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The Sri Lankan torrent toads (Bufonidae: Adenominae: *Adenomus*): species boundaries assessed using multiple criteria

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Abstract

The bufonid genus *Adenomus*, an endemic of the montane and lowland rainforests of central and south-western Sri Lanka, has been considered to comprise of three species, viz. *A. kelaartii*, *A. dasi* and *A. kandianus*, the last of which has been recently highlighted as "the world's rarest toad". We conducted a survey across the known range of *Adenomus* and used multiple criteria to delineate species boundaries within the genus. These include: a molecular phylogeny based on a 16S ribosomal RNA gene fragment; an examination of the external morphology of adults and larvae, and the skeletal morphology of adults; a bioacoustic analysis; and ecological niche modelling. We show that *Adenomus* is monophyletic and that it comprises only two species: *A. kelaartii* and *A. kandianus*, with *A. dasi* being a junior synonym of the latter. For the two valid species of *Adenomus*, we provide detailed osteological descriptions; clarify the distribution patterns; and provide genetic data to facilitate their scientific conservation management.

Key words: *Adenomus dasi* new synonym, barcoding, bioacoustics, integrative taxonomy, niche modeling, osteology, sucker disc, tadpole

Introduction

Cope (1861) established the genus *Adenomus* to contain the Sri Lankan toad *A. badioflavus* Cope, 1861, a junior synonym of *Bufo kelaartii* Günther, 1858. The following year, however, Cope (1862) synonymised this genus with *Bufo* Garsault, 1764, in which status it remained until recognized as valid by Manamendra-Arachchi and Pethiyagoda (1998). Frost (2014), however, observed that the validity of *Adenomus* "without discussion of diagnostic features or phylogenetic placement" was "a move that will likely prove controversial". In addition to describing a further new species, *A. dasi*, from Sri Lanka, Manamendra-Arachchi and Pethiyagoda (1998) included in this genus *Bufo kandianus* Günther, 1872, a species that had not been recorded since its original description. In 2005 *A. kandianus* became one of the 34 amphibians globally declared extinct by the IUCN (Stuart *et al*. 2008), though 'rediscovered' shortly thereafter by Wickramasinghe *et al*. (2012) who, despite meagre population data labelled it "the world's rarest toad". Alongside the announcement of this rediscovery, Wickramasinghe *et al*. (2012) also speculated that the population they recognized as *A. kandianus* could in fact represent a new species, with the identity of *A. kandianus* remaining in doubt due to lack of genetic data and a lack of clarity as to its precise type locality.

Van Bocxlaer *et al*. (2009) recognized the subfamily Adenominae, which includes the genera *Adenomus*, *Duttaphrynus*, *Ghatophryne*, *Pedostibes* and *Xanthophryne* (Biju *et al*. 2009), the first of which is restricted to Sri Lanka, and the last three of which are endemic to the Western Ghats of India. Based on 2 nuclear and 9 mitochondrial gene fragments, their phylogeny recovered *Adenomus* as the sister group of *Duttaphrynus* + *Xanthophryne*, though Frost (2014) cautioned that the phylogenetic status of *Adenomus* "remains questionable".

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(6°47'N, 80°27'E); WHT 1758, juvenile, 15.8 mm SVL, Seraella (Pottotawela, Knuckles), alt. 450m (7°35'N, 80°45'E); WHT 1759, juvenile, 17.5 mm SVL, Puwakpitiya (Laggala, Knuckles), alt. 450 m (7°34'N, 80°45'E); WHT 1764, ♀ 46.8 mm SVL, Kanneliya (Galle), alt. 150 m (6°15'N, 80°20'E); WHT 1767, ♀ 41.7 mm SVL, Kosmulla (Nelluwa), alt. 320m (6°24'N, 80°23'E); WHT 1768, ♂ 29.3 mm SVL, Mawanana (Nelluwa), alt. 150m (6°22'N, 80°21'E); WHT 1771, ♀ 39.5 mm SVL, Pitadeniya (Watugala), alt. 320m (6°22'N, 80°28'E); WHT 1772, ♀ 28.2 mm SVL, Lanakagama (Dombagoda), alt. 460m (6°21'N, 80°28'E); WHT 1773, ♂ 33.1 mm SVL, Dolahena (Bulutota), alt. 16m (6°26'N, 80°36'E).

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