



# Is there more than one Crocodile Lizard? An Integrative Taxonomic Approach Reveals Vietnamese and Chinese *Shinisaurus crocodilurus* Represent Separate Conservation and Taxonomic Units



**Gibt es mehr als eine Krokodilschwanzzechse? Ein integrativer taxonomischer Ansatz zeigt, dass vietnamesische und chinesische *Shinisaurus crocodilurus* separate Schutz-, sowie taxonomische Einheiten darstellen**

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## Abstract

The Crocodile lizard *Shinisaurus crocodilurus*, the only living representative of the family Shinisauridae, is a habitat specialist adapted to remote freshwater habitats within evergreen broadleaf forests. Its current distribution is restricted to few small and isolated remnant occurrences in South China and North Vietnam. Multiple anthropogenic threats such as massive habitat destruction and unsustainable over-collection for the international pet trade brought the species to the brink of extinction. We herein employed an integrative taxonomic approach including comprehensive molecular comparisons based on fragments of mitochondrial genes (cytochrome b, partial *ND6*, and partial tRNA-Glu) in concert with in-depth morphological and ecological analyses in order to determine the status of the extant populations. Based on molecular, morphological, and ecological differences, we herein describe a new subspecies, *Shinisaurus crocodilurus vietnamensis* ssp. n., from Vietnam. Our findings emphasize the importance of improved *in situ* conservation measures in both countries, as both China and Vietnam harbor unique Crocodile lizard forms. We also recommend additional *ex situ* conservation measures, *i.e.*, separate conservation breeding management of the subspecies in order to maintain genetic integrity and adjust husbandry conditions according to detected differences in ecological niche occupation.

**Keywords:** Conservation units; Ecology; Molecular biology; Morphology; New subspecies; Shinisauridae

## Introduction

*Shinisaurus crocodilurus* was described as new species, genus and family by [Ahl \(1930\)](#). Previously only known from southern China, it was subsequently reported from Vietnam by [Le and Ziegler \(2003\)](#). An initial preliminary examination of a potential taxonomic separation of the disjunct populations was conducted by [Ziegler, Le, Vu, Hendrix, and Böhme \(2008\)](#), but available data did not reveal unambiguous differences between samples from China and Vietnam. More recently, additional subpopulations have been discovered in Vietnam, all of which are distinct geographically from known Chinese populations ([Hecht et al., 2013](#); [van Schingen, Ha, et al., 2016](#); [van Schingen, Ihlow, et al., 2014](#)). Similar to the observed population decline in China, the Vietnamese subpopulations have decreased within recent years to less than 150 mature individuals ([Huang et al., 2008](#); [van Schingen, Ha, et al., 2016](#); [van Schingen, Schepp, Pham, Nguyen, & Ziegler, 2015](#)). Anthropogenic impacts such as habitat destruction and poaching for the international trade were found to pose main threats to the species, which led to its inclusion in CITES Appendix II and in the IUCN Red List as Endangered ([Nguyen, Hamilton, & Ziegler, 2014](#)). In contrast to earlier conclusions in [Ziegler et al. \(2008\)](#), recent ecological field studies – conducted by our working group in northern Vietnam revealed ecological differences between Vietnamese and Chinese populations; for example, in perch selection ([van Schingen, Pham, et al., 2015](#)). Based on these findings, questions arose necessitating more detailed information both on habitat use and taxonomic status. Our trade analyses also revealed that individuals from Vietnam have already appeared in both local and international pet trade ([van Schingen, Schepp, et al., 2015](#)), which might cause intermixing of individuals from distinct extant populations. To address the above issues, the present study aims to answer the following

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