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A third new *Cyrtodactylus* (Squamata: Gekkonidae) from Phong Nha-Ke Bang National Park, Truong Son Range, Vietnam

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Abstract

We describe a third cryptic species of the genus *Cyrtodactylus* from Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam. *Cyrtodactylus roesleri* **sp. nov.** is distinguished from the remaining Indochinese bent-toed geckos by a combination of the following characters: size small, with a maximum SVL of 75.3 mm; dorsal pattern consisting of dark nuchal band and 4–5 sometimes irregularly shaped dark transversal bands between limbs; ventrals in 34–40 longitudinal rows at midbody; continuous series of 20–28 precloacal and femoral pores in males; subcaudal scales transversally enlarged. It is the 15th new reptilian taxon described as new from the karst forests of Phong Nha – Ke Bang National Park in the past decade. In addition, it is the 19th species of *Cyrtodactylus* known from Vietnam and the third *Cyrtodactylus* occurring in sympatry in the karst forests of Phong Nha – Ke Bang National Park.

Key words: *Cyrtodactylus roesleri* **sp. nov.**, Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam, morphology, taxonomy

Introduction

The genus *Cyrtodactylus* forms the most diverse group of gekkonid lizards to date (e.g., Kluge 2001), with the Indochinese Peninsula representing one of the centres of undiscovered species diversity. There has been an enormous increase in the number of new species of the genus *Cyrtodactylus* recently described from Vietnam. The *Cyrtodactylus* species number in that country remarkably increased from three recognized species in 1997 (*C. condorensis, C. intermedius, C. irregularis*) to 18 species in 2008 (see Ngo & Bauer 2008), namely *C. badenensis, C. cattienensis,* C. *caovansungi, C. chauquangensis, C. cryptus, C. eisenmanae, C. grismeri, C. hontreensis, C. huynhi, C. nigriocularis, C. paradoxus, C. phongnhakebangensis, C. pseudoquadrivirgatus, C. takouensis,* and *C. ziegleri* (Ziegler *et al.* 2002; Heidrich *et al.* 2007; Orlov *et al.* 2007; Nazarov *et al.* 2008; Ngo 2008; Ngo & Bauer 2008; Ngo *et al.* 2008; Rösler *et al.* 2008; Geissler *et al.* 2009). Some of these newly described species even occur in sympatry (Ngo & Bauer 2008) as it is the case for *C. phongnhakebangensis* and *C. cryptus* in central Vietnam's Phong Nha – Ke Bang National Park (Ziegler *et al.* 2002; Heidrich *et al.* 2007). This National Park is famous for a series of recent herpetological discoveries: 14 new species of amphibians and reptiles have been described from this karst forest region in the past decade only (see overview in Ziegler & Vu 2009). Nazarov *et al.* (2008) further pointed to a possibly third undescribed, cryptic *Cyrtodactylus* occurring in the Phong Nha – Ke Bang region. This gave reason to more closely study the

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variation within *C. cryptus* and *C. phongnhakebangensis* sensu lato from Phong Nha – Ke Bang. Detailed taxonomic study of *Cyrtodactylus* from this karst forest region revealed distinct genetic differences in addition to distinct and continuous differences in pholidosis and size, and thus proved the existence of a third cryptic, unnamed species from Phong Nha – Ke Bang which is described herein.

Material and methods

Specimens of the new *Cyrtodactylus* were collected in and nearby Phong Nha – Ke Bang National Park by Nikolai Orlov in July 2003 (n = 14; 10 males, 4 females), by Thomas Ziegler and Astrid Heidrich in June 2006 (n = 1 female), and by Thomas Ziegler and Kien Ngoc Dang in May 2009 (n = 5; 4 males, 1 subadult). Specimens were anaesthetized, ethanol-fixed and subsequently deposited in the collections of the: Institute of Ecology and Biological Resources, Vietnamese Academy of Science and Technology Hanoi (IEBR), Vietnam; Department of Herpetology and Ichthyology, Muséum d'histoire naturelle, Geneva (MHNG), Switzerland; Zoological Museum of the Vietnam National University, Hanoi (VNUH), Vietnam; Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK), Germany; Zoological Institute, St. Petersburg (ZISP), Russian Academy of Sciences, Russia; Zoological Museum, Moscow State University (ZMMU), Moscow. For comparisons, *C. phongnhakebangensis*, and further *Cyrtodactylus* species deposited in the collections of Senckenberg Naturhistorische Sammlungen Dresden, Museum für Tierkunde (MTD), VNUH, ZFMK, ZISP and ZMMU were studied.

Molecular data were collected to examine the sequence differentiation between the new *Cyrtodactylus* species from Phong Nha – Ke Bang National Park and the syntopical species *C. phongnhakebangensis* and *C. cryptus*. Morphologically, *Cyrtodactylus* **sp. nov.** can easily be differentiated from all of its congeners (compare discussion below). But to confirm the proposed full species status of the new taxon and to exclude the possibility that we are dealing here only with a so-called 'morphospecies', a genetic comparison of *Cyrtodactylus* **sp. nov.** with the two known sympatric *Cyrtodactylus* species *C. cryptus* and *C. phongnhakebangensis* using the uncorrected p-distances of the mitochondrial 16S rRNA gene has been calculated. Also, to be able to differentiate between the typical interspecific 16S genetic differences within the genus *Cyrtodactylus* and intraspecific variation we further sequenced two additional Vietnamese *Cyrtodactylus* species, *C. pseudoquadrivirgatus* and *C. ziegleri* and compared them with the species from the Phong Nha - Ke Bang National Park.

We sequenced a portion of the mitochondrial 16S rRNA gene (605 bp, including gaps) of the holotype of *Cyrtodactylus* **sp. nov.** (ZFMK 89377) from the surroundings of Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam, as a representative of the new species (GenBank accession number: GU591310), and compared it with the two sympatric species *C. phongnhakebangensis* (ZFMK 76193, MHNG 2713.80) (GenBank accession numbers: GU591308, GU591307) and *C. cryptus* (ZFMK 86037) (GenBank accession number: GU591306), as well as with the following two additional representatives from the genus *Cyrtodactylus*: *C. pseudoquadrivirgatus* (private collection Herbert Rösler) from Dong Nai Province, Vietnam (GenBank accession number: GU591309), and *C. ziegleri* (MHNG 2713.81) from Dac Lac Province, Vietnam (GenBank accession number: GU591311).

DNA was extracted using a modified Chelex-Protocol (Walsh *et al.* 1991, Schmitz 2003) or using the peqGold Tissue DNA Mini Kit (PEQLAB Biotechnologie GmbH). The primers 16sar-L (light chain; 5' – CGC CTG TTT ATC AAA AAC AT – 3') and 16sbr-H (heavy chain; 5' – CCG GTC TGA ACT CAG ATC ACG T – 3') of Palumbi *et al.* (1991) were used to amplify a section of the mitochondrial 16S ribosomal RNA gene. PCR cycling procedure followed Schmitz *et al.* (2005). PCR products were purified using QIAquick purification kits (Qiagen). Sequences (including complimentary strands for assuring the accuracy of the sequences) were obtained using an automatic sequencer (ABI 377). The obtained sequences (lengths referring to the aligned sequences including gaps) comprised 605 bp. Sequences were aligned using ClustalX (Thompson *et al.* 1997, default parameters) and manually checked using the original chromatograph data in the program BioEdit (Hall 1999). We used the pairwise alignment option of BioEdit to compute the

uncorrected pairwise distances for all sequences. A neighbor-joining tree (NJ) was calculated with PAUP* 4.0b10 (Swofford 2002) and a maximum-likelyhood tree was recovered using the PhyML 3.0 bioinformatics platform at the LIRMM (Laboratoire d'Informatique de Robotique et de Microélectronique) at Montpellier (http://www.atgc-montpellier.fr/phyml/) (Guidon & Gascuel 2003). Additionally, we used bootstrap analyses with 20000 and 1000 pseudoreplicates for NJ and ML, respectively to evaluate the relative branch support for the two phylogenetic analyes.

Measurements, except body and tail lengths, were taken with a slide-calliper (to the nearest 0.1 mm). Abbreviations are as follows: snout vent length (SVL), from tip of snout to vent; tail length (TaL), from vent to tip of tail; maximum head height (HH), from occiput to underside of jaws; head length (HL), from tip of snout to retroarticular process of jaw; maximum head width (HW); greatest diameter of orbit (OD); snout to eye distance (SE), measured from tip of snout to anteriormost point of eye.

Scale counts were taken as follows: supralabials (SL); infralabials (IL); nasal scales surrounding nare, from rostral to labial (but except counting rostral and labial), i.e. nasorostral, supranasal, postnasals (N); postrostrals or internasals (IN); eyelid fringe scales or ciliaria (CIL); postmentals (PM); granular scales surrounding dorsal tubercles (GST); ventral scales in longitudinal rows at midbody (V); number of scales along the midbody from mental shield to anterior edge of cloaca (SLB); femoral pores (FP); precloacal pores in males (PP); postcloacal tubercles (PAT); subdigital lamellae under the fourth digit (LD4); subdigital lamellae under the fourth toe (LT4). All bilateral scale counts were taken on the right side of body only. For terminology see Rösler (1995).

Results

The molecular data fully support our morphological findings. Both used tree-building algorithms (NJ and ML) recovered the same well-supported topology, the only difference being a non-significant support for the sister-group relationship between *C. pseudoquadrivirgatus* and *C. cryptus* in the ML boostrap (NJ: 82/ML: 50; ML-tree not shown). The alignment identified two subgroups (Fig. 1) based on the presence or absence of two larger deletions within the 16S gene (see below). These subgroups correspond to the two major clades in the tree (Fig. 1). One group consisted of *Cyrtodactylus* **sp. nov.** and *C. phongnhakebangensis* (no deletion) and the other of the remaining three species (3 deletions of 3 bp, 13 bp and 5 bp), respectively. The uncorrected pairwise interspecific sequence divergence of *Cyrtodactylus* **sp. nov.** (ZFMK 89377) from the surroundings of Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam, compared to the two sympatric species of the Phong Nha – Ke Bang National Park were high, ranging from 7.12%–7.26% towards the male holotype of *C. phongnhakebangensis* (ZFMK 76193) and another, recently collected adult male *C. phongnhakebangensis* (MHNG 2713.80) from the surroundings of Phong Nha – Ke Bang National Park (coll. in May 2009 by T. Ziegler in Minh Hoa District). Intraspecific variation between the two included specimens of *C. phongnhakebangensis* was much lower at 1.36%.

Genetic differences between the latter two mentioned species and the three species with the deletions were, of course, much higher. *Cyrtodactylus* **sp. nov.** differs from the male holotype of the sympatric species *C. cryptus* (ZFMK 86037) by about 17.73%, from *C. pseudoquadrivirgatus* (private collection of Herbert Rösler) from Dong Nai Province, Vietnam by about 17.08% and from *C. ziegleri* (MHNG 2713.81) from Chu Yang Sin National Park, Dac Lac Province, Vietnam by about 17.93%.

If one only compares the three species of the group which have the mentioned deletions though, the interspecific genetic distances are of similar magnitude as between *Cyrtodactylus* **sp. nov.** and *C. phongnhakebangensis*: between *C. pseudoquadrivirgatus* and *C. ziegleri* ca. 8.85%; between *C. pseudoquadrivirgatus* and *C. cryptus* ca. 7.21%; and between *C. cryptus* and *C. ziegleri* ca. 9.01%.

The constantly high interspecific genetic differences, especially when compared to the rather low intraspecific differences in *C. phongnhakebangensis* clearly show that the morphological differences of the new taxon identified by us are characteristic for a new full so-far undescribed species occurring sympatrically in the PNKB National Park.

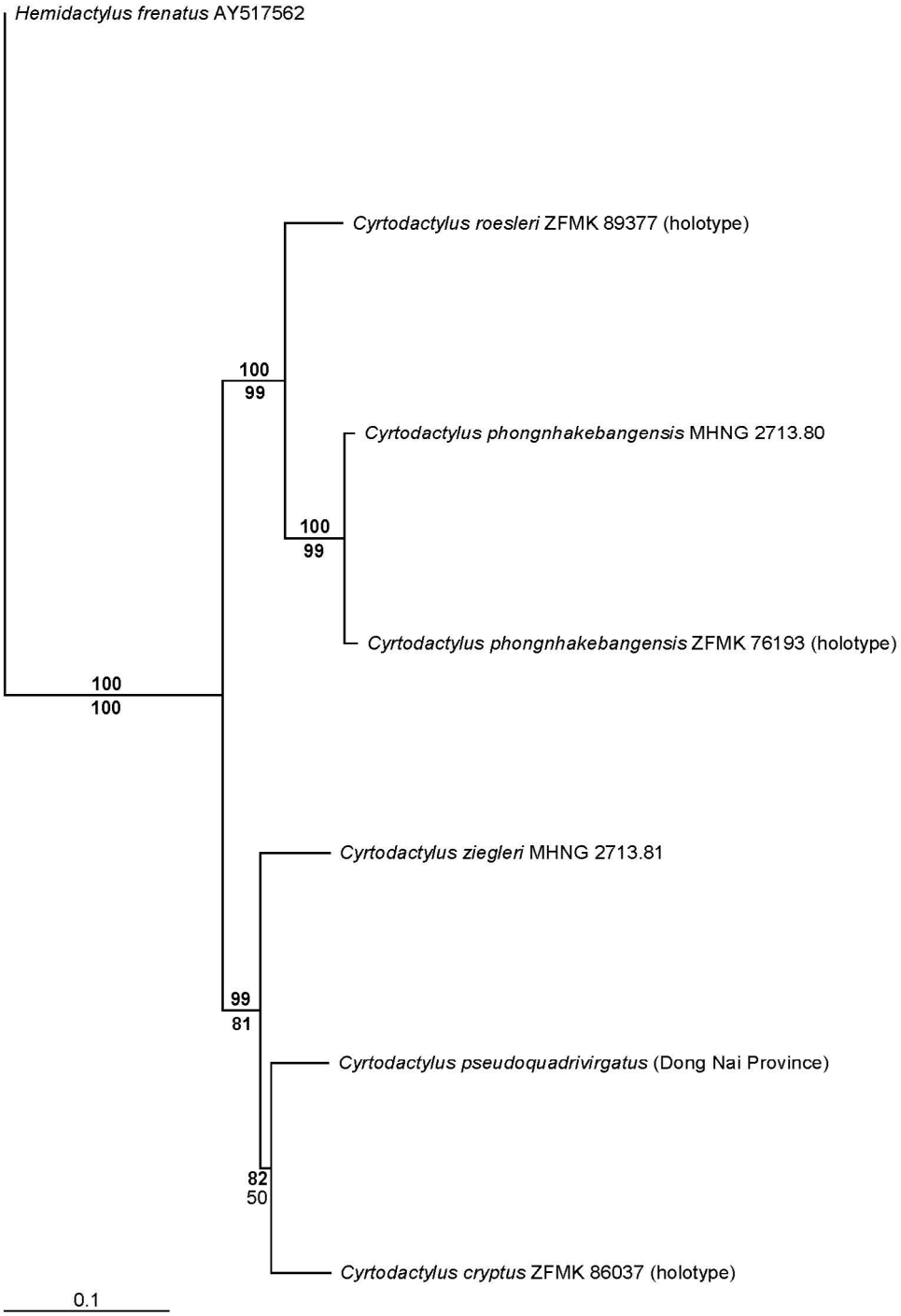

FIGURE 1. Phylogram of the neighbor-joining-tree based on 605 bp of the 16s rRNA gene. Values above the nodes are bootstrap pseudoreplicates (20000 replicates). Values below the nodes are the corresponding maximum-likelihood bootstrap supports (1000 replicates). Significantly supported values are in bold. *Hemidactylus frenatus* (AY517562) was used as outgroup.

The identification of two species groups within *Cyrtodactylus* (Fig. 1) with seemingly characteristic genetic trademarks (absence of presence of the above mentioned deletions) may be the first indications that the very speciose genus *Cyrtodactylus* (currently with about 100 described species) may indeed consist of more than one monophyletic lineage and may be subject to splitting on the genus or subgenus level in the near future.

In view of the constant high genetic interspecific differences between *Cyrtodactylus* **sp. nov.** and especially the sympatric species *C. phongnhakebangensis* and *C. cryptus*, the fact that the interspecific

differences between well established *Cyrtodactylus* species in the group with the identified deletions in the 16S gene are of near identical magnitude than those between *C. phongnhakebangensis* and *Cyrtodactylus* **sp. nov.**, together with distinct morphological differences (see below) we regard *Cyrtodactylus* **sp. nov.** as representing a new species, which we describe herein as:

FIGURE 2. Male holotype of *Cyrtodactylus roesleri* **sp. nov.** in life (ZFMK 89377). Photo T. Ziegler

***Cyrtodactylus roesleri* sp. nov.**

Holotype. Adult male (ZFMK 89377) collected on 22 May 2009 by Thomas Ziegler and Kien Ngoc Dang nearby Phong Nha – Ke Bang National Park, Minh Hoa District, Quang Binh Province, Vietnam.

Paratypes. Three adult males (IEBR A.0932, MHNG 2713.79, VNUH 220509) and one juvenile (ZFMK 89378) from the type locality, collected by Thomas Ziegler and Kien Ngoc Dang on 22 May 2009; one adult female (ZFMK 86433) collected by Thomas Ziegler and Astrid Heidrich in June 2006 within Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam; ten adult males (ZISP 25777-25782, ZMMU R-13061-1, ZMMU R-13061-2, ZMMU R-13061-3, ZMMU R-13061-4) and four adult females (ZISP 25783, ZISP 25784, ZMMU R-13061-5, ZMMU R-13051-6) collected by Nikolai Orlov in July 2003 within Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam.

Diagnosis. A small, slender *Cyrtodactylus* with a maximum SVL of 75.3 mm, distinguished from all congeners by the combination of the following characters: 1) dorsal pattern consisting of dark nuchal band and 4–5 sometimes irregular shaped dark transversal bands between limbs; 2) dorsal tubercles present on the back of head, body, hind limbs and tail base; 3) ventrals in 34–40 longitudinal rows at midbody; 4) lateral folds absent; 5) continuous series of 20–28 precloacal and femoral pores in males; 6) enlarged femoral scales present; 7) enlarged precloacal scales present; 8) precloacal groove absent; 9) 5–8 postcloacal spurs in both sexes; 10) subcaudal scales transversally enlarged; 11) fourth toe with 17–21 subdigital lamellae.

Description of holotype. Size small (SVL 65.7 mm, TaL 77.5 mm), distance from posterior corner of eye to anterior margin of ear including ciliaria 5.0 mm, maximum horizontal ear diameter 1.0 mm; for further measurements see Table 1.

Rostral wider than high (RW 3.3 mm, RH 1.9 mm, RW/RH 1.7) with an inverse Y-shaped median suture; supralabials 11(r)/11(l); scales between orbit and the eighth supralabial 3/3, small; infralabials 9(r)/8(l); nares bordered by rostral anteriorly, first supralabial laterally and 3(r)/4(l) nasals posteriorly; supranasals separated from each other by two nasorostrals and an internasal; medial snout scales granular, those in contact with and nearby the supralabials flattened and approximately 2–4 times larger than the medial scales; upper anterior ciliaries 2–3 times larger than posterior cilaries; head scales somewhat granular, one-half as large as median snout scales; back of dorsal head and temporal region with rounded, conical tubercles, 2–3 times larger than the surrounding scales; mental triangular, slightly wider than rostral; 1 pair of enlarged postmentals, longer than wide, bordering with mental anteriorly, first two labials on the right side, first labial on the left side, and followed by 2 pairs of enlarged gular scales, and some merged smaller gular scales in between; dorsal scales granular, as large as or somewhat larger than medial snout scales; dorsal tubercles round, conical, weakly keeled posteriorly, surrounded by 8–9 granular scales, tubercles forming about 13 ill-defined (irregular) longitudinal rows at midbody; ventral scales smooth, medial scales 2–3 times larger than the dorsal granules, 39 longitudinal rows at midbody; lateral folds absent; upper and lower arm lacking enlarged tubercles; dorsal hind limb covered with scattered, smooth, flat to conical tubercles; 1–2 outermost femoral pores bearing scales enlarged, attached to nine enlarged, poreless femoral scales on each hind limb; fingers and toes lacking distinct webbing; lamellae numbering 14 under first finger (5 basal and 9 distal lamellae), 17 under fourth finger (6 basal and 11 distal lamellae), 14–15 under first toe (5 basal and 9–10 distal lamellae), and 19–20 (7–8 basal and 12 distal lamellae) under fourth toe; claws surrounded by a small scale on upper and a large scale on lower sides; 28 contiguous precloacal and femoral pores in an angular series; precloacal region covered by a patch of about 24 enlarged scales; precloacal groove absent; 5(r)/6(l) enlarged postcloacal tubercles on lateral surface of hemipenial swelling; dorsal tail surface only at early base with distinct tubercles; subcaudals distinctly enlarged, flat, smooth. The apex of the hemipenis is thickened and deeply bifurcated. Sulcus spermaticus thin, deep, bordered by bulging lips; the sulcus bifurcates in the upper truncus region. Apical lobes with spinose calyces.

FIGURE 3. Preserved holotype of *Cyrtodactylus roesleri* **sp. nov.** (ZFMK 89377): Ventral view of the cloacal region with everted hemipenes. Photo T. Ziegler

FIGURE 4. Male paratype of *Cyrtodactylus roesleri* **sp. nov.** in life (VNUH 220509) with five dorsal bands between limbs. Photo T. Ziegler

FIGURE 5. Adult male paratype of *Cyrtodactylus roesleri* **sp. nov.** in life with asymmetrical dorsal banded pattern and with original tail. Photo N. Orlov

TABLE 1. Selected measurements and morphological characters of the male holotype and male paratypes of *Cyrtodactylus roesleri* sp. nov.; measurements in mm, * = regenerated or broken tail, m = mean, min. = minimum, max. = maximum; s = standard deviation.

	ZFMK 89377	IEBR A.0932	MHNG 2713.79	VNUH 220509	ZISP 25777	ZISP 25778	ZISP 25779	ZISP 25780	ZISP 25781	ZISP 25782	ZMMU R–13061–1	ZMMU R–13061–2	ZMMU R–13061–3	ZMMU R–13061–4	min.–max. (m ± s)
SVL	65.7	65.2	51.1	70.3	65.2	61.5	52	65.2	67.6	73.5	69.2	66.2	62,6	71.3	max. 73.5
TaL	77.5	83.5	63.4	61.0*	90	*	*	*	69*	90	101	86	83	67*	max. 101
HH	6.4	6.7	5.9	7.2	6.8	6.5	5.4	7.2	7.0	6.8	7.8	7.4	6.6	6.8	max. 7.8
HL	18.4	17.1	15.4	18.7	18.0	17.8	15.7	18.5	19.0	20.5	19.0	18.8	18.0	19.1	max. 20.5
HW	12.0	11.1	9.7	12.4	11.6	11.8	10	11.7	12.3	12.4	12.7	12.4	12.0	12.5	max. 12.7
OD	4.4	4.0	3.9	4.4	4.0	3.9	3.2	4.0	4.3	4.6	4.2	4.0	3.9	4.5	max. 4.6
SE	7.6	7.5	6.7	7.9	7.0	7.3	6.1	7.3	7.3	8.0	7.5	7.4	7.3	7.2	max. 8.0
SL	11	10	11	12	10	10	10	11	11	12	11	11	10	10	10–12 (10.7±0.7)
IL	9	8	9	8	9	9	8	9	9	10	8	9	9	7	7–10 (8.6±08)
N	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
IN	1	1	1	1	0	0	0	0	1	0	1	0	1	1	0–1 (0.6±0.5)
CIL	23	22	21	18	20	21	18	21	24	24	24	20	20	21	18–24 (21.2±2.0)
PM	2	2	2	2	3	2	2	3	2	3	2	3	2	2	2–3 (2.3±0.5)
GST	8–9	7–8	8	7–8	7	8	7	8	7	8	8	7	7	7	7–9 (7.6±0.6)
V	39	39	34	38	36	37	36	38	34	38	40	40	36	36	34–40 (37.2±2.0)
SLB	171	178	169	187	182	167	158	165	170	170	168	162	168	168	158–187 (170.2±7.6)
PP + FP	28	23	21	21	22	24	23	20	20	26	25	25	23	25	20–28 (23.3±2.4)
PAT	5	5	6	5	6	6	5	–	7	6	6	6	7	6	5–7 (5.9±0.7)
LD4	6+11	7+11	6+12	6+12	7+12	6+12	7+11	7+10	7+11	7+12	6+11	6+11	6+11	6+12	17–19 (17.8±0.7)
LT4	7+12	6+12	6+11	7+13	9+11	8+12	8+12	7+11	8+12	8+12	7–12	8+12	7+12	8+12	17–20 (19.3±1.0)

FIGURE 6. Portrait of an especially brightly coloured male paratype of *Cyrtodactylus roesleri* **sp. nov.** in life (IEBR A.0932). Photo T. Ziegler

Coloration in ethanol. Dorsal head light brownish grey with some ill-defined dark blotches especially in the back; nuchal band not distinctly broadened, dark brown and with white margins, extending from the neck to the posterior margins of eyes; between anterior margin of eye and nostril some ill-defined and in part connected dark blotches; labials greyish-brown without distinct dots. Dorsum brownish-grey with 4 dark brown transverse bands in between limbs; dark bands anteriorly somewhat lighter, with light margins; anterior three dorsal bands distinctly widened towards vertebral region; the last, not distinctly widened dorsal band is located in the sacral region; more or less distinct dark lateral blotches are discernible between dorsal bands; flanks greyish-brown marbled, somewhat lighter than dorsal surface and darker than cream to grey venter. Lower side of toes and fingers grey; dorsal limbs and digits greyish-brown with dark marbling or blotches. Tail dorsum with about 12 light (whitish-grey) transversal bands; tail tip light; in front of the anterior 4–5 light bands there are black transversal bands; the wide interspaces between these black and white or only white transversal bands are grey in colour. Ventral side of tail anterior dark grey with white spots, posterior paler.

For coloration in life see Figs. 2 and 4–6. Especially conspicuous are yellow portions in the pattern, such as the light borders of the dorsal bands including the nuchal and neck band. Here, especially the dorsal tubercles are brightly yellow in colour. Also parts of the ciliaries, the posterior supralabials, and the overall surface colour of limbs, head and body are yellow to yellowish-beige (which seemingly fades to brownish grey in preservative).

Variation of paratypes. For the variation of paratypes see Tables 1–2. Males are somewhat smaller than the females: SVL males 51.1–73.5 mm (64.8±6.5 mm), n = 14; females 63.5–75.3 mm (71.7±4.9 mm), n = 5. Paratypes largely correspond with the description of the holotype. Noteworthy differences are up to about 19 ill-defined dorsal tubercle rows at midbody, 7–10 enlarged poreless femoral scales on each hind limb in males, and minimally 10 enlarged scales in the precloacal region. Concerning the colour pattern, most of the male and female paratypes show a more or less distinct dark stripe stretching from the anterior corner of the eye towards the nostril. Several paratypes also have up to five dark dorsal bands between limbs, and some of them are irregular shaped (such as Y-shaped), medially interrupted or developed only at one side of the dorsum.

Dark lateral blotches between dorsal bands are only discernible in some paratypes and are also lacking in the single juvenile paratype. The male paratype IEBR A.0932 is especially brightly coloured (see Fig. 6), with intensive black blotches on the head, deep black transversal dorsal bands and bright yellow tubercles in lighter interspaces. In this specimen, the gular region is dark grey with light blotches in preservative, which are yellow in live. Such a throat pattern is more or less also discernible in some other adult paratypes as well as in the juvenile paratype. The latter specimen also has a white posterior half of the tail with only faint dark transversal bands, which differs from the adult condition. Original tails of adults may show thin, bright yellow borders of dark transversal bands, with light interspaces of last third of tail being white.

Comparisons. Comparisons are based on the original descriptions or descriptions provided in broader faunal and taxonomic publications (e.g., Smith 1920, 1921, 1935; Taylor 1963; Ulber & Grossmann 1991; Ulber 1993; Darevsky & Szczerbak 1997; Manthey & Grossmann 1997; Ziegler *et al.* 2002; Bauer 2002, 2003; Bauer *et al.* 2002, 2003; David *et al.* 2004; Pauwels *et al.* 2004; Grismer 2005; Grismer & Leong 2005; Ngo & Grismer 2006; Nguyen *et al.* 2006; Grismer *et al.* 2007; Heidrich *et al.* 2007; Hoang *et al.* 2007; Orlov *et al.* 2007; Grismer & Norhayati 2008; Grismer *et al.* 2008; Nazarov *et al.* 2008; Ngo 2008; Ngo & Bauer 2008; Ngo *et al.* 2008; Rösler & Glaw 2008; Rösler *et al.* 2008; Bauer *et al.* 2009; Geissler *et al.* 2009).

TABLE 2. Selected measurements and morphological characters of the female and juvenile paratypes of *Cyrtodactylus roesleri* **sp. nov.**; f = female, j = juvenile, measurements in mm, * = regenerated or broken tail, m = mean, min. = minimum, max. = maximum, s = standard deviation.

	ZFMK 86433	ZISP 25783	ZISP 25784	ZMMU R-13061-5	ZMMU R-13061-6	min.-max. (m ± s)	ZFMK 89378
Sex	f	f	f	f	f		Juv.
SVL	75.3	71.3	63.5	74.6	74	max. 75.3	38.3
TaL	74.2	86.0	*	74.0*	65.0*	max. 86.0	44.4
HH	7.7	8.0	6.7	7.5	7.5	max. 8.0	4.7
HL	20.3	20.4	17.8	20.3	21.0	max. 21.0	10.9
HW	14.0	12.9	11.7	13.6	14.3	max. 14.3	7.0
OD	4.6	4.6	4.2	4.6	4.4	max. 4.6	3.0
SE	8.3	8.3	6.7	8.2	8.4	max. 8.4	4.8
SL	12	11	10	12	12	10–12 (11.4±0.9)	9
IL	9	9	8	10	10	8–10 (9.2±0.8)	9
N	3	3	3	3	3	3	3
IN	1	0	0	1	0	0–1 (0.4±0.6)	0
CIL	22	19	22	21	20	19–22(20.8±1.3)	24
PM	2	3	2	2	3	2–3 (2.4±0.6)	2
GST	7–8	8	9	8	8	7–9 (8.0±0.6)	8–9
V	37	37	36	36	36	36–37 (36.4±0.6)	39
SLB	186	168	189	172	179	168–189 (178.8±8.9)	-
PP + FP	22	22	18	18	17	17–22 (19.4±2.4)	14
PAT	6	5	5	5	8	5–8 (5.8±1.3)	5
LD4	7+12	7+11	7+10	6+11	6+11	17–19 (17.6±0.9)	6+12
LT4	7+14	8+12	7+11	7+10	8+11	17–21 (19.0±1.6)	7+12

TABLE 3. Morphological characters of *Cyrtodactylus roesleri* sp. nov. compared with its Vietnamese congeners (modifed after Geissler *et al.* 2009, ordered by characters); m: male; f: female; –: characters unobtainable from literature.

	SVL (mm)	TL (mm)	V	EFS	FP	EPS	PP (in males)	LF4	LT4	Enlarged subcaudals
C. chauquangensis	90.9–99.3	97–108.3	36–38	absent	absent	present	6–7	16–18	19–23	present
C. phongnhakebangensis	52–96.3	83–110	32–42	–	–	2–6	32–42 (PP + FP)	17–19	17–26	present
C. roesleri sp. nov.	51.1–75.3	63.4–101.0	34–40	7–10	present	present	20–28 (PP + FP)	17–19	17–21	present
C. badenensis	59.3–74.1	58.6–82.4	25–28	absent	absent	present	0	–	18–22	present
C. condorensis	80	100	35–40	present	–	–	4–7	–	–	present
C. grismeri	68.3–95	111.3–115.1	33–38	0	–	19–22	0	16–18	16–19	present
C. paradoxus	52–84	80.8–111	32–40	present	absent	–	0–4	15–18	17–23	present
C. takouensis	74.7–81.1	77.7–91	39–40	3–5	1	present	3–4	16–17	18–20	present
C. nigrocularis	82.7–107.5	70.6–121	42–49	absent	absent	present	0–2	–	17–21	present
C. eisenmanae	76.8–89.2	91–103.8	44–45	4–6	absent	32	0	18–20	17–18	present
C. hontreensis	72.4–88.9	84.2–106.5	40–42	2–5	absent	present	7–8	16	17–19	present
C. intermedius	61–85	80–110	40–50	6–10	–	present	8–10	20	22	present
C. caovansungi	90.4–94	120	38–44	>3	3	present	9	22	23–25	present
C. cryptus	62.5–90.8	63.5–88.4	47–50	absent	absent	16–27	9–11	18–19	20–23	absent
C. pseudoquadrivirgatus	48.6–83.3	55.7–82.3	41–57	absent	absent	1–12	5–9	15–21	16–25	absent
C. irregularis	72–86	66–74	38–45	7–8	–	–	5–7	15–16	18–19	absent
C. huynhi	54.8–79.8	61.5–78.6	43–46	3–5	1–4	present	7–9	15–17	17–20	absent
C. cattienensis	43.5– 69	51–64.7	28–42	3–8	absent	8–21	6–8	12–16	14–19	absent
C. ziegleri	84.6–93	95–107	33–39	8–10	0–6	–	5–8	16–19	18–21	absent

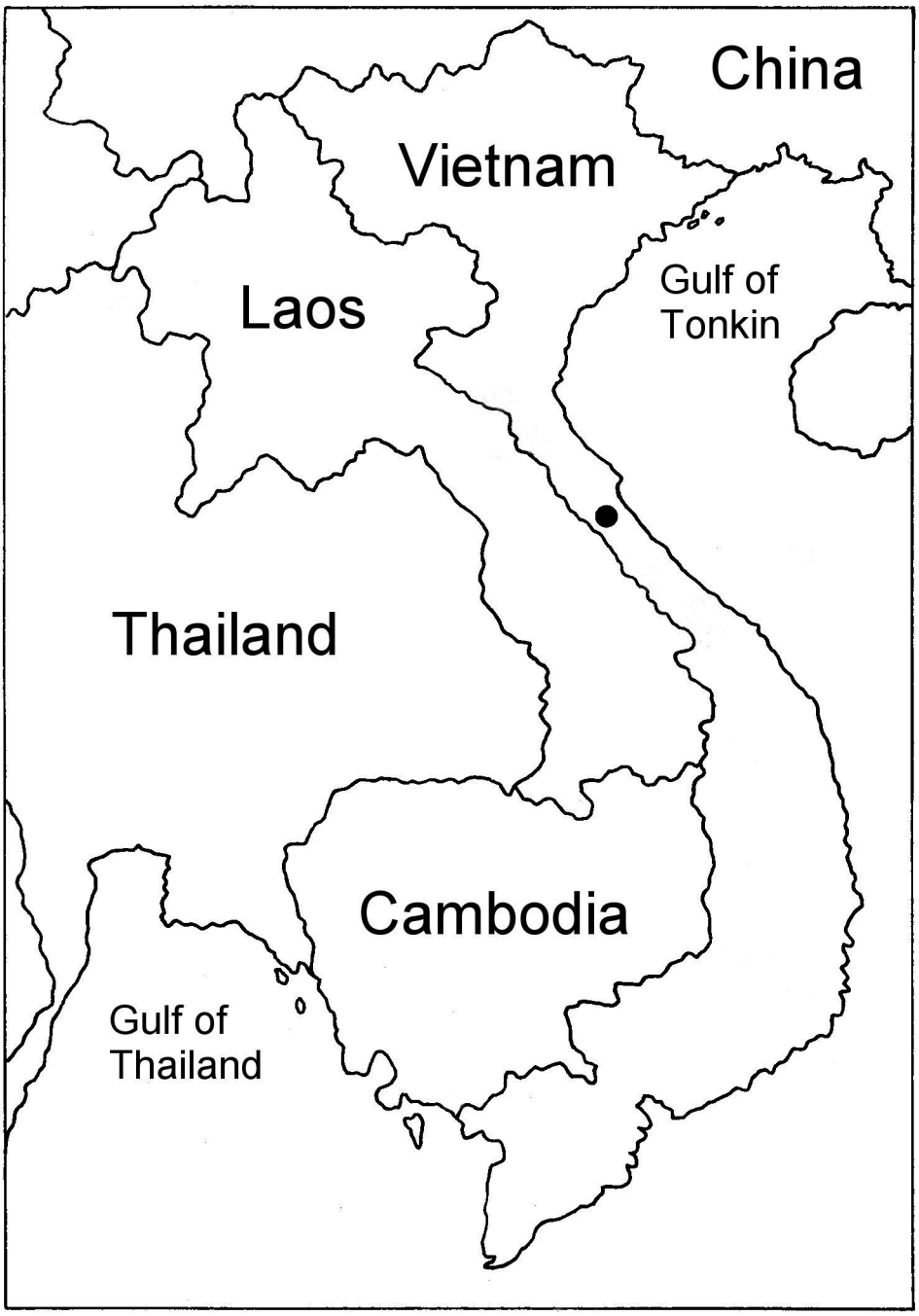

FIGURE 7. Map showing the type locality of *Cyrtodactylus roesleri* **sp. nov.** in Vietnam.

In comparison with Vietnamese congeners, *Cyrtodactylus roesleri* **sp. nov.** is distinguishable from *C. cattienensis*, *C. cryptus*, *C. huynhi*, *C. irregularis*, *C. pseudoquadrivirgatus*, and *C. ziegleri* by the presence of transversally enlarged subcaudals which are lacking in the latter species. *Cyrtodactylus roesleri* **sp. nov.** furthermore has series of 20–28 precloacal and femoral pores in males, and 17–22 in females, whereas precloacal pores are completely lacking in males of *C. badenensis*, *C. eisenmanae* and *C. grismeri*, or are lacking or only rudimentarily developed in males of *C. nigriocularis* (0–2) and *C. paradoxus* (0–4); in addition, *Cyrtodactylus roesleri* **sp. nov.** differs from *C. phongnhakebangensis* in a lower number of precloacal and femoral pores in males (20–28 versus 32–42), and the new species differs from the remaining species by distinctly higher pore counts: *C. caovansungi* (9 PP + 6 FP), *C. chauquangensis* (6–7), *C. condorensis* (4–7), *C. hontreensis* (7–8), *C. intermedius* (8–10), and *C. takouensis* (3–4 PP + 1 FP). For detailed comparisons see Table 3.

TABLE 4. Most obvious distinguishing characters between the sympatric species *Cyrtodactylus phongnhakebangensis*, *C. cryptus* and *Cyrtodactylus roesleri* **sp. nov.** (after Ziegler *et al.* 2002, Heidrich *et al.* 2007, and own data).

	Cyrtodactylus phongnhakebangensis	*Cyrtodactylus cryptus*	*Cyrtodactylus roesleri* **sp. nov.**
SVL	max. 104.4 mm	max. 90.8	max. 75.3 mm
nuchal band	enlarged in neck region	enlarged in neck region (triangular)	not enlarged in neck region
transversal dorsal bands between limbs	4–5, normally with indentations in mid-dorsal region, stretching to body sides	3–5, irregularly shaped, dissolve into large blotches on body sides	4–5, normally without indentations in mid-dorsal region, stretching to body sides
first dorsal band between forelimbs	distinctly enlarged on back, with anterior and posterior indentations in vertebral region, stretches to front of forelimb insertion	ends above limb insertions and usually is separated from limb insertion by large longish blotch	not distinctly enlarged on back, without indentations in vertebral region, stretches to front of forelimb insertion
dorsal neck tubercles	large (ca. 4–6 times larger than adjacent granules)	large (ca. 5–7 times larger than adjacent granules)	faintly developed to medium (only 1–3 times larger than adjacent granules)
V	32–42	47–50	34–40
PP (+ FP)	32–42	9–11	20–28
PAT	4–5	0–3	5–8
subcaudals	transversally enlarged	not enlarged	transversally enlarged

Compared with the sympatric species *Cyrtodactylus cryptus* and *C. phongnhakebangensis*, *Cyrtodactylus roesleri* **sp. nov.** at first glance mostly resembles the latter species. Here, closer examination allows for proper separation (see Table 4). In addition, *C. phongnhakebangensis* is a relatively large species and we examined a subadult *C. phongnhakebangensis* with a SVL of 79.4 mm (which is beyond the currently known maximum SVL of adult *Cyrtodactylus roesleri* **sp. nov.**), that still showed the juvenile colour pattern on its tail, i.e. light dorsal tail bands that are completely yellow at base, and becoming lighter towards the tail tip which is completely white.

When comparing *Cyrtodactylus roesleri* **sp. nov.** with remaining congeners from the neighbouring countries in mainland Southeast Asia, it differs from *C. angularis*, *C. ayeyarwadyensis*, *C. brevidactylus*, *C. buchardi*, *C. gansi*, *C. pantiensis*, *C. quadrivirgatus*, *C. semenanjungensis*, *C. stresemanni*, *C. sworderi*, and *C. wakeorum* by having enlarged subcaudal scales (versus lacking in latter species). *Cyrtodactylus roesleri* **sp. nov.** has a higher precloacal (precloacal-femoral) pore count in males (20–28) compared with *C. consobrinoides* (4), *C. feae* (8–10), *C. khasiensis* (12–14), *C. nebulosus* (0), *C. oldhami* (1–4), *C. papilionoides* (4–6), *C. peguensis* (7–9), *C. rubidus* (12–14), *C. sumonthai* (1–2), and *C. thirakhupti* (0). In contrast, *Cyrtodactylus roesleri* **sp. nov.** has a lower precloacal (precloacal-femoral) pore count in males (20–28) compared with *C. chanhomeae* (32–34) and *C. jarujini* (52–54). *Cyrtodactylus roesleri* **sp. nov.** has a continuous series of precloacal and femoral pores, whereas in *C. pulchellus*, precloacal and femoral pores are well distinguishable, and in the species *C. aequalis*, *C. annandalei*, *C. brevipalmatus*, *C. erythrops*, *C. gubernatoris*, *C. interdigitalis*, *C. russeli*, *C. slowinskii*, and *C. tigroides* there is a diastema separating femoral from precloacal pores. *Cyrtodactylus roesleri* **sp. nov.** differs from *C. consobrinus* by fewer ventrals in longitudinal rows at midbody (34–40 versus 65–70); the new species differs from *C. elok*, *C. macrotuberculatus* and *C. variegatus* by a higher number of ventrals at midbody (34–40 versus 6–10 in *C. elok*, 19–22 in *C. macrotuberculatus*, and 22 in *C. variegatus*). Finally, *Cyrtodactylus roesleri* **sp. nov.** differs by fewer (4–5) transversal dark dorsal bands between limbs from *C. chrysopylos* who has a dorsal pattern consisting of nine bands between occiput and sacrum.

Distribution. *Cyrtodactylus roesleri* **sp. nov.** is currently known only from Phong Nha – Ke Bang National Park and surroundings in Quang Binh Province, Vietnam (see Fig. 7).

Etymology. We name this species after our friend and colleague Herbert Rösler to honour his long-term engagement in breeding and studying geckonid lizards. Herbert Rösler published several books dealing with

geckos and is specialized in geckonid morphology and taxonomy, which resulted among others in the description of diverse new gecko species.

Ecological notes. Most of the observations took place at night. The specimens were usually found on karst outcrops in limestone forest, at a height of about 1–1.5 m (sometimes also at 2 m height) above ground (even during rain).

Key to the species of *Cyrtodactylus* from Vietnam

1a. Subcaudals enlarged 2
1b. Subcaudal not enlarged 14
2a. Precloacal pores present in both males and females 3
2b. Precloacal pores absent or present only in males 5
3a. Femoral pores absent ..... *chauquangensis*
3b. Femoral pores present 4
4a. Males with 32–42 femoral and precloacal pores ..... *phongnhakebangensis*
4b. Males with 20–28 femoral and precloacal pores ..... *roesleri* **sp. nov.**
5a. Ventral scales in 25–28 rows ..... *badenensis*
5b. Ventral scales in 32–50 rows 6
6a. Males with 0–7 precloacal pores 7
6b. Males with 7–10 precloacal pores 12
7a. Males with 4–7 precloacal pores, 35–40 ventral scale rows ..... *condorensis*
7b. Males with 0–4 precloacal pores 8
8a. Ventral scales in 32–40 rows 9
8b. Ventral scales in 42–49 rows 11
9a. Enlarged femoral scales absent ..... *grismeri*
9b. Enlarged femoral scales present 10
10a. Males without femoral pores and with 0–4 precloacal pores ..... *paradoxus*
10b. Males with 1 femoral pore and 3–4 precloacal pores ..... *takouensis*
11a. Enlarged femoral scales 4–6 ..... *eisenmanae*
11b. Enlarged femoral scales absent ..... *nigriocularis*
12a. 16 lamellae under fourth finger, 17–19 lamellae under fourth toe ..... *hontreensis*
12b. 20–22 lamellae under fourth finger, 22–25 lamellae under fourth toe 13
13a. 22 lamellae under fourth finger, 23–25 lamellae under fourth toe ..... *caovansungi*
13b. 20 lamellae under fourth finger, 22 lamellae under fourth toe ..... *intermedius*
14a. Enlarged femoral scales absent 15
14b. Enlarged femoral scales 3–10 16
15a. Enlarged precloacal scales 1–12, males with 5–9 precloacal pores ..... *pseudoquadrivirgatus*
15b. Enlarged precloacal scales 16–27, males with 9–11 precloacal pores ..... *cryptus*
16a. Dark patches on dorsum not edged by white margin 17
16b. Dark patches on dorsum edged by white margin or tubercles 18
17a. SVL 43.5–69 mm, enlarged femoral scales 3–8 ..... *cattienensis*
17b. SVL 84.6–93mm, enlarged femoral scales 8–10 ..... *ziegleri*
18a. Enlarged femoral scales 3–5, males with 7–9 precloacal pores, dark patches on dorsum edged by white tubercles ..... *huynhi*
18b. Enlarged femoral scales 7–8, males with 5–7 precloacal pores, dark patches on dorsum edged by white margin ..... *irregularis*

Discussion

Vietnam has been one of the regions of greatest discovery of new *Cyrtodactylus*. Many of the newly described species appear to have highly restricted distributions and are associated with karst outcrops or limestone cave formations, which appear to have promoted speciation within *Cyrtodactylus* while acting as isolated habitat "islands". From some sites in central and southern Vietnam even pairs of limestone restricted species were reported recently to occur in sympatry (see overview in Ngo & Bauer 2008). Phong Nha – Ke Bang is one of

these sites, where two species occur in sympatry, i.e. *C. phongnhakebangensis* and *C. cryptus* (Ziegler *et al.* 2002; Heidrich *et al.* 2007). This now is to our knowledge the first case where three species of *Cyrtodactylus* occur at the same site, at least in Vietnam. This raises the interesting question about microhabitat use and niche segregation. According to Heidrich *et al.* (2007), *C. cryptus* inhabits both karst cliffs and tree trunks. But when occurring together with *C. phongnhakebangensis*, *C. cryptus* mainly occupies tree trunks and *C. phongnhakebangensis* karst cliffs. We found *Cyrtodactylus roesleri* sp. n. always in association with karst rocks, and, when occurring together with the larger *C. phongnhakebangensis*, the new species occupied the lower karst outcrop regions whereas *C. phongnhakebangensis* then was found in higher regions. However, this will have to be studied in detail in the future. *Cyrtodactylus roesleri* **sp. nov.** is the 19th species of *Cyrtodactylus* known from Vietnam.

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Note added in proof

While the present paper was in press, five further *Cyrtodactylus* have been described as new:

Onn, C.K. & Ahmad, N. (2010) A new insular species of *Cyrtodactylus* (Squamata: Gekkonidae) from northeastern Peninsular Malaysia, Malaysia. *Zootaxa*, 2389, 47–56.

Shi, L. & Zhao, H. (2010) A new species of *Cyrtodactylus* (Reptilia: Squamata: Geckkonidae) from Xizang Autonomous Region, China. *Zootaxa*, 2336, 51–60.

Sumontha, M., Panitvong, N. & Deein, G. (2010) *Cyrtodactylus auribalteatus* (Squamata: Gekkonidae), a new cave-dwelling gecko from Phitsanulok Province, Thailand. *Zootaxa*, 2370, 53–64.

Welton, L.J, Siler, C.D., Diesmos, A.C. & Brown, R.M. (2009) A new bent-toed gecko (genus *Cyrtodactylus*) from southern Palawan Island, Philippines and clarification of the taxonomic status of *C. annulatus*. – *Herpetologica* 65(3), 328–343.

Welton, L.J, Siler, C.D., Diesmos, A.C. & Brown, R.M. (2010) Phylogeny-based species delimitation of southern Philippines bent-toed geckos and a new species of *Cyrtodactylus* (Squamata: Gekkonidae) from western Mindanao and the Sulu Archipelago. *Zootaxa*, 2390, 49–68.