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A molecular phylogeny recovers *Strabomantis aramunha* Cassimiro, Verdade and Rodrigues, 2008 and *Haddadus binotatus* (Spix, 1824) (Anura: Terrarana) as sister taxa

RENATA C. AMARO^{1,7}, IVAN NUNES², CLARISSA CANEDO², MARCELO F. NAPOLI³, FLORA A. JUNCÁ⁴, VANESSA K. VERDADE⁵, CÉLIO F.B. HADDAD⁶ & MIGUEL T. RODRIGUES¹

¹Universidade de São Paulo, Instituto de Biociências, Departamento de Zoologia, Caixa Postal 11.461, 05422-970 São Paulo, São Paulo, Brazil

²Universidade Federal do Rio de Janeiro, Museu Nacional, Departamento de Vertebrados, 20940-040 Rio de Janeiro, Rio de Janeiro, Brazil

³Universidade Federal da Bahia, Museu de Zoologia, Instituto de Biologia, Departamento de Zoologia, 40170-115, Salvador, Bahia, Brazil

⁴Universidade Estadual de Feira de Santana, Departamento de Ciências Biológicas, 44036-900 Feira de Santana, Bahia, Brazil

⁵Universidade Federal do ABC, Centro de Ciências Naturais e Humanas, Avenida dos Estados, n5001, 09210-971 Santo André, São Paulo, Brazil

⁶Universidade Estadual Paulista “Júlio de Mesquita Filho”, Instituto de Biociências, Departamento de Zoologia, 13506-900 Rio Claro, São Paulo, Brazil

⁷Corresponding author. E-mail: amarorc@usp.br

Abstract

The taxonomic and biogeographic affinities of *Strabomantis aramunha* from the Campos Rupestres of Brazil are intriguing. A unique skull morphology of females suggest affinities with the broad-headed eleutherodactylines of Northwestern South America in the genus *Strabomantis*. Male and juvenile morphology nonetheless suggest *S. aramunha* could be related to members of the recently described genus *Haddadus* from eastern Brazil. We assess the affinities of *S. aramunha* using molecular phylogenetic analyses of mitochondrial (12S, tRNA^{Val}, 16S, cyt *b*) and nuclear sequences (RAG-1 and rhodopsin). Bayesian inference, likelihood, and parsimony analysis recover a highly supported clade with *S. aramunha* and *H. binotatus* as sister taxa. Accordingly, we transfer *S. aramunha* to *Haddadus*, and provide a new generic definition of the later. The distribution of species in *Haddadus* (highlands of the Espinhaço mountain Range and coastal eastern Brazil) is now concordant with the general pattern observed for other species in the area.

Key words: *Haddadus aramunha*, molecular data, new combination, nomenclature, phylogeny

Introduction

Molecular phylogenetic studies have resulted in several taxonomic changes at the family and generic levels within Terrarana (an unranked name for direct developing frogs created by Hedges *et al.* 2008) during the last ten years (see Darst & Cannatella 2004; Crawford & Smith 2005; Frost *et al.* 2006; Heinicke *et al.* 2007, 2009; Hedges *et al.* 2008; Padial *et al.* 2009; Canedo & Haddad 2012). In this context, frogs formerly placed in the highly speciose paraphyletic genus *Eleutherodactylus* were partitioned in several other genera (e.g., Frost *et al.* 2006; Hedges *et al.* 2008; Padial *et al.* 2009). The recent results presented by Canedo & Haddad (2012) indicated the non-monophyly of yet some other genera in the current taxonomy (e.g. *Ischnocnema* *sensu* Hedges *et al.* 2008). Despite progress in our understanding of the phylogenetic relationships of Terraranas and the consequent improvement in their taxonomy, several relationships inferred by Frost *et al.* (2006), Hedges *et al.* (2008), Padial *et al.* (2009), Pyron & Wiens (2011), and Canedo & Haddad (2012) are poorly supported, many species have not yet been sampled, and other lack substantial amounts of evidence. These limitations suggest that additional work is still much needed.

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APPENDIX 1. Genbank accession numbers of 12S/16S; cyt *b*; Rag-1; Rhodopsin of Terrarana and outgroup taxa included in gene-rich analyses of this study. MZUSP=Museu de Zoologia da Universidade de São Paulo. *Different species to represent the genus as a terminal taxon.

Acris crepitans: EF566970, AY843782, EF107304, AY844533; *Adelophryne guttuosa*: EU186679, GQ345201, GQ345280, GQ345302; *Allophryne ruthveni*, AY843564, AY843786, -, AY844538; *Batrachyla**, AY843572 (*B. leptopus*), AY843794 (*B. leptopus*), AY948936 (*B. taeniata*), AY844546 (*B. leptopus*); *Brachycephalus ephippium*: AY326008, GQ345195, GQ345275, DQ283808; *Calyptocephalella gay*: DQ283439, -, EF107334, DQ284036; *Ceratophrys**: AY326013 (*C. ornata*), AY843797 (*C. cranwelli*), AY364218 (*C. ornata*), AY364399 (*C. ornata*); *Ceuthomantis smaragdinus* A, EU186677, GQ345208, -, GQ345306; *Ceuthomantis smaragdinus* W1, GQ345132, GQ345206, -, GQ345305; *Craugastor**: EF493360 (*C. podiciferus*), GQ345197 (*C. podiciferus*), GQ345277 (*C. podiciferus*), DQ283960 (*C. rhodopsis*); *Dendrobates auratus*: AY364565, DQ502491, AY364214, AY364395; *Diasporus diastema*: EU186682, GQ345200, GQ345279, -, *Duttaphrynus melanostictus*: AY458592, AY458592, AY364197, AF249097; *Eleutherodactylus**: EF493539 (*E. cooki*), GQ345199 (*E. cooki*), EF107341 (*E. coqui*), DQ283937 (*E. planirostris*); *Epipedobates**: AY364577 (*E. tricolor*), DQ502584 (*E. anthonyi*), EF107295 (*E. tricolor*), DQ283768 (*E. boulengeri*); *Espadarana prosoblepon*: AY843574, AY843796, AY364223, AY844548; *Flectonotus**: AY843589 (*F. sp.*, CFBH 5720), AY843809 (*F. sp.*, CFBH 5720), DQ679274 (*F. fitzgeraldi*), AY844562 (*F. sp.*, CFBH 5720); *Haddadus binotatus*: EF493361, GQ345198, GQ345278, DQ283807; *Haddadus aramunha*: **MZUSP138687**: JQ182718/JQ182714, JQ182710, JQ182706, JQ182722; **MZUSP138689**: JQ182719/JQ182715, JQ182711, JQ182707, JQ182723; **MZUSP138691**: JQ182720/JQ182716, JQ182712, JQ182708, JQ182724; **MZUSP138692**: JQ182721/JQ182717, JQ182713, JQ182709, JQ182725; *Hemiphractus**: DQ679263 (*H. bubalus*)/AY843594 (*H. helioi*), AY843813 (*H. helioi*), DQ679303 (*H. bubalus*), AY844566 (*H. helioi*); *Hyla arenicolor*: EF566960, AY843824, AY364220, AY844577; *Hylodes**: DQ502171 (*H. phyllodes*), DQ502606 (*H. phyllodes*), GQ345289 (*H. nasus*), DQ503253 (*H. phyllodes*); *Hypodactylus*: EF493357 (*H. brunneus*), GQ345203 (*H. brunneus*), GQ345282 (*H. brunneus*), GQ345304 (*H. dolops*); *Ischnocnema**: EF493533 (*I. guentheri*), GQ345196 (*I. guentheri*), GQ345276 (*I. guentheri*), DQ283809 (*I. juipoca*); *Lepidobatrachus laevis*: DQ283152, -, EF107298, DQ283851; *Leptodactylus**: AY843688 (*L. ocellatus*), AY843934 (*L. ocellatus*), AY364224 (*L. melanotus*), AY844681 (*L. ocellatus*); *Litoria caerulea*: AY326038, AY843938, AY948926, AY844685; *Lymnodynastes**: AY326071 (*L. salmini*), GQ345209 (*L. tasmaniensis*), AY364219 (*L. salmini*), DQ283954 (*L. depressus*); *Mannophryne/Allobates**: DQ502131 (*M. trinitatis*), DQ502654 (*A. femoralis*), GQ345274 (*M. trinitatis*), DQ503236 (*M. trinitatis*); *Melanophryniscus**: AY325999 (*M. stelnzeri*), DQ502444 (*M. klappenbachi*), AY948927 (*M. stelnzeri*), DQ283765 (*M. klappenbachi*); *Myobatrachidae**: DQ283221 (*Uperoleia laevigata*) AY84, 3988 (*Pseudophryne bibronii*), -, DQ283955 (*Myobatrachus gouldii*); *Odontophrynus**: AY843704 (*O. americanus*), AY843949 (*O. americanus*), AY948934 (*O. occidentalis*), AY844695 (*O. americanus*); *Oreobates quixensis*: AY819344/DQ679380, EU368889, -, *Phrynopus bracki*: EF493709, GQ345202, GQ345281, GQ345303; *Phyllomedusa hypochondrialis*: AY843724, AY843969, AY948929, AY844711; *Physalaemus**: AY843729 (*P. cuvieri*), AY843975 (*P. cuvieri*), EF107299 (*Engystomops pustulosus*), AY844717 (*P. cuvieri*); *Pleurodema**: AY843733 (*P. brachyops*), AY843979 (*P. brachyops*), AY948932 (*P. sp.*, VUB1030), AY844721 (*P. brachyops*); *Pristimantis**: EF493697 (*P. cruentus*), EU368884 (*P. fenestratus*), AY948935 (*P. cruentus*), *Psychrophynella**: EU186696 (*P. wettsteini*), GQ345205 (*P. usurpator*), GQ345284 (*P. wettsteini*), *Rana temporaria*: AY326063, AY522428, DQ347231, AF249119; *Rhinella arenarum*: AY843573, AY843795, DQ158354, AY844547; *Rhinoderma darwini*: DQ283324, DQ502589,