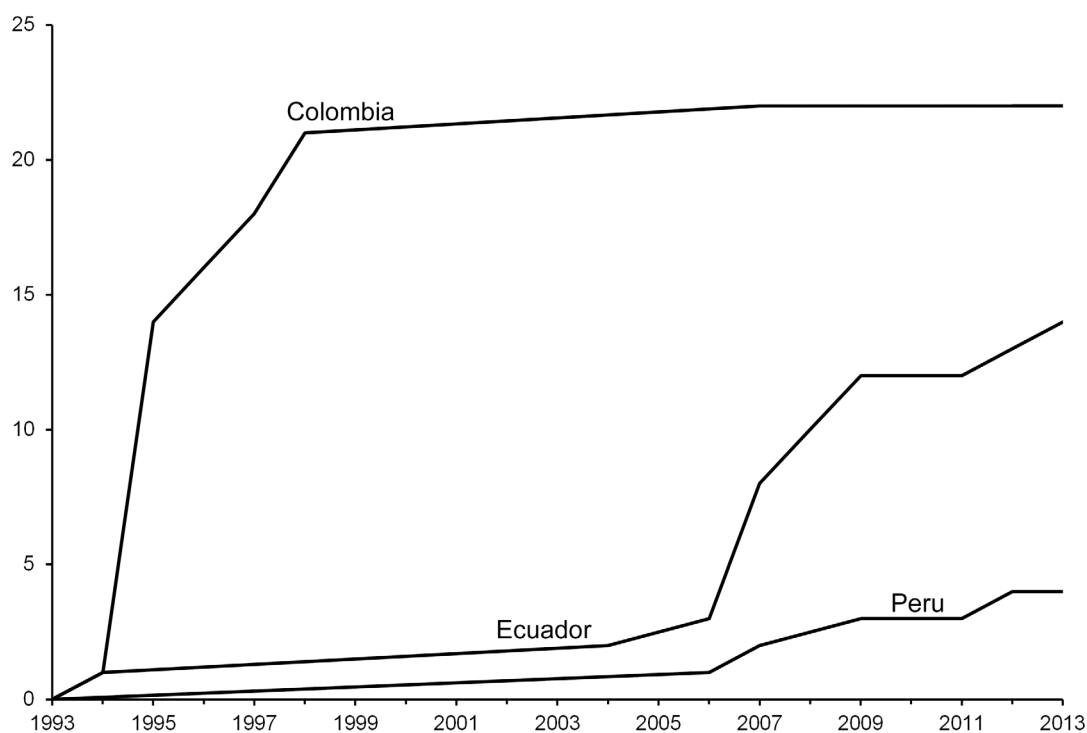


FIGURE 1. Accumulation curves of new centrolenid species described from Colombia, Ecuador and Peru since 1993.

Recently, there have been major advances contributing to the systematics and taxonomy of this family (Guayasamin *et al.* 2006; Cisneros-Heredia & McDiarmid 2007; Guayasamin *et al.* 2008; Guayasamin *et al.* 2009; Castroviejo-Fisher *et al.* 2011). With the incorporation of molecular data for phylogenetic analyses, there has been increased awareness that certain morphological characters previously used to define supra-specific groups are homoplastic (e.g., humeral spines, liver shape, see Guayasamin *et al.* 2008). There has also been increased appreciation that, in certain groups, some morphological characters are often insufficiently variable to recognize divergent lineages that are supported by other kinds of data (*i.e.*, ‘cryptic species’). For example, *Hyalinobatrachium carlesvilai* is only subtly different in terms of morphology from the sympatric *H. bergeri*. However, bioacoustics and DNA sequences clearly support the recognition of two distinct species (Castroviejo-Fisher *et al.* 2009). A similar situation was recently documented in the description of *Nymphargus lasgralarias*, which is nearly morphologically identical to *N. griffithsi*, but readily distinguishable on the basis of its call (Hutter & Guayasamin 2012). In other cases, intraspecific variation in morphological characters may be confounded with interspecific differences, which can happen when species descriptions are based on limited sample sizes insufficient to assess character variability (see examples in Castroviejo-Fisher *et al.* 2011). Both the limitations and the usefulness of morphological data in centrolenid species delimitation have been extensively discussed elsewhere (see Cisneros-Heredia & McDiarmid 2007), and it is not our intention to undermine its use. Rather, we emphasize the need to incorporate as many lines of evidence as possible (e.g., morphological, bioacoustic, genetic) when

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