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A new species of the *Gekko japonicus* group (Squamata: Gekkonidae) from central Laos

VINH QUANG LUU[1,4,8,9], THOMAS CALAME[2], TRUONG QUANG NGUYEN[3,4], MINH DUC LE[5,6,7], MICHAEL BONKOWSKI[4] & THOMAS ZIEGLER[4,8]

[1]*Department of Wildlife, Faculty of Forest Resources and Environmental Management, Vietnam Forestry University, Xuan Mai, Chuong My, Hanoi, Vietnam. E-mail: qvinhfuv@yahoo.com.au*
[2]*WWF Greater Mekong, House No. 39, Unit 05, Ban Saylom, Vientiane, Lao PDR. E–mail: calame@gmail.com*
[3]*Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Hanoi, Vietnam. E-mail: nqt2@yahoo.com*
[4]*Zoological Institute, Department of Terrestrial Ecology, University of Cologne, Zülpicher Strasse 47b, D–50674 Cologne, Germany. E-mail: m.bonkowski@uni–koeln.de*
[5]*Faculty of Environmental Sciences, Hanoi University of Science, Vietnam National University, 334 Nguyen Trai Road, Hanoi, Vietnam. E-mail: le.duc.minh@hus.edu.vn*
[6]*Centre for Natural Resources and Environmental Studies, Hanoi National University, 19 Le Thanh Tong, Hanoi, Vietnam*
[7]*Deparment of Herpetology, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024*
[8]*AG Zoologischer Garten Köln, Riehler Strasse 173, D–50735 Cologne, Germany. E–mail: ziegler@koelnerzoo.de*
[9]*Corresponding author*

Abstract

A new species of the *Gekko japonicus* group is described from Khammouane Province, central Laos, based on distinct morphological and molecular features. *Gekko thakhekensis* sp. nov. is distinguished from the remaining congeners by a combination of the following characters: size moderate (SVL 67.6–79.2 mm); nares in contact with rostral; internasals absent; postmentals enlarged; interorbital scales between anterior corners of the eyes 22–26; dorsal tubercles absent; ventral scales between mental and cloacal slit 165–174; midbody scale rows 110–116; ventral scale rows 32–40; subdigital lamellae on first toe 11–13, on fourth toe 14–15; finger and toe webbing present at base, about one fifth of length of digits; tubercles on upper surface of fore and hind limbs absent; precloacal pores 1–5 in males; postcloacal tubercles two; tubercles absent on dorsal surface of tail base; subcaudals enlarged; dorsal surface of body with greyish brown blotches. In molecular analyses, the new species is recovered as a sister taxon to *G. scientiadventura*, but the two species are separated by approximately 12% divergence as shown by the partial mitochondrial ND2 gene.

Key words: *Gekko thakhekensis* sp. nov., Khammouane Province, karst forest, morphology, molecular phylogeny

Introduction

The diversity of the genus *Gekko* in Laos is poorly studied. Only three species are currently recognized from this country, namely *Gekko gecko* (Linnaeus), *Gekko scientiadventura* Rösler, Ziegler, Vu, Hermann & Böhme (Teynié & David 2010), and *Gekko petricolus* Taylor (Bain & Hurley 2011). Another gekkonid species, *G. reevesii* (Gray), has been reported to be common in southern China and northern Vietnam (Rösler *et al.* 2011). However, the distribution of this species in Laos needs to be confirmed due to its morphological similarity to *G. gecko* (Linnaeus).

During our recent field surveys in central Laos, two gekkonid specimens were collected in the karst forests of Khammouane Province. Morphologically, these specimens can be assigned to the *Gekko japonicus* group based on the following features: size moderate; nare in contact with rostral; postcloacal tubercles present; webbing between fingers and toes weakly developed; lateral folds without tubercles; subcaudals enlarged; dorsum with large light blotches and bands (see Rösler *et al.* 2011; Nguyen *et al.* 2013). Our molecular data showed that the specimens

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from Laos were clustered in the same clade with *G. scientiadventura*. However, the molecular divergence calculated using data from a fragment of the mitochondrial NADH dehydrogenase subunit 2 (ND2) gene between these species is approximately 12%. Although only two male individuals are available, morphological differences are so distinct and in addition supported by our molecular findings that we describe it as a new species.

Material and methods

Sampling. Field surveys were conducted in mixed secondary forest near Thakhek Town, Khammouane Province, Laos, by Thomas Calame and Peter Jäger in April 2012, and by Vinh Quang Luu and Thomas Calame in June 2014. Tissue samples were preserved separately in 95% ethanol and voucher specimens were fixed in approximately 85% ethanol, then later transferred to 70% ethanol for permanent storage. Specimens were subsequently deposited in the collection of the Institute of Ecology and Biological Resources (IEBR) and Vietnam Forestry University (VFU), Hanoi, Vietnam. Other abbreviations are as follows: PNKB: Zoological Collection of the Phong Nha—Ke Bang National Park, Quang Binh Province, Vietnam; VNMN: Vietnam National Museum of Nature, Hanoi, Vietnam; ZFMK: Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany.

Molecular data and phylogenetic analyses. We included samples of *Gekko scientiadventura* collected from Phong Nha—Ke Bang National Park, central Vietnam, and from Khammouane, central Laos. Additional samples of *G. adleri* Nguyen, Wang, Yang, Lehmann, Le, Ziegler & Bonkowski, *G. palmatus* Boulenger, and *G. truongi* Phung & Ziegler were sequenced. We also used all sequences available on Genbank for taxa in the *Gekko japonicus* group. Two species, *G. badenii* Shcherbak & Nekrasova and *G. grossmanni* Günther of the *G. petricolus* complex were used as outgroups. We used the protocols of Le *et al*. (2006) for DNA extraction, amplification, and sequencing. A fragment of the mitochondrial gene, the ND2, was amplified using the primer pair L4437b (Macey *et al.* 1997) and ND2r102 (Greenbaum *et al.* 2007). After sequences were aligned by Clustal X v2 (Thompson *et al.* 1997), data were analyzed using maximum parsimony (MP) and maximum likelihood (ML) as implemented in PAUP*4.0b10 (Swofford 2001) and Bayesian analysis (BA), as implemented in MrBayes v3.2 (Ronquist *et al.* 2012). Settings for these analyses followed Le *et al.* (2006), except that the number of generations in the Bayesian analysis was increased to 1×10^7 to identify better converged trees. The optimal model for nucleotide evolution was set to GTR+I+G as selected by Modeltest v3.7 (Posada & Crandall 1998). The cutoff point for the burn-in function was set to 7 in the Bayesian analysis, as -ln*L* scores reached stationarity after 7,000 generations in both runs. Nodal support was evaluated using Bootstrap replication (BP) as calculated in PAUP and posterior probability (PP) in MrBayes v3.2. Uncorrected pairwise divergences were calculated in PAUP*4.0b10 (Table 1).

Morphological characters. Measurements were taken with digital calipers to the nearest 0.1 mm. The following abbreviations were used: Measurements: SVL = snout–vent length (from tip of snout to anterior margin of cloaca), TaL = tail length (from posterior margin of cloaca to tip of tail), AG = distance between axilla and groin, HL = maximum head length (from tip of snout to posterior margin of auricular opening), HW = maximum head width, HH = maximum head height, SE = distance from snout tip to anterior corner of eye, EE = distance between posterior margin of eye to posterior margin of ear opening, RW = maximum rostral width, RH = maximum rostral height, MW = maximum mental width, ML = maximum mental length. Scalation: CS = ciliary spines, N = nasals (nasorostrals, supranasals, postnasals), I = intersupranasals (scales between supranasals, in contact with rostral), SPL = supralabials (number of scales from below the middle of eye to the rostral scale), IFL = infralabials (number of scales from below the middle of eye to the mental scale), IO = interorbitals (number of scales in a line between anterior corners of eyes), PO = preorbitals (number of scales in a line from nostril to anterior corner of the eye), PM = postmentals, GP = gulars bordering the postmentals, DTR = dorsal tubercle rows at midbody, GSDT = granules surrounding dorsal tubercles, SMC = scales in a line from mental to the front of cloacal slit, SR = scale rows at midbody (including ventral scales), V = ventral scale rows at midbody, LF1 = subdigital lamellae under whole first finger, LF4 = subdigital lamellae under whole fourth finger, LT1 = subdigital lamellae under whole first toe, LT4 = subdigital lamellae under whole fourth toe, PP = precloacal pores (in males), PAT = postcloacal tubercles. Bilateral scale counts were given as left/right. Pictures of the species were taken with a digital microscope (Keyence VHX–500F).

Table 1. Uncorrected ("p") distance matrix showing percentage pairwise genetic divergence (ND2) between *Gekko* species

Species name with Genbank number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. *G. adleri* IEBR A.2012.24 (KP205389)	-																
2. *G. auriverrucosus* (JN019062)	24.5	-															
3. *G. badenii* (JN019065)	24.2	26.2	-														
4. *G. chinensis* (019058)	15.7	26.4	26.4	-													
5. *G. grossmanni* (JN019064)	29.0	32.0	25.5	30.3	-												
6. *G. hokouensis* (JN019060)	22.6	21.2	24.6	22.6	30.3	-											
7. *G. japonicus* (JQ173424)	23.2	18.5	23.1	22.8	30.8	20.8	-										
8. *G. palmatus* IEBR 3622 (KP205390)	7.5	23.6	25.1	15.5	30.1	21.5	22.1	-									
9. *G. palmatus* IEBR 3672 (KP205391)	7.3	22.8	24.8	15.2	30.6	21.5	21.9	1.2	-								
10. *G. scientiadventura* PNKB 2011.67 (KP205393)	24.6	20.4	25.8	22.8	30.6	21.2	21.2	23.5	23.0	-							
11. *G. scientiadventura* IEBR 2014.7 (KP205392)	24.4	20.4	25.8	22.6	30.3	21.2	21.2	23.3	22.8	0.4	-						
12. *G. scientiadventura* VFU 2014.1 (KP205395)	24.2	19.6	24.0	22.3	31.5	20.5	20.3	23.1	22.6	2.8	3.2	-					
13. *G. scientiadventura* VFU 2014.2 (KP205394)	24.7	20.0	25.4	22.6	31.7	21.0	21.0	24.0	23.5	2.8	3.2	1.8	-				
14. *G. subpalmatus* (JN019063)	23.7	18.9	24.2	24.6	31.2	22.1	22.6	24.2	23.8	19.8	19.8	18.9	19.2	-			
15. *G. swinhonis* (JN019061)	23.7	18.9	24.0	21.0	30.1	19.2	19.4	20.6	20.3	21.0	21.0	19.6	20.6	20.3	-		
16. *G. thakhekensis* IEBR A.2014.6, VFU R 2014.9 (KP205396-7)	22.8-23.0	20.6-20.7	24.2-24.4	21.2-21.8	29.7-30.3	21.0-21.2	19.7-19.9	22.8-23.0	22.2-22.4	13.2	13.2	11.7	11.9	20.3	20.3	-	
17. *G. truongi* IEBR A.2011.1 (KP205398)	22.6	24.3	25.3	21.7	29.7	22.6	21.9	22.1	21.9	22.1	22.1	20.6	21.7	21.9	21.2	20.3-20.5	-

Results

Molecular phylogeny. The combined matrix contained 565 aligned characters. MP analysis of the dataset recovered a single most parsimonious tree with 883 steps (Consistency Index = 0.55; Retention Index = 0.59). One tree with a score of 4301. 43 was retained in the ML analysis after 2076 rearrangements tried. The ML and BA topologies are similar to that produced by the MP analysis (Fig. 1). Overall, two clades within the *Gekko japonicus* group are strongly supported in all three analyses. The first one contains three species, *G. adleri*, *G. chinensis* Gray, and *G. palmatus*. In the second clade, the new species is strongly supported as a sister taxon to *G. scientiadventura* (BP = 100 and 99, PP = 100) (Fig. 1). It is also significantly divergent from others in terms of genetic distance with a minimum pairwise divergence of approximately 12% in the mitochondrial fragment of ND2 (see Table 1).

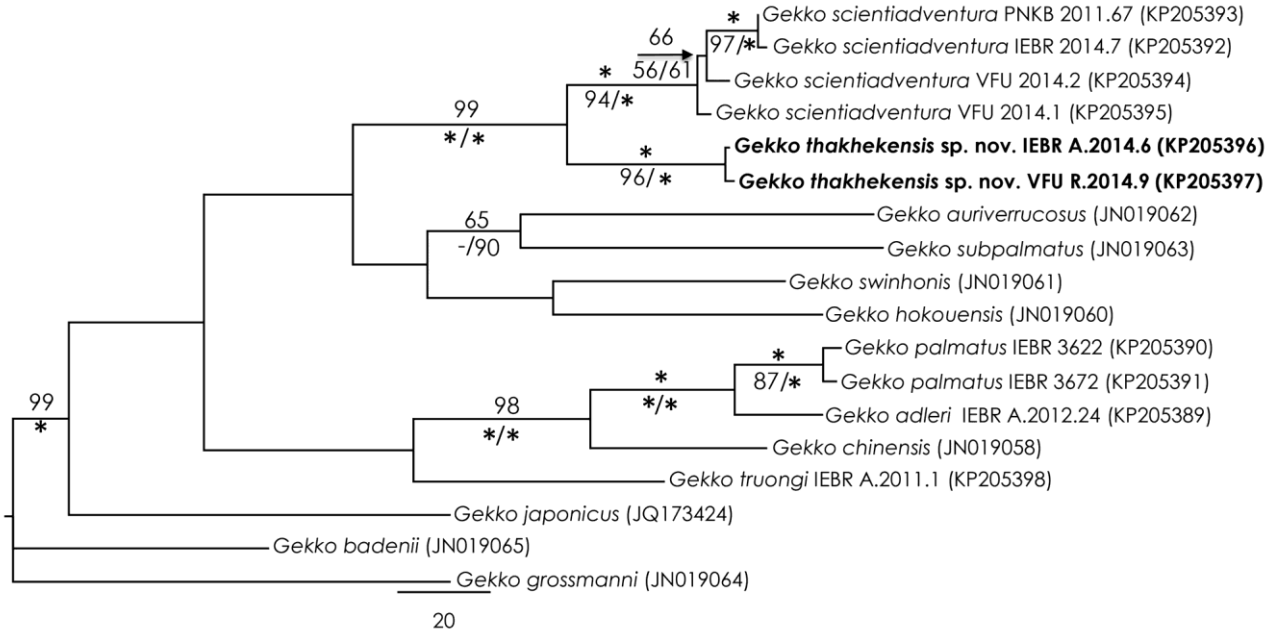

FIGURE 1. Single most parsimonious tree. Number above and below branches are MP and ML bootstrap values and Bayesian posterior probabilities (>50%), respectively. Asterisk denotes 100% value.

Gekko thakhekensis sp. nov.
(Figs. 2 and 4)

Holotype. IEBR A.2014.6, subadult male, collected on 29 April 2012 by Thomas Calame and Peter Jäger on a karst wall of a karstic massif, ca. 1.5 m above the forest floor, in a mixed secondary forest of hardwoods and shrubs near Thakhek Town (17°27.64'N, 104°55.24'E), Khammouane Province, Laos, at an elevation of 170 m a.s.l.

Paratype. VFU R.2014.9, adult male, collected on 02 June 2014 by Vinh Quang Luu and Thomas Calame on a liana near the wall of a karstic massif, ca. 2 m above the forest floor, in a mixed secondary forest of hardwoods and shrubs near Thakhek Town (17°27.707'N, 104°52.496'E), Khammouane Province, Laos, 4 km from the holotype locality at an elevation of 168 m a.s.l.

Diagnosis. The new species differs from its relatives on the basis of the following combination of characters: size moderate (SVL 67.6–79.2 mm); nares in contact with rostral; internasals absent; postmentals enlarged; interorbital scales between anterior corners of the eyes 22–26; dorsal tubercles absent; ventral scales between mental and cloacal slit 165–174; midbody scale rows 110–116; ventral scale rows 32–40; subdigital lamellae on first toe 11–13, on fourth toe 14–15; finger and toe webbing present at base, about one fifth of length of digits; tubercles on upper surface of fore and hind limbs absent; precloacal pores 1–5 in males; postcloacal tubercles two; tubercles absent on dorsal surface of tail base; subcaudals enlarged; dorsal surface of body with greyish brown blotches.

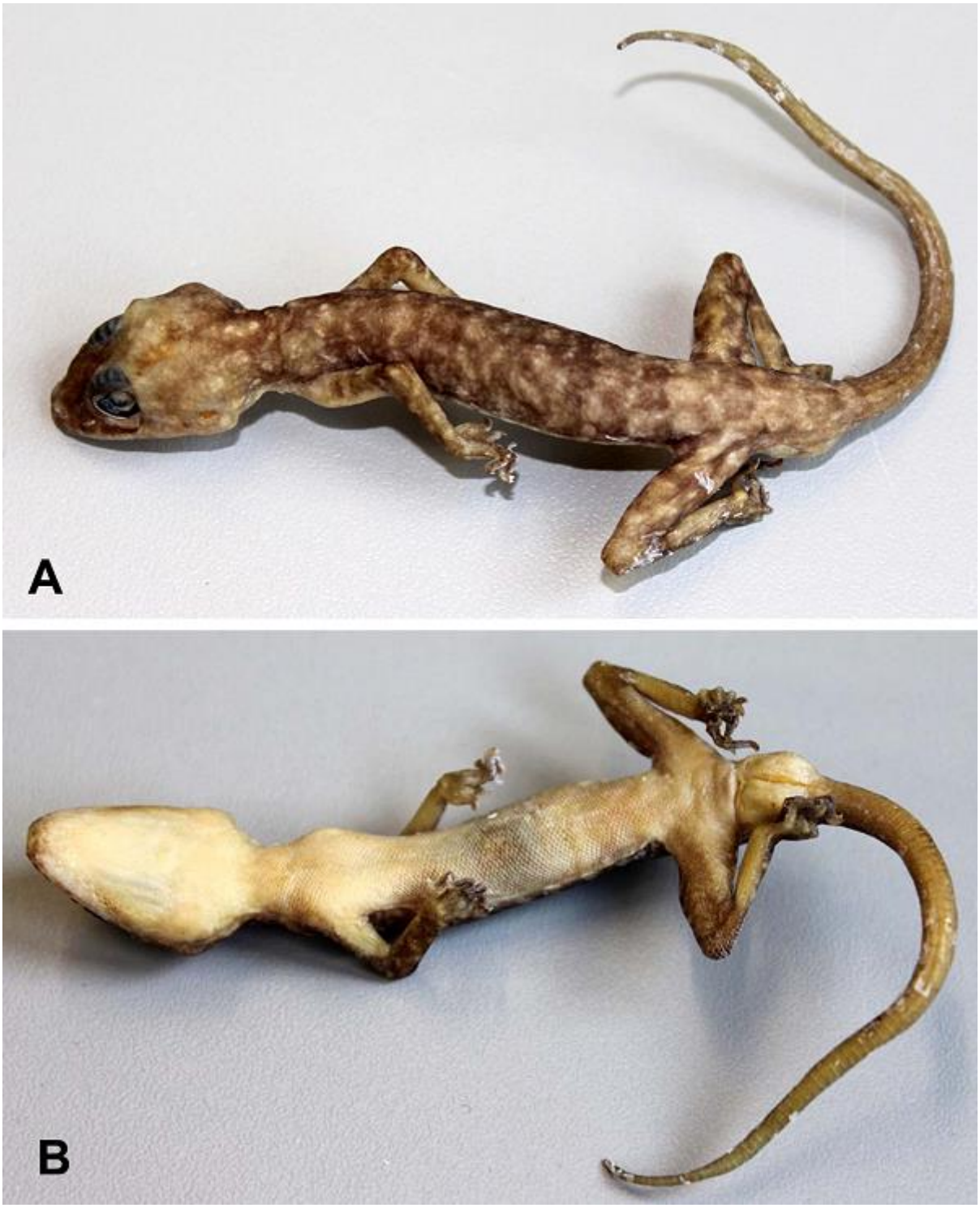

FIGURE 2. Holotype of *Gekko thakhekensis* sp. nov. (IEBR A.2014.6) in preserved state: A) dorsolateral view and B) ventral view. Photos V. Q. Luu.

FIGURE 3. Head portraits: A) dorsal view and B) ventral view; Body portraits: C) dorsal view and D) ventral view; and E) cloacal region of the preserved holotype (X mark: precloacal pore) of *Gekko thakhekensis* sp. nov. (IEBR A.2014.6). Photos V. Q. Luu.

TABLE 2. Measurements (in mm) and morphological characters of the type series of *Gekko thakhekensis* sp. nov. (* = regenerated partially; for other abbreviations see material and methods).

	IEBR A.2014.6 (holotype)	VFU R.2014.9 (paratype)
Sex	subadult male	adult male
SVL	67.6	79.2
TaL	66.7*	76.5
AG	29.3	35.7
HL	18.5	23.0
HW	14.1	16.3
HH	8.0	8.7
SE	7.7	9.4
EE	4.5	5.6
RW	3.3	3.4
RH	1.6	1.7
MW	2.2	2.2
ML	1.7	1.5
CS	3/5	3/5
N	3/3	3/3
PO	18	18
I	0	0
SPL	10/11	12/13
IFL	10/9	11/11
IO	22	26
PM	2	2
GP	5	5
DTR	0	0
GSDT	0	0
SMC	174	165
SR	110	116
V	32	40
LF1	13/13	13/10
LF4	15/15	13/13
LT1	13/13	11/12
LT4	15/15	14/14
PP	1	5
PAT	2/2	2/2

Description of holotype. Size moderate, SVL 67.6 mm, tail partially regenerated, TaL 66.7 mm, AG 29.3 mm; head longer than wide (HL 18.5 mm, HW 14.1 mm); rostral quadrangular, wider than high (RW 3.3 mm, RH 1.6 mm) and wider than mental (MW 2.2 mm), without suture; rostral in contact with first supralabial and supranasal; nostrils round, each surrounded by rostral, first supralabial, supranasal, and two enlarged nasals posteriorly; internasal absent; preorbitals 18; interorbitals 22; eye large (EE 4.5 mm, HL 18.5 mm), pupil vertical; ear opening oval, oblique, about 40% of the eye diameter (maximum tympanum diameter 1.7 mm, horizontal eye diameter 4.5 mm; mental triangular, wider than long (MW 2.2 mm, ML 1.7 mm); postmentals two, relatively trapezoidal, twice longer than wide, and longer than length of mental, in contact with mental and first infralabials anteriorly, medial suture between; postmentals longer than the length of mental; postmental in contact with 5 gular scales posteriorly, outer gular scales larger than inner scales; supralabials 10/11; infralabials 10/9; dorsal scales on body smooth,

round, granular and juxtaposed; lateral fold weakly developed; ventral scales much larger than dorsal scales, smooth, relatively hexagonal, imbricate, and largest in the middle of belly; ventrals between lateral folds 32; scales around midbody in 110 rows; ventral scales in a line between mental and cloacal slit 174; scales on upper and lower arm slightly enlarged; tubercles absent on dorsal surface of fore and hind limbs; scales on anterior and ventral parts of thigh larger than those on dorsal and posterior parts; enlarged femoral scales absent; fingers and toes basally webbed (about 1/5); subdigital lamellae under first finger 13/13, under fourth finger 15/15, under first toe 13/13, under fourth toe 15/15; precloacal pore one, precloacal scales enlarged; postcloacal tubercles 2/2, blunt; tail thickened at base, without tubercles on dorsal surface of tail base; dorsal caudal scales approximately twice the size than dorsal body scales, flat, in regular transverse rows; subcaudals flat, enlarged.

FIGURE 4. Adult male paratype (VFU R.2014.9) of *Gekko thakhekensis* sp. nov. in life. Photo T. Calame.

Coloration in ethanol. Dorsal surface of head, body, limbs, and tail greyish brown with irregular vertebral blotches; nuchal surface with a light-colored patch, nuchal loop absent; upper eyelids greyish black; snout and interorbital region vermiculate; some small light spots present in temporal region and on sides of neck; neck with a light grey blotch; dorsum without vertebral stripe; some light and grey spots present on dorsal surface; a row of light spots present along lateral folds; limbs with small light spots and bars; throat, venter, and precloacal region yellowish cream with dark marbling; lower surface of tail brown. For coloration in life see Fig. 4.

Variation. Measurements and scalation characters of the paratype are shown in Table 2. The following scale counts vary between the paratype and the holotype: interobitals 22–26, scale rows from mental to the front of cloacal slit 165–174, ventrals 32–40, and precloacal pores 1–5.

Distribution. *Gekko thakhekensis* sp. nov. is currently known only from the type locality in Khammouane Province, Laos (Fig. 5).

Ecological notes. The type specimens were collected at night, between 1.5–2.0 m above the ground in a small belt of the secondary vegetation in front of a limestone cliff, at elevations of 168–170 m a.s.l.

Etymology. The specific epithet *thakhekensis* refers to the name of the type locality, Thakhek Town, Khammouane Province, Laos. Suggested common name: Thakhek Gecko.

TABLE 3. Morphological comparisons among the species of the *Gekko japonicus* group (modified after Nguyen *et al*. 2013, abbreviations defined in text, - = data unavailable)

Character	*Gekko* sp. nov.	*adleri*	*auriverrucosus*	*canhi*	*chinensis*	*japonicus*	*hokouensis*	*liboensis*	*melli*	*palmatus*	*scabridus*	*scientiadventura*
Maximum SVL (mm)	79.2	75.3	69	99.2	72	74	70	85	84.6	79.7	77	73
SPL (min)	10	10	9	14	10	9	10	12	10	11	9	12
SPL (max)	13	15	11	14	14	13	14	12	13	15	11	14
IFL (min)	9	9	9	10	9	8	8	11	9	9	9	9
IFL (max)	11	13	11	12	13	13	11	11	12	13	11	13
Nostril touching rostral	1	1	0	1	1	1	1	1	1	1	1	1
N (min)	3	3	3	3	2	3	3	3	3	3	3	3
N (max)	3	3	3	3	3	3	3	3	3	3	3	3
I (min)	0	1	0	1	1	0	1	0	1	0	1	0
I (max)	0	1	1	1	1	1	2	0	1	3	2	0
IO (min)	22	27	25	49	35	32	30	40	34	27	30	41
IO (max)	26	36	25	50	48	35	33	40	40	36	30	51
Postmentals (enlarged = 1, not enlarged = 0)	1	1	0	1	1	0	0	0	0	1	0	1
DTR (min)	0	7	16	11	10	9	12	10	0	4	17	0
DTR (max)	0	11	20	12	10	14	18	10	0	12	21	0
SMC (min)	165	168	-	168	156	169	153	-	181	160	-	118
SMC (max)	174	190	-	170	167	188	174	-	200	194	-	140
SR (min)	110	123	-	205	118	130	119	-	147	116	-	139
SR (max)	116	144	-	227	140	144	130	-	160	147	-	143
V (min)	32	35	-	49	37	39	36	-	43	36	-	38

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TABLE 3. (Continued)

Character	*Gekko* sp. nov.	*auriverrucosus*	*canhi*	*chinensis*	*japonicus*	*hokouensis*	*liboensis*	*melli*	*palmatus*	*scabridus*	*scientiadventura*
V (max)	40	-	51	39	44	43	-	49	47	-	48
LT 1 (min)	11	6	13	8	10	8	8	10	10	6	12
LT1 (max)	13	8	16	10	12	11	8	12	13	9	15
LT 4 (min)	14	6	14	9	14	15	9	11	10	7	14
LT4 (max)	15	8	17	12	16	18	9	14	16	9	17
Toes webbed	1	0	0	1	0	0	0	1	1	0	1
Tubercles on fore-limbs (present = 1, absent = 0)	0	1	0	0	1	0	0	0	0	1	0
Tubercles on hind limbs (present = 1, absent = 0)	0	1	1	1	1	0	0	0	0	1	0
PP (in males, min)	1	8	5	17	6	5	-	9	23	10	5
PP (in males, max)	5	11	5	27	9	9	-	11	30	15	8
PAT (min)	2	2	2	1	2	1	1	1	1	1	2
PAT (max)	2	3	3	1	4	1	1	1	1	3	3
Tubercles on dorsal surface of tail (present = 1, absent = 0)	0	1	0	1	1	1	-	0	1	1	0
Subcaudals enlarged	1	1	1	1	1	1	-	1	1	1	1
Marking on upper side of head	0	0	0	0	0	0	0	1	0	0	1
Back flecked or blotched	1	0	1	1	0	1	0	0	1	1	1
Back banded	0	1	1	0	1	0	1	1	1	1	0
Tail banded	1	1	1	1	1	1	-	1	1	1	1

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TABLE 3. (continued)

Character	*Gekko* sp. nov.	*shibatai*	*similignum*	*subpalmatus*	*swinhonis*	*taibaiensis*	*tawaensis*	*vertebralis*	*wenxianensis*	*yakuensis*
Maximum SVL (mm)	79.2	70.9	58.9	72	66	69	71	69.2	59	72
SPL (min)	10	10	12	8	7	9	13	10	12	12
SPL (max)	13	13	14	12	12	10	13	15	12	13
IFL (min)	9	10	11	7	7	8	15	10	11	9
IFL (max)	11	14	11	12	11	10	15	15	11	13
Nostril touching rostral	1	1	1	1	1	1	1	1	1	1
N (min)	3	3	3	3	-	-	-	3	-	3
N (max)	3	3	3	3	-	-	-	3	-	3
I (min)	0	0	1	1	-	-	2	0	1	1
I (max)	0	1	1	1	-	-	2	2	1	1
IO (min)	22	37	46	32	23	28	-	35	-	-
IO (max)	26	52	48	32	24	28	-	50	-	-
Postmentals (enlarged = 1, not enlarged = 0)	1	0	0	0	0	-	0	0	-	0
DTR (min)	0	5	11	0	6	-	0	2	10	-
DTR (max)	0	14	11	0	8	-	0	12	10	-
SMC (min)	165	-	-	-	-	-	-	-	-	-
SMC (max)	174	-	-	-	-	-	-	-	-	-
SR (min)	110	114	144	-	-	-	-	112	-	-
SR (max)	116	134	153	-	-	-	-	139	-	-
V (min)	32	-	-	48	40	-	-	-	42	-

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TABLE 3. (Continued)

Character	*Gekko* sp. nov.	*shibatai*	*similignum*	*subpalmatus*	*swinhonis*	*taibaiensis*	*tawaensis*	*vertebralis*	*wenxianensis*	*yakuensis*
V (max)	40	-	-	48	40	-	-	-	44	-
LT 1 (min)	11	-	11	7	6	6	10	-	6	10
LT1 (max)	13	-	13	9	9	7	10	-	6	10
LT 4 (min)	14	9	12	7	6	7	12	9	9	15
LT4 (max)	15	16	14	10	9	8	12	17	9	15
Toes webbed	1	0	1	1	0	-	0	0	0	0
Tubercles on fore-limbs (present = 1, absent = 0)	0	0	0	0	1	-	0	0	0	0
Tubercles on hind limbs (present = 1, absent = 0)	0	0	0	0	1	-	0	0	1	0
PP (in males, min)	1	0	17	5	7	4	0	0	6	6
PP (in males, max)	5	3	17	11	9	6	0	1	8	8
PAT (min)	2	1	1	1	2	-	1	1	2	1
PAT (max)	2	1	1	1	3	-	1	2	3	1
Tubercles on dorsal surface of tail (present = 1, absent = 0)	0	1	1	0	-	-	0	0	-	1
Subcaudals enlarged	1	1	1	1	1	-	1	1	-	1
Marking on upper side of head	0	0	0	0	0	0	0	0	0	0
Back flecked or blotched	1	1	1	1	1	1	1	1	1	1
Back banded	0	0	0	1	0	1	1	0	0	0
Tail banded	1	1	1	1	1	1	1	-	1	1

FIGURE 5. Map showing the type locality of *Gekko thakhekensis* in Khammouane Province, Laos.

Comparisons. We compared the undescribed gecko species from Khammouane Province, central Laos with all other members of the *Gekko japonicus* group based on examination of specimens and data obtained from the literature (Boulenger 1907; Ota *et al.* 1995; Rösler *et al*. 2005, 2010, 2011; Yang *et al*. 2012, Nguyen *et al.* 2013). Although only two male specimens were available for morphological comparisons, the undescribed species from Laos clearly differs from the remaining species of the *G. japonicus* group by a unique suite of features.

The new *Gekko* species differs from the members of the *G. japonicus* group as follows: from *G. adleri* by lacking internasals (vs. one in *G. adleri*), dorsal tubercles absent (vs. present in *G. adleri*), fewer scale rows around midbody (110–116 vs. 123–144 in *G. adleri*), fewer precloacal pores in males (1–5 vs. 17–21 in *G. adleri*), more postcloacal tubercles (two vs. one in *G. adleri*), and tubercles on dorsal surface of hind limbs absent (present in *G. adleri*); from *G. auriverrucosus* Zhou & Liu by having a nostril touching rostral (not touching in *G. auriverrucosus*), postmentals enlarged (not enlarged in *G. auriverrucosus*), dorsal body tubercles absent (vs. present in *G. auriverrucosus*), and fewer precloacal pores in males (1–5 vs. 8–11 in *G. auriverrucosus*); from *G. canhi* Rösler, Nguyen, Doan, Ho & Ziegler by having fewer interorbitals (22–26 vs. 49–50 in *G. canhi*), internasal absent (vs. present in *G. canhi*), dorsal tubercles absent (vs. present in *G. canhi*), fewer scale rows around midbody (110–116 vs. 205–227 in *G. canhi*), fewer ventral scale rows (32–40 vs. 49–51 in *G. canhi*), and tubercles on dorsal surface of hind limbs absent (present in *G. canhi*); from *G. chinensis* Gray by lacking internasals (vs. one in *G. chinensis*), fewer interorbitals (22–26 vs. 35–48 in *G. chinensis*), dorsal tubercles absent (vs. present in *G. chinensis*), tubercles on dorsal surface of hind limbs absent (present in *G. chinensis*), fewer precloacal pores in males (1–5 vs. 17–27 in *G. chinensis*), more postcloacal tubercles (two vs. one in *G. chinensis*), and tubercles on dorsal surface of tail absent (vs. present in *G. chinensis*); from *G. japonicus* (Schlegel) by having fewer interorbitals (22–26 vs. 32–35 in *G. japonicus*), postmentals enlarged (vs. not enlarged in *G. japonicus*), dorsal tubercles absent (vs. present in *G. japonicus*), fewer scale rows around midbody (110–116 vs. 130–144 in *G. japonicus*), tubercles on dorsal surface of fore and hind limbs absent (present in *G. japonicus*), fewer precloacal pores in males (1–5 vs. 6–9 in *G. japonicus*), and tubercles on dorsal surface of tail absent (vs. present in *G. japonicus*); from *G. hokouensis* Pope by lacking internasals (vs. one or two in *G. hokouensis*), fewer interorbitals (22–26 vs. 30–33 in *G. hokouensis*), postmentals enlarged (vs. not enlarged in *G. hokouensis*), dorsal tubercle rows absent (vs. present in *G. hokouensis*), fewer precloacal pores in males (1–5 vs. 5–9 in *G. hokouensis*), more postcloacal tubercles (two vs. one present in *G. hokouensis*), and tubercles on dorsal surface of tail absent (vs. present in *G. hokouensis*); from *G. liboensis* Zhao & Li by having fewer interorbitals (22–26 vs. 40 in *G. liboensis*), dorsal tubercle rows absent (vs. present in *G. liboensis*), and more postcloacal tubercles (two vs. one in *G. liboensis*); from *G. melli* Vogt by lacking internasals (vs. one present in *G. melli*), fewer interorbitals (22–26 vs. 34–40 in *G. melli*), postmentals enlarged (vs. not enlarged in *G. melli*), fewer scales in a line from mental to the front of cloacal slit (165–174 vs. 181–200 in *G. melli*), fewer scale rows around midbody (110–116 vs. 147–160 in *G. melli*), fewer ventral scale rows (32–40 vs. 43–49 in *G. melli*), fewer precloacal pores in males (1–5 vs. 9–11 in *G. melli*), and more postcloacal tubercles (two vs. one in *G. melli*); from *G. palmatus* by having dorsal tubercle rows absent (vs. present in *G. palmatus*), fewer precloacal pores in males (1–5 vs. 23–30 in *G. palmatus*), more postcloacal tubercles (two vs. one in *G. palmatus*), and tubercles on dorsal surface of tail absent (vs. present in *G. palmatus*); from *G. scabridus* Liu & Zhou by lacking internasals (vs. present in *G. scabridus*), fewer interorbitals (22–26 vs. 30 in *G. scabridus*), postmentals enlarged (vs. not enlarged in *G. scabridus*), dorsal tubercle rows absent (vs. present in *G. scabridus*), tubercles on dorsal surface of fore and hind limbs absent (present in *G. scabridus*), fewer precloacal pores in males (1–5 vs. 10–15 in *G. scabridus*), and tubercles on dorsal surface of tail absent (vs. present in *G. scabridus*); from *G. scientiadventura* by having fewer interorbitals (22–26 vs. 41–51 in *G. scientiadventura*), more scale rows from mental to cloacal slit (165–174 vs. 118–140 in *G. scientiadventura*), fewer scale rows around midbody (110–116 vs. 139–143 in *G. scientiadventura*), and fewer precloacal pores in males (1–5 vs. 5–8 in *G. scientiadventura*); from *G. shibatai* Toda, Sengoku, Hikida & Ota by having fewer interorbitals (22–26 vs. 37–52 in *G. shibatai*), postmentals enlarged (vs. not enlarged in *G. shibatai*), dorsal tubercle rows absent (vs. present in *G. shibatai*), more postcloacal tubercles (two vs. one in *G. shibatai*), and tubercles on dorsal surface of tail absent (vs. present in *G. shibatai*); from *G. similignum* Smith by having fewer interorbitals (22–26 vs. 46–48 in *G. similignum*), lacking internasals (vs. present in *G. similignum*), postmentals enlarged (vs. not enlarged in *G. similignum*), dorsal tubercle rows absent (vs. present in *G. similignum*), fewer scale rows around midbody (110–116 vs. 144–153 in *G. similignum*), fewer precloacal pores in males (1–5 vs. 17 in *G. similignum*), more postcloacal tubercles (two vs. one in *G. similignum*), and tubercles on dorsal surface of tail absent (vs. present in *G. similignum*); from *G. subpalmatus* Günther by having fewer interorbitals (22–26 vs. 32 in *G. subpalmatus*), postmentals enlarged (vs. not enlarged in *G. subpalmatus*), internasals absent (vs. present in *G. subpalmatus*), fewer ventral scale rows (32–40 vs. 48 in *G. subpalmatus*), and fewer precloacal pores in males (1–5 vs. 5–11 in *G. subpalmatus*), and more postcloacal tubercles (two vs. one in *G. subpalmatus*); from *G. swinhonis* Günther by having postmentals enlarged (vs. not enlarged in *G. swinhonis*), dorsal tubercle rows absent (vs. present in *G. swinhonis*), tubercles on dorsal surface of

fore and hind limbs absent (present in *G. swinhonis*), and fewer precloacal pores in males (1–5 vs. 7–9 in *G. swinhonis*); from *G. taibaiensis* Song by having a larger size (SVL 79.2 vs. 69.0 mm in *G. taibaiensis*), more lamellae under first and fourth toes (11–13 vs. 6−7 and 14–15 vs. 7–8, respectively, in *G. taibaiensis*), and fewer precloacal pores in males (1–5 vs. 4–6 in *G. taibaiensis*); from *G. tawaensis* Okada by lacking internasals (vs. present in *G. tawaensis*), postmentals enlarged (vs. not enlarged in *G. tawaensis*), precloacal pores present (vs. absent in *G. tawaensis*), and more postcloacal tubercles (two vs. one in *G. tawaensis*); from *G. vertebralis* Toda, Sengoku, Hikida & Ota by having fewer interorbitals (22–26 vs. 35−50 in *G. vertebralis*), postmentals enlarged (vs. not enlarged in *G. vertebralis*), dorsal tubercle rows absent (vs. present in *G. vertebralis*), and tubercles on dorsal surface of tail absent (vs. present in *G. vertebralis*); from *G. wenxianensis* Zhou & Wang by lacking internasals (vs. present in *G. wenxianensis*), dorsal tubercle rows absent (vs. present in *G. wenxianensis*), fewer ventral scale rows (32–40 vs. 42−44 in *G. wenxianensis*), tubercles on dorsal surface of hind limbs absent (present in *G. wenxianensis*), and fewer precloacal pores in males (1–5 vs. 6–8 in *G. wenxianensis*); and from *G. yakuensis* Matsui & Okada by having internasals absent (vs. present in *G. yakuensis*), postmentals enlarged (vs. not enlarged in *G. yakuensis*), fewer precloacal pores in males (1–5 vs. 6–8 in *G. yakuensis*), more postcloacal tubercles (two vs. one in *G. yakuensis*), and tubercles on dorsal surface of tail absent (vs. present in *G. yakuensis*).

Discussion

Morphologically, *G. thakhekensis* is most similar to *G. scientiadventura*, a sympatric species occurring in Khammouane Province. However, they can be clearly distinguished from each other based on several morphological characters such as body scalation (number of scales from mental to cloacal slit, scale rows around midbody), and the number of precloacal pores in males.

The molecular analyses demonstrate that the new species falls within the *G. japonicus* species group, and is strongly supported as a sister taxon to *G. scientiadventura*. Our phylogenetic results are in agreement with those generated by Nguyen *et al*. (2013) in that the clade containing *G. adleri*, *G. chinensis*, and *G. palmatus* is strongly corroborated by both the Baysian and MP analyses. However, the relationship between *G. subpalmatus* and *G. swinhonis* are not well supported as shown in Nguyen *et al*. (2013). In fact, beside the two strongly supported clades, all other nodes within the *G. japonicus* species complex have low levels of support from all three analyses. To resolve these issues, it will be important to include more data, including more mitochondrial and nuclear genes, in future studies. Rösler *et al.* (2011) stated that the *Gekko japonicus* group is very complex in morphology. This genetically well-defined clade is morphologically variable (e. g., nares in contact with rostral or not, broad webbing between fingers and toes or not, dorsal tubercles absent or present, and tubercles on limbs absent or present).

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APPENDIX. *Gekko* specimens examined.

G. adleri (25): Vietnam: Cao Bang Province: IEBR A.2012.24 (holotype), ZFMK 93993–93999, IEBR A.2012.25–2012.31, VNMN A.2012.4–2012.6 (paratypes); China: Guangxi: SYS r000456−r0000461, SYS r000263 (paratypes).

G. canhi (4): Vietnam: Lang Son Province: IEBR A.0910 (holotype), VNMN 1001–1002 (paratypes); Lao Cai Province: ZFMK 88879 (paratype).

G. palmatus (30): Vietnam: Lao Cai Province: IEBR FN.29174; Tuyen Quang Province: IEBR A.0948; Bac Kan Province: IEBR 2301, IEBR A.0950−A.0951; Lang Son Province: IEBR 2474, IEBR 3619–3623, IEBR A.0949, A.0952; Quang Ninh Province: IEBR A.0807; Bac Giang Province: IEBR 3638, 3672; Vinh Phuc Province: IEBR 3223–3224a-c, ZFMK 44210, 59214−59215, 66517, 74552−74553; Hanoi: IEBR LQV3−LQV4; Thanh Hoa Province: IEBR TH.2011.1; Nghe An Province: IEBR A.0953−A.0955; Quang Binh Province: ZFMK 82888, 86434.

G. scientiadventura (9): Vietnam: Quang Binh Province: IEBR A.2014.7; PNKB 2011.67; ZFMK 76198 (holotype), ZFMK 76174–76179 (paratypes); ZFMK 80651–80652. Laos: Khammouane Province: VFU 2014.1−2014.2.