



<http://dx.doi.org/10.11646/zootaxa.3755.5.3>

<http://zoobank.org/urn:lsid:zoobank.org:pub:B06C2DCA-78B6-46F9-8D4F-1716DD20C4A5>

A new species of karst forest-adapted Bent-toed Gecko (genus *Cyrtodactylus* Gray, 1827) belonging to the *C. sworderi* complex from a threatened karst forest in Perak, Peninsular Malaysia

L. LEE GRISMER¹, DAICUS M. BELABUT^{2,3}, EVAN S. H. QUAH⁴, CHAN KIN ONN⁵, PERRY L. WOOD, JR.⁶ & ROSLI HASIM²

¹Department of Biology, La Sierra University, 4500 Riverwalk Parkway, Riverside, California 92515 USA.

E-mail: lgrismer@lasierra.edu

²Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia.

E-mail: daicus@um.edu.my & roslihashim@um.edu.my

³Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

⁴School of Biological Sciences, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Penang, Malaysia.

E-mail: evanquah@yahoo.com. E-mail: shahrulanuar@gmail.com

⁵Biodiversity Institute and Department of Ecology and Evolutionary Biology, University of Kansas, Lawrence, Kansas 66045, USA.

E-mail: chan@ku.edu

⁶Department of Biology, Brigham Young University, 150 East Bulldog Boulevard, Provo, Utah 84602 USA. E-mail: pwood@byu.edu

Abstract

A new species of Bent-toed Gecko *Cyrtodactylus guakanthanensis* **sp. nov.** of the *C. sworderi* complex is described from a limestone forest in Perak, Peninsular Malaysia whose karst formations at the type locality are within an active quarry. *Cyrtodactylus guakanthanensis* **sp. nov.** can be distinguished from all other Sundaland species by having the following suite of character states: adult SVL 77.7–82.2 mm; moderately sized, conical, weakly keeled, body tubercles; tubercles present on occiput, nape, and limbs, and extend posteriorly beyond base of tail; 37–44 ventral scales; no transversely enlarged, median, subcaudal scales; proximal subdigital lamellae transversely expanded; 19–21 subdigital lamellae on fourth toe; abrupt transition between posterior and ventral femoral scales; enlarged femoral scales; no femoral or precloacal pores; precloacal groove absent; wide, dark postorbital stripes from each eye extending posteriorly to the anterior margin of the shoulder region thence forming a transverse band across the anterior margin of the shoulder region; and body bearing five (rarely four) wide, bold, dark bands. Destruction of the karst microhabitat and surrounding limestone forest will extirpate this new species from the type locality and perhaps drive it to complete extinction given that it appears to be restricted to the particular microhabitat structure of the type locality and is not widely distributed throughout the karst formations. As with plants and invertebrates, limestone forests are proving to be significant areas of high herpetological endemism and should be afforded special conservation status rather than turned into cement.

Key words: new species, *Cyrtodactylus*, karst, limestone, conservation, biodiversity, Gua Kanthan, Peninsular Malaysia

Introduction

Karst forests compose some of the most unique microhabitats found in tropical ecosystems. They are generally open canopy forests surrounding formations of ancient limestone and comprised of a number of unique, small, spindly trees and spiny plants adapted to nutrient poor conditions and periodic drought (Kiew 1998). Despite the astonishing degree of floral endemism in karst forests, vertebrate systematists have generally overlooked these areas and thus, only a few specialized vertebrates are known to exploit the unique microhabitats they compose (i.e. Jenkins *et al.* 2004; Alström *et al.* 2010; Woxvold *et al.* 2009). The growing exception to this lack of scientific inquiry is the recent increase in the discovery of highly specialized, endemic species of reptiles found in Peninsular Malaysia. We have been surveying karst forests and their associated limestone formations since 2008 and have discovered seven new karst-adapted species of Rock Geckos (genus *Cnemaspis*: Grismer *et al.* 2008b, c, 2009,

The discovery of *Cyrtodactylus guakanthanensis* **sp. nov.** adds to a growing body of evidence that karst regions should be protected and better studied. If reptiles are an indication of the hidden diversity within these unique habitats, then limestone forests may be some of the most biotically rich habitats in Peninsular Malaysia with a level of herpetological endemism approaching that of Malaysia's islands (see Chan *et al.* 2010; Grismer 2008, 2011b; Grismer *et al.* 2011). Terminating this species before it is discovered, described, and studied is not only illogical, it is tantamount to discarding a wrapped gift before it is opened and its value assessed.

Acknowledgements

Many thanks to Lafarge Malaysia Berhad for their unfailing support of biodiversity inventories at the Gunung Kanthan. We too are grateful to Universiti Malaya's Group (Mohd Rasul Abdullah Halim, Saharul Kasim, Alwyn Cabil, Nur Farahin Mustafa, Nur Sakinah Md Yassin, Lim Tze Shen, Uni Shigehiko, Thary Gazi), Lafarge HQ's Group (Dallen Wong, Farhanah Ahmad Shah, Fatin Hamizah Samni, Nurul Ainie Arifin) and Lafarge Kanthan Plant's Group (Sekar Kaliannan, Jasri Jolan, Mohd Redzuan Mohd Ramli, Muhamad Yusri Abdul Talib, Mohamad Afandi Mat Said, Mohd Hafiz Mohd Shaffi) for field companionship. A research pass (40/200/19 SJ.1105) was issued to LLG by the Economic Planning Unit, A research pass (40/200/19 SJ.1105) was issued to LLG by the Economic Planning Unit, Prime Minister's Department, Malaysia. This research was supported in part by grants to LLG from the College of Arts and Sciences, La Sierra University, Riverside, California and grants to Chan K.O. by the Department of Ecology and Evolutionary Biology fellowship fund, Biodiversity Institute Panorama fund, Graduate Student Organization Research and Travel Award, and the Rafe Brown lab at the University of Kansas, Lawrence, Kansas.

References

- Alström, P., Davidson, P., Duckworth, J.W., Eames, J.C., Trai, T.L., Nguyen, C., Ollson, U., Robinson, C. & Timmins, R. (2010) Description of a new species of *Phylloscopus* warbler from Vietnam and Laos. *Ibis*, 152, 145–168.
- Chan, K.O. & Norhayati, A. (2010) A new species of *Cyrtodactylus* (Squamata: Gekkonidae) from northeastern Peninsular Malaysia, Malaysia. *Zootaxa* 2389, 47–56.
- Chan, K.O., van Rooijen, J., Grismer, L.L., Belabut, D., Akil, M.A.M.M., Jamaludin, R., Gregory, R. & Norhayati, A. (2010) First report on the herpetofauna of Pulau Pangkor, Perak, Malaysia. *Russian Journal of Herpetology*, 17, 139–146.
- Das, I. & Lim, L.J. (2000) A new species of *Cyrtodactylus* (Sauria: Gekkonidae) from Pulau Tioman, Malaysia. *The Raffles Bulletin of Zoology*, 48, 223–231.
- De Rooij, N. (1915) The Reptiles of the Indo-Australian Archipelago. I. Lacertilia, Chelonia, Emydosauria. E. J. Brill Ltd., Leiden, 384 pp.
- Dring, J.C.M. (1979) Amphibians and reptiles from northern Trengganu, Malaysia, with descriptions of two new geckos: *Cnemaspis* and *Cyrtodactylus*. *Bulletin of the British Museum (Natural History)*, 34, 181–241.
- Drummond, A. & Rambaut, A. (2007) Beast: Bayesian Evolutionary Analysis by Sampling Trees. *BMC Evolutionary Biology*, 7, 214.
<http://dx.doi.org/10.1186/1471-2148-7-214>
- Grismer, L.L. (2008) A new species of insular skink (Genus *Sphenomorphus* Fitzinger 1843) from the Langkawi Archipelago, Kedah, West Malaysia with the first report of the herpetofauna of Pulau Singa Besar and an updated checklist of the herpetofauna of Pulau Langkawi. *Zootaxa*, 1691, 53–56.
- Grismer, L.L. (2011a) *Lizards of Peninsular Malaysia, Singapore and Their Adjacent Archipelagos*. Edition Chimaira, Frankfurt am Main, 728 pp.
- Grismer, L.L. (2011b) *Field Guide to the Amphibians and Reptiles of the Seribu Archipelago, Peninsular Malaysia*. Edition Chimaira, Frankfurt am Main, 258 pp.
- Grismer, L.L., Anuar, S., Muin, M.A., Quah, E.S.H. & Wood, P.L. Jr. (2013) Phylogenetic relationships and description of a new upland species of Bent-toed Gecko (*Cyrtodactylus* Gray, 1827) of the *C. sworderi* complex from northeastern Peninsular Malaysia. *Zootaxa*, 3616, 239–252.
<http://dx.doi.org/10.11646/zootaxa.3616.3.2>
- Grismer, L.L., Chan, K.O., Grismer, J.L., Wood, P.L. Jr. & Belabut, D. (2008a) Three new species of *Cyrtodactylus* (Squamata: Gekkonidae) from Peninsular Malaysia. *Zootaxa*, 1921, 1–23.
- Grismer, L.L., Chan, K.O., Nurohuda, N. & Sumontha, M. (2008b) A new species of karst dwelling gecko (genus *Cnemaspis* Strauch 1887) from the border region of Thailand and Peninsular Malaysia. *Zootaxa*, 1875, 51–68.
- Grismer, L.L., Grismer, J.L., Wood, P.L., Jr. & Chan, K.O. (2008c) The distribution, taxonomy, and redescription of the geckos *Cnemaspis affinis* (Stoliczka 1887) and *C. flavolineata* (Nicholls 1949) with descriptions of a new montane species and two new lowland, karst-dwelling species from Peninsular Malaysia. *Zootaxa*, 1931, 1–24.
- Grismer, L.L., Grismer, J.L., Wood, P.L. Jr., Ngo, V.T. & Chan, K.O. (2011) Herpetology on the fringes of the Sunda Shelf: a

discussion of discovery, taxonomy, and biogeography. *Bonner Zoologische Monographien*, 57, 57–97.

- Grismer, L.L., Norhayati, A., Chan, K.O., Belabut, D., Muin, M.A., Wood, P.L. Jr. & Grismer, J.L. (2009) Two new diminutive species of *Cnemaspis* Strauch 1887 (Squamata: Gekkonidae) from Peninsular Malaysia. *Zootaxa*, 2019, 40–56.
- Grismer, L.L., Wood, P.L. Jr., Quah, E.S.H., Shahrul, A., Muin, M.A., Sumontha, M., Norhayati, A., Bauer, A.M., Wangkulangkul, S., Grismer, J.L. & Pauwels, O.S.G. (2012a) A phylogeny and taxonomy of the Thai-Malay Peninsula Bent-toed Geckos of the *Cyrtodactylus pulchellus* complex (Squamata: Gekkonidae): combined morphological and molecular analyses with descriptions of seven new species. *Zootaxa*, 3520, 1–55.
- Grismer, L.L., Wood, P.L. & Lim, K.K.P. (2012b) *Cyrtodactylus majulah*, a new species of Bent-toed Gecko (Reptilia: Squamata: Gekkonidae) from Singapore and the Riau Archipelago. *Raffles Bulletin of Zoology*, 60, 487–499.
- Grismer, L.L., Wood, P.L., Jr., Mohamed, M., Chan, K.O., Heinz, H.M., Sumarli, A.S.-I., Chan, J.A., & Loredó, A.I. (2013) A new species of karst-adapted *Cnemaspis* Strauch, 1887 (Squamata: Gekkonidae) from a threatened karst region in Pahang, Peninsular Malaysia. *Zootaxa*, 3756, 463–472.
- Hikida, T. (1990) Bornean geckonid lizards of the genus *Cyrtodactylus* (Lacertilia: Gekkonidae) with descriptions of three new species. *Japanese Journal of Herpetology*, 13, 91–107.
- Huelsenbeck, J.P. & Ronquist, F. (2001) MRBAYES: Bayesian inference of phylogeny. *Bioinformatics*, 17, 754–755. <http://dx.doi.org/10.1093/bioinformatics/17.8.754>
- Inger, R.F. & King, W. (1961) A new cave-dwelling lizard of the genus *Cyrtodactylus* from Niah. *Sarawak Museum Journal* 11, 274–276.
- Jenkins, P.D., Kilpatrick, C., William, C., Robinson, M.F. & Timmins, R.J. (2004) Morphological and molecular investigations of a new family, genus and species of rodent (Mammalia: Rodentia: Hystricognatha) from Lao PDR. *Systematics and Biodiversity*, 2, 419–454. <http://dx.doi.org/10.1017/s1477200004001549>
- Johnson, C.B., Quah, E.S.H., Anuar, S., Muin, M.A., Wood, Jr., P.L., Grismer, J.L., Greer, L.F., Chan, K.O., Norhayati, A., Bauer, A.M. & Grismer, L.L. (2012) Phylogeography, geographic variation, and taxonomy of the Bent-toed Gecko *Cyrtodactylus quadrivirgatus* Taylor, 1962 from Peninsular Malaysia with the description of a new swamp dwelling species. *Zootaxa*, 3406, 39–58.
- Kiew, R. (1998) Limestone, quartzite and ultramafic vegetation. In: Soepadmo (Ed.), *The Encyclopedia of Malaysia: Plants*. Editions Didier Miller, Singapore, pp. 26–27.
- Manthey, U. & Grossmann, W. (1997) *Amphibien & Reptilien Südostasiens*. Natur und Tier Verlag, Münster, 512 pp.
- Nylander, J., Olsson, U., Alström, P. & Sanmartín, I. (2008) Accounting for phylogenetic uncertainty in biogeography: A Bayesian approach to dispersal-vicariance analysis of the thrushes (Aves: *Turdus*). *Systematic Biology*, 57, 257–268.
- Platnick, N.I., Schwendinger, P.J. & Steiner, H. (1997) Three new species of the spider genus *Liphistius* (Araneae, Mesothelae) from Malaysia. *American Museum Novitates*, 3209, 1–13.
- Posada, D. & Crandall, K.Z. (1998) Modeltest: Testing the Model of DNA Substitution. *Bioinformatics*, 14, 817–818. <http://dx.doi.org/10.1093/bioinformatics/14.9.817>
- Price, L. (2001) *Caves and Karst of Peninsular Malaysia*. Gua Publications, Kuala Lumpur, Malaysia, pp. 3–98.
- Ronquist, F., Teslenko, M., van der Mark, P., Ayres, D.L., Darling, A., Höhna, S., Larget, B., Liu, L., Suchard, M.A. & Huelsenbeck, J.P. (2012) MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology*, 61, 539–542.
- Rösler, H. & Glaw, F. (2008) A new species of *Cyrtodactylus* GRAY, 1827 (Squamata: Gekkonidae) from Malaysia including a literature survey of mensural and meristic data in the genus. *Zootaxa* 1729, 8–22.
- Sabaj Pérez, M.H. (Ed.) (2010) Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an Online Reference. Version 2.0. American Society of Ichthyologists and Herpetologists, Washington, DC. Available from: <http://www.asih.org/> (accessed 8 November 2010)
- Smith, M.A. (1930) The Reptilia and Amphibia of the Malay Peninsula from the Isthmus of Kra to Singapore including the adjacent islands. *Bulletin of the Raffles Museum*, 3, 1–149.
- Stamatakis, A., Hoover, P. & Rougemont, J. (2008) A rapid bootstrap algorithm for the RAxML web servers. *Systematic Biology*, 57, 758–771.
- Swofford, D.L. (2002) *Paup*^{*}*: Phylogenetic Analysis Using Parsimony (and Other Methods), Version 4.0. Sinauer Associates, Sunderland, Massachusetts.
- Taylor, E.H. (1963) The lizards of Thailand. *University of Kansas Science Bulletin*, 44, 687–1077.
- Wilson, D.E. & Reeder, D.M. (Eds.) (2005) *Mammal Species of the World*. John Hopkins University Press, Baltimore, 2142 pp.
- Wood, P.L. Jr., Heinicke, M.P., Jackman, T.R. & Bauer, A.M. (2012) Phylogeny of Bent-toed geckos (*Cyrtodactylus*) reveals a west to east pattern of diversification. *Molecular Phylogenetics and Evolution*, 65, 992–1003. <http://dx.doi.org/10.1016/j.ympev.2012.08.025>
- Wood, P.L. Jr., Quah, E.S.H., Anuar, S. & Muin, M.A. (2013) A new species of owland karst dwelling *Cnemaspis* Strauch 1887 (Squamata: Gekkonidae) from northwestern Peninsular Malaysia. *Zootaxa*, 3691, 538–558. <http://dx.doi.org/10.11646/zootaxa.3691.5.2>
- Woxvold, I.A., Duckworth, J.W. & Timmins, R.J. (2009) An unusual new bulbul (Passeriformes: Pyconotidae) from the limestone karst of Lao PDR. *Forktail* 25, 1–12.
- Zhaoran, X., Burt, B.L., Skog, L.E. & Middleton, D.J. (2008) A revision of *Paraboea* (Gesneriaceae). *Edinburgh Journal of Botany*, 65, 161–347. <http://dx.doi.org/10.1017/s0960428608005106>