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A taxonomic revision of the Asian keelback snakes, genus *Amphiesma* (Serpentes: Colubridae: Natricinae), with description of a new species

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Abstract

The Asian keelback snakes (genus *Amphiesma*) are a widely distributed group of Old World natricines, inhabiting a variety of niches and exhibiting significant morphological variation. Recent molecular phylogenies suggest that this genus is not monophyletic, and that additional cryptic diversity is also likely present. We conducted a phylogenetic analysis of the group based on 3162 bp of one mitochondrial gene (Cyt. *b*) and three nuclear genes (C-mos, Rag1, NT3), sampling 18 species in addition to those sequenced in previous works. All analyses consistently show that *Amphiesma* consists of three distinct, monophyletic lineages with strong support. We divide *Amphiesma* into three genera, *Amphiesma*, *Hebius*, and *Herpetoreas*. The genus *Amphiesma* is monotypic, *Herpetoreas* contains three species, and *Hebius* comprises the remaining 39 species. On the basis of a combination of molecular analyses and external morphological comparisons, we describe a new species in the *Herpetoreas* group from China as *H. burbrinki* sp. nov. Several other species are shown to be non-monophyletic or contain significant levels of intraspecific genetic diversity. Another Old World natricine genera, *Xenochrophis* is also found to be non-monophyletic. Our results indicate that further taxonomic revisions are needed in Natricinae, at multiple levels.

Key words: Natricinae, *Amphiesma*, *Hebius*, *Herpetoreas*, Snakes, new species, Southeastern Asia, systematics

Introduction

The genus *Amphiesma* sensu lato is one of the largest and most diverse groups in Natricine, with at least 42 species (Pyron *et al.* 2011; Guo *et al.* 2012; Uetz 2013). The members of this group are generally small- or medium-sized, with total lengths not exceeding one meter (Zhao 2006). They are terrestrial to semiaquatic, oviparous, and generally considered harmless (non-venomous). Species in this group also have a wide distribution throughout southern, eastern, and southeastern Asia, ranging from Pakistan and India to eastern China, north into southernmost Russia and Japan, and southwards to Sumatra and Sulawesi (Fig. 1; see Uetz 2013).

Based on morphological characters including hemipenial morphology, dentition, and external scalation, Malnate (1960) divided the genus *Natrix* sensu lato into several genera, revalidating the genus *Amphiesma*, which had been erected by Duméril, Bibron, and Duméril (1854) with the type species *A. stolatum*. The diagnostic characters of *Amphiesma* are defined as: hemipenes and sulci spermaticus simple; maxillary teeth in continuous series, gradually becoming larger posteriorly in the series or the last two teeth abruptly enlarged; terrestrial; internasals broad anteriorly, nostrils lateral; apical pits present or absent (Malnate 1960).

Due to their wide distribution, secretive habits, rarity of many species, and cryptic diversity, it is very difficult to collect the samples needed for a comprehensive systematic study on this group. A recent molecular study of Natricinae found that this genus is paraphyletic (Guo *et al.* 2012). A similar result was also found in subsequent works (Pyron *et al.* 2013a, b). However, incomplete sampling in these works precluded a taxonomic

H. conelarum, ***H. craspedogaster***, ***H. deschauenseei***, *H. flavifrons*, *H. frenatum*, *H. groundwateri*, *H. inas*, *H. ishigakiense*, ***H. johannis***, *H. kerinciense*, ***H. khasiense***, *H. leucomystax*, ***H. metusium***, *H. miyajimae*, ***H. modestum***, *H. monticola*, *H. nicobariense*, ***H. octolineatum***, ***H. optatum***, ***H. parallelum***, *H. pealii*, *H. petersii*, ***H. popei***, *H. pryeri*, *H. sanguineum*, *H. sarasinorum*, *H. sarawacense*, ***H. sauteri***, ***H. venningi***, ***H. vibakari***, *H. viperinum*, and *H. xenura*.

Notes. Species in bold are sampled in the molecular phylogeny, and confidently placed in *Hebius*. The remaining 23 species are placed tentatively, as this group contains the majority of morphological variation and geographic coverage of the former *Amphiesma*, and thus it seems likely that most of these species are allied with *Hebius*. However, it is possible that future studies will show that some are actually placed in *Amphiesma* sensu stricto or *Herpetoreas*. Gender of name is masculine. Several of these taxa are not monophyletic, and thus likely contain multiple cryptic species.

Conclusion

This study is the first presenting an overview of the relationships of Asian keelback snakes of *Amphiesma* sensu lato in the framework of a multi-locus molecular phylogeny. Although not all species were included and analyzed, the data generated and results presented here will benefit subsequent work on the systematics and taxonomy of this group. Future studies should focus on addressing the specific boundaries and distribution, and resolving the genus-level taxonomy of *Amphiesma* sensu stricto, *Atretium*, *Rhabdophis*, and *Xenochrophis*.

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