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Integrative taxonomy and phylogeny-based species delimitation of Philippine water monitor lizards (*Varanus salvator* Complex) with descriptions of two new cryptic species

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Abstract

We describe two new species of morphologically cryptic monitor lizards (genus *Varanus*) from the Philippine Archipelago: *Varanus dalubhasa* **sp. nov.** and *V. bangonorum* **sp. nov.** These two distinct evolutionary lineages are members of the *V. salvator* species complex, and historically have been considered conspecific with the widespread, northern Philippine *V. marmoratus*. However, the new species each share closer phylogenetic affinities with *V. nuchalis* (and potentially *V. palawanensis*), than either does to one another or to *V. marmoratus*. Divergent from other recognized species within the *V. salvator* Complex of water monitors by as much as 3.5% pairwise genetic distance, these lineages are also distinguished by unique gular coloration, metrics of body size and scalation, their non-monophyly with “true” *V. marmoratus*, and insular allopatric distributions, suggesting biogeographically distinct and unique evolutionary histories. We compare the new species with the most geographically proximate and phenotypically relevant lineages. Although we show that these new taxa are nearly indistinguishable morphologically from *V. marmoratus*, both species can be readily distinguished from their closest relatives (each’s respective sister taxon, *V. palawanensis* and *V. nuchalis*) by traditional morphological characters. Our findings underscore the high herpetological diversity and biogeographical complexity of vertebrates in the Philippines, and further emphasize the need for detailed study of species-level diversity, mechanisms of reproductive isolation, gene flow, and biologically relevant boundaries between taxa within the *V. salvator* Complex.

Key words: biogeography, cryptic diversity, Southeast Asia, Varanidae, within-island speciation

Introduction

The past decade has seen a paradigm shift in methods of species delimitation. The addition of multi-locus, molecular phylogenies and robust biogeographical reconstructions to the toolkits of systematists and taxonomists has led to rigorous pluralistic species delimitation approaches (derived from multiple sources of data). When coupled with the increased availability of specimen-based information due to continued survey efforts, we find ourselves in the midst of a new generation of biodiversity studies aimed at the identification and description of novel evolutionary lineages in Southeast Asia. A call for integrative approaches to taxonomy has been promoted across disciplines (Wilson 2003, 2004; Dayrat 2005; Vogler & Monaghan 2007; Knapp 2008). Proponents of this perspective suggest that the combined use of classic morphological characters with molecular data, environmental niche information, and biogeographic inference may inform researchers best about the origins and evolutionary trajectories of lineages (Padial *et al.* 2010; Welton *et al.* 2013a).

Many of these studies invoke the Evolutionary Species Concept of Simpson (1961), and Wiley (1978; see also Templeton 1989), and a recent extension of these ideas in the form of the General or “Unified” Species Concept of Mayden (1997, 2002) and de Queiroz (2005, 2007). These applications consider a species a distinctly evolving lineage (ancestor-descendant series of populations) whose members share a common evolutionary trajectory and

Luzon Island, Aurora Province, Municipality of Casiguran, Barangay Casapsipan: KU 323434, 323439; Municipality of Maria Aurora, Barangay Villa Aurora, Sitio Dimani, Aurora Memorial National Park: KU 323435; Municipality of San Luis, Barangay Real, Sitio Minoli: KU 323440; Batanes Province, Municipality of Basco, Barangay Kayvalugangn, Sitio Masupit: KU 314033; Bulacan Province, Municipality of Doña Remedios Trinidad, Barangay Kabayunan, Sitio Langud: KU 329428; Ilocos Norte Province, Municipality of Adams, Barangay Adams: KU 330133.

Varanus nuchalis (7 specimens): Philippines, Masbate Island, Masbate Province, Municipality of Masbate City: KU 335261; Negros Island, Negros Occidental Province, Municipality of Cauayan, Barangay Camalanda-an: KU 305153, 305157; Municipality of Silay City, Barangay Patag: KU 335262; Sibuyan Island, Romblon Province, Municipality of Magdiwang, Barangay Talaba, Mt. Guiting-Guiting Natural Park: KU 305134, 305148; Barangay Tampayan: KU 305172.

Varanus palawanensis (9 specimens): Philippines, Candaraman Island, Palawan Province, Municipality of Balabac: USNM 39928; Malapina Island, Palawan Province, Municipality of Coron: USNM 39929; Palawan Island, Palawan Province, Municipality of Puerto Princessa: KU 79146–50; Puerto Princessa City: KU 327843; Municipality of Brooke's Point, Barangay Mainit, Mainit Falls: KU 309607.

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