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## **Systematics of the *Hyloxalus bocagei* complex (Anura: Dendrobatidae), description of two new cryptic species, and recognition of *H. maculosus***

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## Abstract

The *bocagei* clade is a species complex of dendrobatid frogs evidenced from recent molecular systematic studies. This lineage is endemic to the eastern Andean slopes and adjacent Amazonian lowlands in southern Colombia, Ecuador and northern Peru. Herein, we analyze the taxonomy of the *bocagei* clade by means of qualitative and quantitative morphological characters and call parameters. We recognize and provide accounts for six species: *Hyloxalus bocagei*, *H. faciopunctulatus*, *H. maculosus*, *H. sauli* and two new species. We also provide phylogeographic data. We formally assign the name of *Hyloxalus bocagei* only to populations from the surroundings of Volcán Reventador (Provincia Napo, Ecuador). Additionally, we describe the tadpoles of *Hyloxalus bocagei*, *H. maculosus*, and two new species, plus vocalizations of *H. bocagei*, *H. maculosus*, *H. sauli*, and two new species. Morphological variation was estimated from 16 morphometric characters using multivariate analysis. Adults of the two new species were indistinguishable using quantitative and qualitatively morphological characters. Nevertheless, molecular data, call parameters (dominant frequency, note repetition rate), and tadpole morphology supported the recognition of these two species as cryptic taxa. A current phylogenetic tree using molecular characters of five species of the *bocagei* clade is also provided including the maximum likelihood (ML) phylogeny and a chronogram of the group. Our phylogeny confirms the close relationship of members of the *bocagei* clade with Andean relatives of *Hyloxalus* and recurrent dispersal events from the Andes to the Amazon Basin in the late Miocene (< 10 MYA). Our data also corroborate that the sister lineage of *bocagei* clade includes the Andean *H. subpunctatus* clade. We anticipate that further detailed morphological and molecular data will be necessary to reveal the existence of additional cryptic species within the *bocagei* clade.

**Key words:** Amazonia, Andes, Anura, cryptic species, Dendrobatidae, Ecuador, *Hyloxalus bocagei*, *Hyloxalus faciopunctulatus*, *Hyloxalus maculosus*, *Hyloxalus sauli*, morphology, new species, tadpoles, taxonomy, vocalization

## Resumen

El clado *bocagei* es un complejo de especies de ranas dendrobátidas evidenciado por recientes estudios de sistemática molecular. Este linaje es endémico de las estribaciones orientales andinas y las zonas bajas amazónicas adyacentes en el sur de Colombia, Ecuador y el norte de Perú. Estudiamos la taxonomía de las ranas del clado *bocagei* utilizando caracteres morfológicos cualitativos y cuantitativos y parámetros de las vocalizaciones. Reconocemos y proveemos sumarios de seis especies: *Hyloxalus bocagei*, *H. faciopunctulatus*, *H. maculosus*, *H. sauli* y dos especies nuevas. Además proveemos datos filogeográficos. Asignamos formalmente el nombre de *Hyloxalus bocagei* únicamente a las poblaciones localizadas en los alrededores del volcán Reventador (Provincia Napo, Ecuador). Adicionalmente, describimos los renacuajos de *Hyloxalus bocagei*, *H. maculosus* y las dos especies nuevas; además de las vocalizaciones de *H. bocagei*, *H. italoï*, *H. maculosus* y las dos especies nuevas. Se estimó la variación morfológica a partir de 16 caracteres morfométricos, examinados mediante análisis multivariados. Adultos de las dos especies nuevas son indistinguibles entre ellos utilizando caracteres morfológicos cuantitativos y cualitativos. No obstante, datos moleculares, parámetros de los cantos (frecuencia dominante, tasa de repetición de notas) y morfología de los renacuajos sustentan el reconocimiento de estas dos especies como taxa crípticos. Se provee un árbol filogenético actualizado de cinco especies del clado *bocagei* incluyendo una filogenia inferida con máxima verosimilitud (ML) y un cronograma del grupo. Nuestra filogenia confirma la cercana relación de miembros del clado *bocagei* con parientes andinos de *Hyloxalus* y las dispersiones repetidas desde los Andes a la Cuenca Amazónica durante el Mioceno tardío (< 10 MA). Nuestros datos también corroboran que el linaje hermano del clado *bocagei* incluye el clado de la especie andina *H. subpunctatus*. Preveemos que datos morfológicos y moleculares detallados serán necesarios para confirmar la existencia de más especies crípticas en el clado *bocagei*.

**Palabras clave:** Amazonia, Andes, Anura, Dendrobatidae, Ecuador, especies crípticas, especies nuevas, *Hyloxalus bocagei*, *Hyloxalus faciopunctulatus*, *Hyloxalus maculosus*, *Hyloxalus sauli*, morfología, renacuajos, taxonomía, vocalización

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