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The discovery of Rock Geckos *Cnemaspis* Strauch, 1887 (Squamata: Gekkonidae) in the Tanintharyi Region, Myanmar with the description of two new species

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Abstract

We report the first occurrence of the Asian Rock Gecko genus *Cnemaspis* Strauch, 1887 from mainland Myanmar based on a series of specimens recently collected from the Tanintharyi Region. These records come from several localities in the Tanintharyi Region and fill a significant sampling gap for the genus. Molecular phylogenetic analyses using the mitochondrial gene ND2 identify two distinct clades, the first includes *Cnemaspis siamensis* of the Southeast Asian *Cnemaspis* group and the second includes two new species belonging to the South Asian *Cnemaspis kandiana* group. These two species are morphologically distinct and are distinguished from all other members in the *C. kandiana* group by a combination of character states. The first species, *Cnemaspis tanintharyi* **sp. nov.** occurs on the mainland in southern Tanintharyi and is distinguished from all congeners by the possession of keeled pectoral scales; smooth ventral scales and abdominal scales; 2–4 precloacal pores; 4–5 femoral pores on each leg; smooth subcaudal scales with the median row enlarged; coloration of the gular region beige, dark gray-brown with dark blue hueing towards throat; 15–18 subdigital lamellae on the 4th toe; and 21–23 ventral scales at midbody. The other, *Cnemaspis thayawthadangyi* **sp. nov.** is known only from the island group of Thayawthadangyi, in the Myeik Archipelago and is distinguished from all congeners by the possession of keeled pectoral scales; keeled ventral scales and abdominal scales; three precloacal pores; four femoral pores on each leg; smooth subcaudal scales, scales on median row enlarged; coloration of the gular region silver with dark-gray irregularly shaped streaks; 16–18 subdigital lamellae on the 4th toe; and 18–20 ventral scales at midbody. In addition, we address the taxonomic status of populations referred to as *C. kandiana* (a species now restricted to Sri Lanka) found in peninsular Thailand and provisionally assign them as *C.* cf. *tanintharyi* **sp. nov.** until further analysis can be conducted. Finally, we briefly discuss the biogeography of the South Asian clade of *Cnemaspis*.

Key words: Taxonomy, lizards, Southeast Asia, biodiversity, Reptilia, morphology

Introduction

Our collective knowledge of Myanmar's herpetofauna remains incomplete. Because major portions of the country remain unexplored, there is tremendous potential for both new species discoveries and range extensions (Wogan *et al.* 2008; Wilkinson *et al.* 2012; Lee *et al.* 2015, 2018; Connette *et al.* 2017; Grismer *et al.* 2017a,b; Grismer *et al.* 2018a,b,c; Mulcahy *et al.* 2017, 2018; Zug *et al.* 2017; Zaw *et al.* 2019). Recent surveys in remote and under-studied areas of Myanmar, such as the Tanintharyi, have yielded numerous herpetofaunal specimens that increase our knowledge of biodiversity in that region (Zug *et al.* 2017; Lee *et al.* 2018; Mulcahy *et al.* 2018), a region under studied since the late 19th century (Theobald 1868). The Tanintharyi Region is the southernmost administrative unit of Myanmar; it is bordered on its eastern edge by Thailand, on its western edge by the Andaman Sea, and to the north by Mon State. The Tanintharyi along with adjacent peninsular Thailand make up the Isthmus of Kra region, a bio-geographic transition zone separating the Sundaic subregion from the Indochinese subregion (Pauwels *et al.* 2003; Parnell 2013). At present, the Tanintharyi supports large tracts of tropical rainforest and karst outcrops, although the former is disappearing rapidly due to clear-cutting for palm-oil plantations (Connette *et al.* 2017) and karstic regions across Myanmar are threatened by cement mining (Grismer *et al.* 2018b). Contemporary herpetological surveys in

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the Tanintharyi (2009–2010 and 2014–2017) have yielded range extensions and new species (e.g., Wilkinson *et al.* 2012; Lee *et al.* 2015, 2018; Connette *et al.* 2017; Mulcahy *et al.* 2017, 2018; Zug *et al.* 2017) as well as additional, unstudied material awaiting future examination.

Rock Geckos (*Cnemaspis* Strauch, 1887) are a speciose and widespread polyphyletic genus, with over 120 species distributed over Equatorial Africa, the Indian Subcontinent, and Southeast Asia, usually in forested regions with rocky microhabitats (Grismer *et al.* 2014; Uetz *et al.* 2018). A number of *Cnemaspis* species have been described recently (21st century and onwards), especially in Southeast Asia (e.g., Grismer *et al.* 2014; Amarasinghe *et al.* 2015; Wood *et al.* 2017; Iskandar *et al.* 2017), where a substantial Sundaic radiation exists. The phylogeny of *Cnemaspis* is complex; molecular studies identify that the genus is not monophyletic but consists of three distinct clades (Gamble *et al.* 2012) corresponding to geographic regions. The first clade contains all *Cnemaspis* from Equatorial Africa; the second clade (South Asian) contains *Cnemaspis* from localities primarily in India and Sri Lanka, with scattered populations along the southern edges of Thailand, Sumatra and islands off its west coast (Das 2005; Bauer *et al.* 2007; Manamendra-Arachchi *et al.* 2007; Agarwal *et al.* 2017); and the third (and most speciose) clade (Southeast Asian) contains all species, ranging from Vietnam and Laos southward through the Malay Peninsula and Sundaland (Grismer *et al.* 2014). Because *Cnemaspis* has not yet been split into separate genera, we refer to the second and third clades as the South Asian and Southeast Asian clades respectively. If a split were to be proposed, the generic name would be applied to the Southeast Asian clade, which includes the type species, *Cnemaspis boulengerii* Strauch, 1887.

Previously, only a single species, *Cnemaspis wicksi* (Stoliczka, 1873), was known from Myanmar in the Andaman Islands. This rare species is known from only five specimens collected during the mid-19th century from Preparis Island, a small island owned by Myanmar but part of the Andaman Island chain in the Bay of Bengal (Stoliczka 1873; Manamendra-Arachchi *et al.* 2007). Another species, *Cnemaspis andersonii* (Annandale, 1905) occurs in India on Narcondam Island of the Andaman chain. Both of these species belong to the South Asian clade (Manamendra-Arachchi *et al.* 2007). There are also reports of additional undescribed species of *Cnemaspis* related to *Cnemaspis kandiana* (Kelaart, 1852) from other islands in the Andaman & Nicobar Islands (Harikrishnan *et al.* 2010). Despite the wide distribution of this genus in Southeast Asia, no *Cnemaspis* has previously been detected on mainland Myanmar. This absence is surprising, as there are many other karst and rock-associated gecko species known from Myanmar (i.e., *Cyrtodactylus*) and several *Cnemaspis* occur in adjacent Thailand (Wood *et al.* 2017). During recent surveys in southern Tanintharyi, ten specimens of *Cnemaspis* were collected, representing the first records of the genus from mainland Myanmar. We subsequently amplified and sequenced the mitochondrial protein-coding gene ND2 to determine their phylogenetic placement amongst the three *Cnemaspis* clades. Of these ten specimens, three are identified to the Southeast Asian clade and are affiliated with the species *Cnemaspis siamensis* (Smith, 1925). This species was previously known from adjacent west Thailand in the Isthmus of Kra region, and now has here been detected in the Tanintharyi, Myanmar, 40 km northwest of the nearest known locality in Thailand.

The other six specimens form two sister species nested within the South Asian clade and lie within the *C. kandiana* group (*sensu* Agarwal *et al.* 2017). A few species of *Cnemaspis* from the *C. kandiana* group are known from Southeast Asia in Sumatra and islands off its west coast, the Andaman & Nicobar Islands in the Bay of Bengal, and peninsular Thailand, including Phuket Island (Das 1999; Das & Leong 2004; Manamendra-Arachchi *et al.* 2007; Agarwal *et al.* 2017; Iskandar *et al.* 2017). Most of these populations were originally identified as *Cnemaspis kandiana*, indicating that *C. kandiana* had a wide but disjunct distribution. However, authors have found that most of these Southeast Asian populations represent morphologically distinct taxa and described them as new species (Das & Leong 2004; Das 2005; Manamendra-Arachchi *et al.* 2007). A few populations of *C. kandiana sensu lato* are also reported from the Isthmus of Kra region of Thailand near the Tanintharyi specimen localities (Taylor 1963; Dring 1979). The recent literature has recognized this (e.g., Pauwels *et al.* 2003; Chan-ard *et al.* 2015), but no author has officially designated a name for this taxon (Bauer *et al.* 2007).

Within our Tanintharyi specimens, we discovered that individuals are derived from two distinct lineages based on mtDNA sequence data and morphology. The first lineage contains four specimens collected on limestone karst outcrops and forests in the proposed Lenya National Park of Tanintharyi. The second lineage contains two specimens, found on Thayawthadangyi Kyun (Island) Group in the Myeik Archipelago collected on tree trunks near a waterfall. We compared the molecular and morphological data of these two clades to topotypic *C. kandiana* and Thailand populations of the *C. kandiana* complex. The genetic and morphological distinctiveness of both lineages prompts us to describe them as new species in this paper.

Materials and methods

Specimens were collected in the field by hand on biodiversity surveys conducted by Smithsonian scientists and Fauna & Flora International (FFI) field teams in the proposed Lenya National Park and the proposed Lenya Extension during 2015–2016 and on the Myeik Archipelago in 2017. Specimens were euthanized following Smithsonian National Museum of Natural History (NMNH) Animal Care and Use Committee (ACUC) protocol (2017-05). Tissue samples were taken from heart or muscle, stored in DMSO/EDTA buffer (Mulcahy *et al.* 2016), and specimens were preserved in 10% formalin, then transferred to 70% ethanol. Specimens and tissue samples were collected and exported to NMNH on permits and an MOU arranged between FFI, the Forest Department of Myanmar, and Smithsonian Institution. Tissue samples were then transferred to and stored at -80º C in the NMNH Biorepository. Extractions of genomic DNA from all specimens were performed on an AutoGen prep 965 (2011 AutoGen, Inc.), using standard phenol manufacturer protocols. Genomic DNA was eluted in 100 µl of AutoGen R9 re-suspension buffer. Polymerase chain reactions (PCR) were conducted for the mtDNA gene ND2 using primers L4437 and H5934 (Macey *et al.* 1997). PCRs were performed in 96-well plates, in 10 µl reactions, following protocols "3.6 PCR Methods: Amplification" and "3.8 PCR Purifications: EXOSAP-IT" of Weigt *et al.* (2012), with an annealing temperature of 52°C in both directions, the standard for ND2 primers. Sequence reactions were performed in 96-well plates with the PCR primers using BigDye® Terminator v3.1 Cycle Sequencing Kit's in 0.25 × 10 µl reactions and run on an Automated ABI3730 Sequencer (2011 Life Technologies). Raw trace files were edited in Geneious v10.2.4 (Biomatters Ltd 2005-2017), complementary strands were aligned, edited, and inspected for translation. All sequences were manually edited and aligned in Geneious v10.2.4 (Biomatters Ltd 2005-2017) using the MAFFT v7.308 plug-in (Katoh & Standley 2013; Katoh *et al.* 2002) using default settings and subsequently inspected for translation.

We also sequenced the DNA barcode markers COI and 16S, following previously published protocols (Mulcahy *et al.* 2018), in order to initially verify the identities of our specimens. These data will be published elsewhere in a larger report of amphibians and reptiles from the Tanintharyi Region (Mulcahy *et al.* unpublished). The ND2 alignment included all other available *Cnemaspis* ND2 sequences from GenBank and was comprised of 1044 base-pairs, which required minor manual adjustments to ensure appropriate codon translation and the lack of premature stop codons. The adjacent tRNA region was omitted from sequences during alignment editing because the vast majority of available GenBank sequences lacked the region, or was available but largely incomplete. Subsequently, the last codon in the alignment for all specimens was an ND2 stop-codon. Maximum-likelihood analyses were performed using the RAxML (v8.2.9, Stamatakis, 2014) plugin implemented in Geneious with rapid bootstrap inferences (1000 replicates) and subsequent GTRCAT thorough ML search. We calculated uncorrected percent sequence divergences (p-distances) in MEGA7 (Kumar *et al.* 2016). We also conducted Bayesian analyses using MrBayes (v3.2.6; Ronquist *et al.* 2012). We partitioned our dataset by locus, applied the GTR+I+G model, and unlinked all partitions. We ran our analyses for 50 x 10^6 generations with four chains, sampling every 1000 generations. Stationarity was assessed by the average standard deviation of split frequencies (ASDSF < 0.01) and visual plots of log-likelihood by generation in Tracer v1.2 (Rambaut & Drummond, 2004); the first 5,000 trees (of 50,000) were discarded as the burn-in. A 50% majority-rule with compatible groups consensus was taken from the remaining trees and posterior probabilities (pp) of 0.95 or above were considered significant. Our new ND2 sequences were deposited under the GenBank accession numbers MN104943–MN104951. We provide our ND2 alignment and resulting RAxML and MrBayes trees as supplemental files under this link (https://doi.org/10.6084/m9.figshare.c.4555031.v2), and we used the species *Ailuronyx seychellensis* (Duméril & Bibron, 1836) and *Alsophylax pipiens* (Pallas, 1827) as outgroups (GenBank nos. KY038014 and JX041309, respectively). The tree displayed in Fig. 1 is rooted with *Alsophylax pipiens* (Gamble *et al.* 2012).

Several morphological and color pattern character states have been developed for taxonomic use in *Cnemaspis sensu stricto* (see Grismer *et al.* 2014). However, we prefer to score specimens for the same morphological characters used in recent descriptions of members of the *C. kandiana* group (Das 2005; Manamendra-Arachchi *et al.* 2007; Iskandar *et al.* 2017) to make consistent comparisons between taxa. For morphological analyses, all body measurements were taken with digital calipers to the nearest 0.1 mm beneath a standard dissecting microscope. We measured snout-vent length (SVL, from tip of snout to anterior margin of vent), tail length (TailL, length of the tail posterior to the vent to the tip of the tail), tail width (TailW, width of the tail at its widest point), brachium length (BrachiumL, from the dorsal surface from the axilla to the inflection of the flexed elbow), forearm length (ForearmL, from the dorsal surface from the elbow's posterior margin while flexed to the inflection of the flexed wrist), axilla-groin length (AxillaGroinL, from the posterior margin of the forelimb at its insertion point on the body to the anterior margin of the hindlimb at its insertion point on the body), thigh length (ThighL, from the dorsal surface of the groin to the knee), crus length (CrusL, from the posterior margin of the knee to the inflection of the heel), head length (HeadL, from the posterior edge of mandible to tip of snout); head width (HeadW, maximum width of head at the posterior angle of the jaws), head depth (HeadD, from the top of head to the ventral surface of the lower mandible articulation), eye diameter (EyeD, the greatest horizontal diameter of the eye), ear-eye length (EyeEar, from the posterior border of eye to anterior border of tympanum), snout length (SnEye, from the anterior border of eye to tip of snout), eye-naris length (NarEye, from the anterior border of eye to middle of nostril), interorbital distance (InterorbD, distance between the margins of the eyes), ear length (EarL, greatest diameter of ear), and internarial distance (InternarD, distance between dorsal margins of nares).

We counted supralabial and infralabial scales from below the middle of the eye to the rostral and mental scales, respectively. We counted subdigital lamellae on the 4th toe, starting from the first proximal enlarged scale wider than the width of the largest palm scale to the distal-most lamella (excluding the claw sheath) at the base of the claw. We evaluated the texture of the scales on the ventral surface of the brachium, forearm and subtibial regions of the limbs, as well as the size of the brachium, forearm and subtibial scales on the dorsal and ventral surface. We counted the number of vertebral tubercles in one straight line between the insertion of the forelimb and hindlimb. We measured the amount and arrangement of body and tail tuberculations, the relative size and morphology of the subcaudal scales. If present, we counted the total number of precloacal and femoral pores and assessed their orientation. Sex and maturity was determined by hemipenial bulges and by lateral incision to examine the gonads. The coloration of the gonads is a diagnostic character for other geckos (Zug 2010), so pigmentation of specimens examined were also noted.

We compared our molecular data to all available samples of *Cnemaspis* in GenBank (Grismer *et al.* 2014; Agarwal *et al.* 2017; Wood *et al.* 2017). We compared our morphological data to datasets provided by taxonomic studies on *C. kandiana* species group, including Das (2005), Manamendra-Arachchi *et al.* (2007) and Iskandar *et al.* (2017). Because of the low sample size, we did not conduct a statistical analysis of morphological data. All specimens examined are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA (USNM).

Results

Maximum-likelihood analyses corroborated results from past investigations (Grismer *et al.* 2014; Agarwal *et al.* 2017; Wood *et al.* 2017) on the phylogenetic relationships amongst *Cnemaspis*. The Bayesian analysis largely agrees with the Maximum-likelihood analysis particularly at the well-supported and relevant nodes. The two *C. siamensis* specimens sequenced for ND2 form a well-supported (99% bootstrap support, pp = 1.00) monophyletic group with respect to the two other *C. siamensis* specimens available on GenBank, and are 13.9% divergent from its sister species, *Cnemaspis vandeventeri* Grismer, Sumontha, Cota, Grismer, Wood, Pauwels & Kunya, 2010. There were significant intraspecific sequence divergences (5.1%) within *C. siamensis,* which could indicate unrecognized diversity or population structure in this species. The other specimens from mainland Tanintharyi and Thayawthadangyi Kyun both nest in the *C. kandiana* species group (Fig. 1), and form a clade sister to the Sumatran species *C. modiglianii* Das, 2005 with strong support (99% bootstrap support, pp = 1.00). The mainland Tanintharyi and Thayawthadangyi specimens each form well supported (100% bootstrap support, pp = 1.00), monophyletic groups and are separated from each other by an uncorrected pairwise sequence divergence of 5.3%. There are intraspecific sequence divergences of 0.4% and 0.1% within the mainland Tanintharyi and Thayawthadangyi specimens respectively. From their sister taxon, *C. modiglianii*, the mainland Tanintharyi and Thayawthadangyi specimens are separated by a sequence divergence of 7.1% and 6.6%, respectively.

The two clades in the *C. kandiana* species group are easily distinguished from each other based on morphological counts (see Tables 1–2 for full summary) and are distinguished from all *Cnemaspis* from the Southeast Asian clade by the presence of femoral and precloacal pores, dark gonadal pigmentation and other morphological characteristics. The two clades can be distinguished from *Cnemaspis kandiana,* from Central Sri Lanka, by the presence of four spinous tubercles along the flank (*versus* six) and 6–7 supralabials (*versus* 8–9). Other morphological

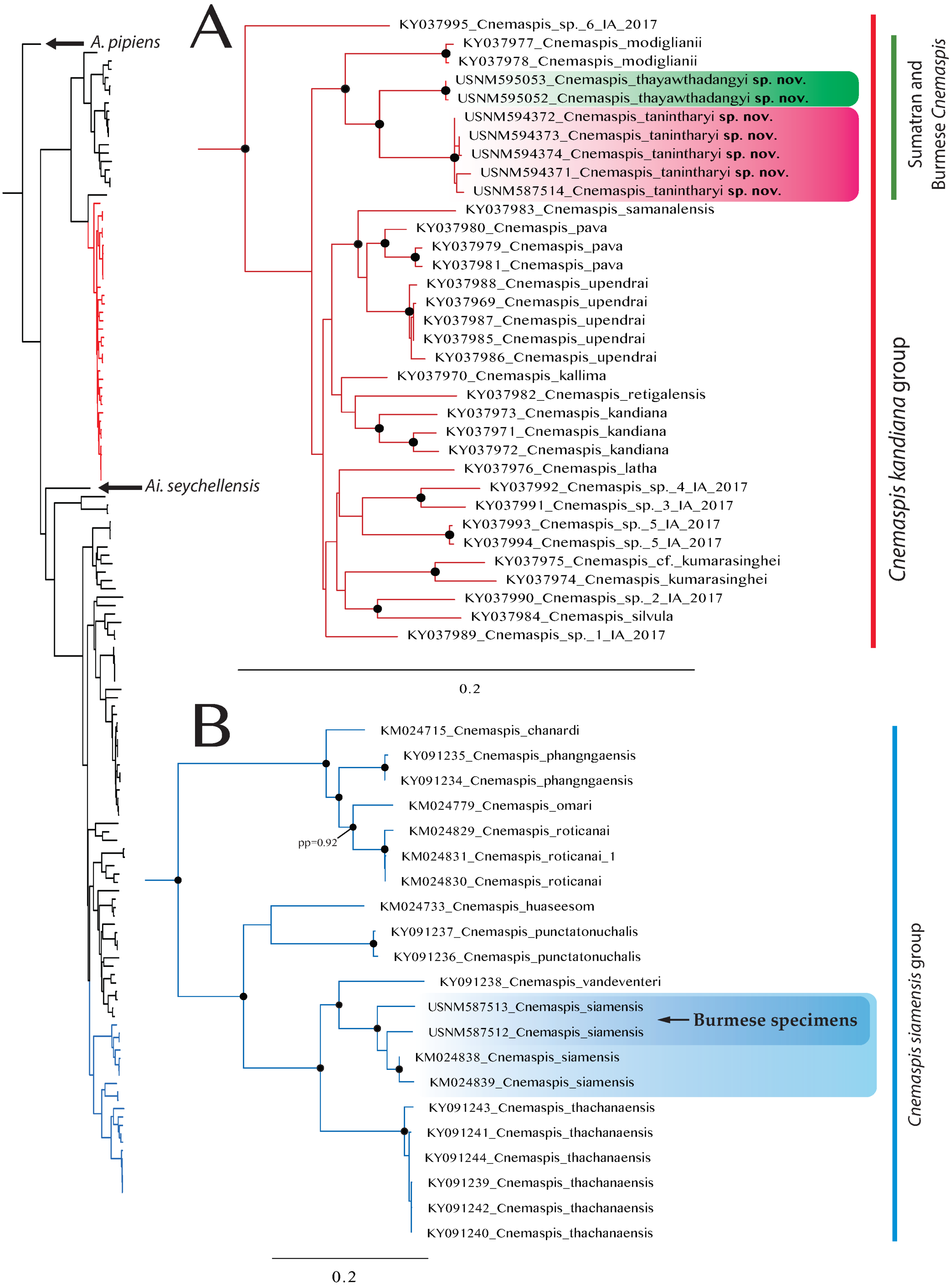

FIGURE 1. Phylogenetic tree showing placement of *Cnemaspis tanintharyi* **sp. nov.** (magenta) and *Cnemaspis thayawthadangyi* **sp. nov.** (green) in relation to other South Asian *Cnemaspis* (A) and phylogenetic placement of *Cnemaspis siamensis* (Blue) from Myanmar in the Southeast Asian Clade (B). Solid dots = strong support for ML (>90%) and BI (> 0.95). Side panel shows full tree, rooted on *Alsophylax pipiens* (*A. pipiens*), and *Ai. seychellensis* represents *Ailuronyx seychellensis.*

characters examined separate each of the two clades from all other members of the *C. kandiana* group found in the Bay of Bengal, Peninsular Thailand, Sumatra and islands along its west coast (see comparisons section and Table 3 for more details). Our examination of gonadal morphology in both clades showed that all specimens collected were males. No visceral pigmentation was present in *C. siamensis* collected from Tanintharyi Region. However, both new species nested in the South Asian *C. kandiana* group have pigmented ductus deferens, which are marbled black. An examination of a small sample of Sri Lankan *C. kandiana* also shows that males have pigmented ductus deferens, thus it seems likely that the pigmented state is a characteristic of the *kandiana* clade. In summary, both South Asian lineages of *Cnemaspis* from Myanmar are allopatric with respect to one another, are presumably reproductively isolated, are separated by significant molecular genetic distance, and are morphologically diagnosable—all in agreement with the General Lineage Concept of Species *fide* de Queiroz (1998). Based on the ML and Bayesian phylogenetic analyses and morphological comparisons, we describe these specimens from proposed Lenya National Park and Thayawthadangyi Kyun as new species.

Cnemaspis tanintharyi **sp. nov.**

Tanintharyi Rock Gecko
Figs. 2–5
urn:lsid:zoobank.org:act:6FA94D80-F8A8-4D32-A355-602815A43CD5

Holotype. USNM 587514 (GenBank accession no. MN104944), adult male collected by Daniel G. Mulcahy, Myint Kyaw Thura and Thaw Zin on 17 May 2015, between 0830–1000 h, near Payarhtan Cave, 28 km from Bokpyin town, proposed Lenya National Park, Tanintharyi Region, Myanmar (11.22945°N, 99.17611°E; 55 m elevation).

Paratypes. Adult males: USNM 594371 (GenBank accession no. MN104946), collected by Daniel G. Mulcahy, Myint Kyaw Thura, and Thaw Zin on 19 May 2016, 0845–1045 h, near Nint Tenku village, proposed Lenya National Park extension, Tanintharyi Region, Myanmar (11.45189°N, 99.22590°E; 54 m elevation); USNM 594372–594374 (GenBank accession nos. MN104947–49 respectively), collected by Grant Connette and Katherine J. LaJeunesse Connette on 22 May 2016, 1620–2200 h, same location as the holotype. One of these specimens, USNM 594373, is immature and was only included in the molecular analysis.

Diagnosis. *Cnemaspis tanintharyi* **sp. nov.** is a diminutive member of the *C. kandiana* group distinguished from all other members of the group by the combination of the following morphological characters: 1) a maximum SVL of 29.6 mm; 2) each postmental bordered by 2–4 scales; 3) four spine-like ventrolateral tubercles on flank; 4) gular scales smooth; 5) pectoral scales keeled, abdominal scales smooth; 6) ventral scales smooth; 7) 2–4 precloacal pores; 8) 4–5 femoral pores on each leg; 9) subcaudal scales smooth, scales on median row enlarged and smooth; 10) coloration of the gular region beige, dark gray-brown with dark blue hueing towards throat; 11) 6–7 supralabials; 12) 5–7 infralabials; 13) 15–18 subdigital lamellae on the 4th toe; 14) 21–23 ventral scales at midbody.

Description of the holotype. Adult male (USNM 587514) in good condition, with some of skin missing from the back and anterior portion of the tail. Lateral insertions along venter for gonadal examination and tissue retrieval, testes pigmented marbled black. SVL 28.9 mm, TailL 32.1 mm, TailW 2.6 mm, BrachiumL 3.8 mm, ForearmL 4.6 mm, AxillaGroinL 11.8 mm, ThighL 5.6 mm, CrusL 5.4 mm, HeadL 8.8 mm, HeadW 4.6 mm, HeadD 2.7 mm, EyeD 1.6 mm, EyeEar 2.0 mm, SnEye 3.6 mm, NarEye 3.1, InterorbD 2.6 mm, EarL 0.5 mm, InternarD 0.9 mm, HeadL/SVL 30.4%, HeadW/SVL 15.9%, HeadD/HeadL 26.1%, SnEye/HeadL 40.9%, EyeD/HeadL 18.2%.

Head oblong dorsally, moderately sized, narrow, highly flattened, distinct from neck; snout moderate in proportions, slightly concave in lateral view; rostral scale concave, divided by a median groove in dorsal view, posteroventrally in contact with the first supralabial; rostral contacted posteriorly by the nostril and dorsally by two enlarged supranasals; nostril round, dorsally oriented; scales along snout and occipital regions granular, slightly elevated, scales on snout larger than scales on occipital region; from eye, approximately five or six scale rows blocking contact with supralabials; seven supralabials; mental scale subtriangular, wider than long, in contact along its posteriolateral edge with two large postmental scales and one smaller medial postmental; lateral postmental scales bordered posteriorly by four smooth scales, medial scale bordered by only three; scales on gular region smooth; seven infralabials, both supra and infralabial rows decrease in size posteriorly.

Body slender and elongate; ventrolateral furrow separating dorsal scales from ventral scales; dorsal tubercles keeled, round, slightly enlarged, separated from each other by 3–6 scales; 17 paravertebral tubercles form a straight line; four ventrolateral spine-like tubercles; dorsal scales small, weakly keeled, slightly raised, granular, smaller than ventral scales; pectoral scales keeled, ventral scales on midbody and abdominal region smooth; ventrolateral scales smooth, round, slightly elevated; 23 ventral scales at midbody; three precloacal pores, arranged in a circular patch; four femoral pores arranged in a single row on each hindleg, completely separated from precloacal pores. Ventral scales on brachium keeled, smooth under thigh; digits slender, elongate, lacking webbing, bearing distinct recurved claws; 18 subdigital lamellae entire on the 4th toe; relative length of toes 4 > 3 > 5 > 2 > 1; no significantly enlarged submetatarsal scale on toes.

FIGURE 2. *Cnemaspis tanintharyi* **sp. nov.** Holotype. USNM 587514. Dorsal (A) and Ventral (B) views after preservation. Scale Bar = 10 mm. Photographs by Esther M. Langan.

Tail base swollen, latter half appears regenerated; two postcloacal openings, one on each side, presumably openings of hemipenial sheaths; one ventrolateral row of nine enlarged spiny tubercles; caudal tubercles whorled, present anteriorly, extending the full length of the tail; each caudal tubercle bordered by five scales laterally; dorsal caudal scales keeled, slightly pointed; subcaudal scales smooth; enlarged medial subcaudal row present, approximately 1.5–2.0x as large as surrounding scales. All scales on regenerated part of tail strongly keeled.

Coloration in preservative. After formalin fixation and three years of preservation the dorsum is brown dorsally; a series of irregularly shaped dark brown paravertebral markings occur along the body transforming into irregularly shaped dark-brown caudal bands; a pair of dark-brown round poorly defined spots starting at nape and terminating posterior to the hindlimbs on anterior portion of the tail; scattered mottling of gray and white spots, especially along tubercles; area around eyelids bluish; scattered broken dark-brown bands on limbs and toes. Top of head brown, labial scales mainly gray-brown, edged with white; dark brown postorbital stripe present. Venter light-gray; mid-pectoral and midbody region immaculate bordered laterally with gray mottling; limbs and abdominal regions with scattered gray mottling and dark colored scale edges; subdigital lamellae gray-brown; underside of regenerated subcaudal region gray brown; underside of throat and gular region gray-brown, edges of scales white; postmental region immaculate, silver in color.

Coloration in life. Based on a photograph of the holotype (Fig. 4), ground color light brown bearing scattered cream-colored mottling on dorsal scales and tubercles; pairs of irregularly shaped dark-brown, well-defined blotches, unevenly arranged along midbody; ground color of head brown with dark-brown mottling; iris yellow; ground color of limbs tan, overlain with brown irregularly shaped bands along thigh and forearm; digits with small well-defined brown bands; ventrolateral spine-like tubercles on tail and midbody yellow.

Description of the paratypes and variation. Paratypes largely match coloration and scalation of holotype. Detailed comparisons in scale morphology and measurements are provided in Table 1. Notably, USNM 594374 has two enlarged postmentals, with both scales contacting each other medially. Only two or three posterior genial scales bordering each postmental. USNM 594371 has four postmentals, two of which are enlarged and border the mental and two smaller postmentals along the midline with four or five genial scales bounding each postmental. The dorsal coloration of the paratypes in preservative is quite variable. In addition to the row of round dark brown blotches observed in the holotype, the paratypes USNM 594372 and USNM 594374 have a row of light gray irregularly shaped dorsal body blotches extending from the nape to the anterior portion of the tail along with a small gray vertebral stripe separating each blotch. Light-colored blotches are also present in paratype USNM 594372, but are faded and more poorly defined than in other two specimens. The coloration of the paratypes were not recorded in life, but are assumed to be similar to the holotype.

TABLE 1. Summary of morphological variation of the holotype and paratypes of *Cnemaspis tanintharyi* **sp. nov.** Entry marked with a "–" represents a character not available for study.

USNM 594314	USNM 594314	USNM 594371	USNM 594372	USNM 587574
Status	Holotype	Paratype	Paratype	Paratype
Sex	Male	Male	Male	Male
Tail Broken (2) Regenerated (1) or original (0)	1	1	0	2
SVL	29.6	28.9	27	28.9
TailL	39.7	24.5	–	32.1
BrachiumL	4	3.5	3.7	3.6
ForearmL	4.8	4.2	3.9	4.6
AxillaGroinL	13.1	12.1	11.6	11.8
ThighL	5.6	5.2	4.8	4.5
CrusL	5.4	5.1	5.2	4.7
HeadL	8.7	8	8.3	8.8
HeadW	4.3	4.5	4.5	4.6
HeadD	2.7	2.6	2.2	2.3
EyeD	1.7	1.7	1.5	1.6
EyeEar	2.3	2	2.2	2
SnEye	3.3	3.7	3.5	3.6
NarEye	2.4	3.2	3.3	3.1
InterorbD	2.7	2.3	1.9	2.6
EarL	0.6	0.5	0.3	0.5
InternarD	1	0.8	0.8	0.9
Supralabials	6/6	7/7	6/6	7/7
Infralabials	6/5	6/6	7/6	7/7
Postmentals	2	4	3	3
Precloacal Pores	3	4	3	2
Femoral Pores	5	5	4	4
Paravertebral Tubercles	19	20	19	17
Ventral Scales at Midbody	23	21	23	23
Ventrolateral Caudal Tubercles Anteriorly	1	1	1	1
4th Toe Lamellae	15	17	17	18

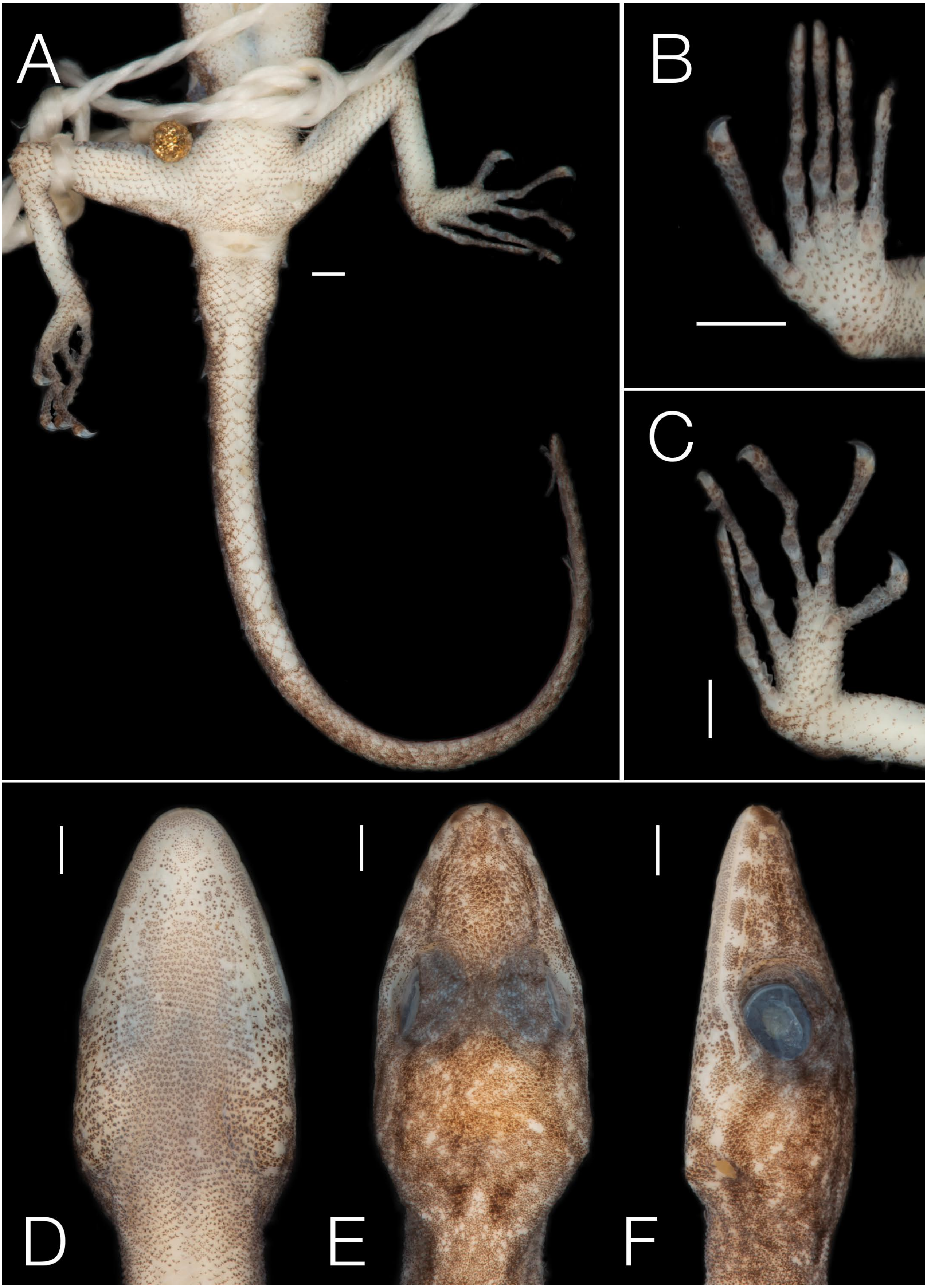

FIGURE 3. *Cnemaspis tanintharyi* **sp. nov.** Holotype. USNM 587514. Ventral view of cloacal, femoral and caudal region (A), underside of forefoot (B), underside of hindfoot (C), ventral (D) dorsal (E) and lateral (F) views of the head. Scale bars = 1 mm. Photographs by Esther M. Langan.

FIGURE 4. *Cnemaspis tanintharyi* **sp. nov.** Holotype. USNM 587514. Photographed in life (A) with view of the habitat surrounding the Type Locality (B). Photograph A by Daniel G. Mulcahy, Photograph B by Bonnie B. Blaimer.

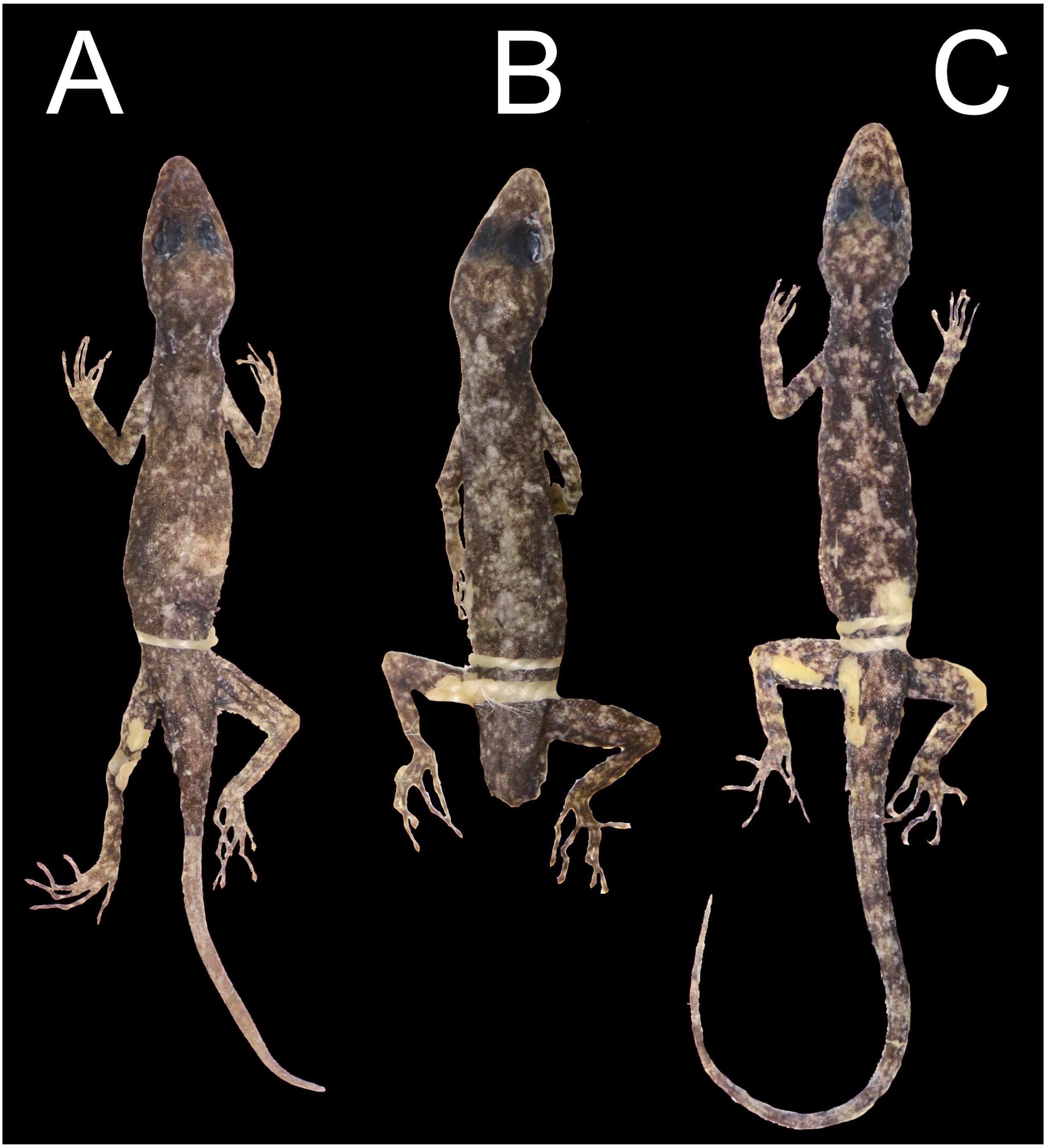

FIGURE 5. Variation in the paratypes, USNM 594371 (A), USNM 594372 (B) and USNM 594374 (C), of *Cnemaspis tanintharyi* **sp. nov.** Photographs by Justin L. Lee.

Comparisons. We compare the species *Cnemaspis tanintharyi* **sp. nov.** to all other members of the *Cnemaspis kandiana* group from southern Thailand, Sumatra and islands off its western coast and the Bay of Bengal. Further comparisons can be found in Table 3. *C. tanintharyi* **sp. nov.** is distinguished from *Cnemaspis phuketensis* Das & Leong, 2004 by having an enlarged medial subcaudal row (*versus* subequal), presence of both precloacal and femoral pores in males (*versus* both absent) and smooth gular scales (*versus* keeled). From the adjacent species *C. thayawthadangyi* **sp. nov.**, *C. tanintharyi* **sp. nov.** is distinguished by 21–23 ventral scales at midbody (*versus* 18–20), ventral scales on pectoral, abdominal, subcaudal and thigh regions smooth (*versus* all keeled), HeadD 26.1–32.5% of HeadL (*versus* 34.4–36.5%) and a gular coloration that is beige, dark gray-brown with dark-blue hueing towards throat (*versus* gular coloration with irregularly-shaped dark-gray streaks). From species of *Cnemaspis* in the Bay of Bengal, *C. tanintharyi* **sp. nov.** can be distinguished from *C. andersonii* by the presence of smooth gular scales (*versus* weakly keeled), keeled pectoral scales (*versus* smooth), the presence of enlarged medial subcaudals (*versus* subcaudals equal sized) and a blotched coloration with dark-edged blotches sometimes present (*versus* coloration plain brown, rather immaculate) and from *C. wicksi* by having 6–7 supralabials (*versus* 5 supralabials), 15–18 subdigital lamellae on the 4th toe (*versus* 14), the presence of smooth gular scales (*versus* keeled) and a blotched color pattern (*versus* no prominent features on color pattern).

The presence of smooth gular scales distinguishes *C. tanintharyi* **sp. nov.** from all members of the *C. kandiana* species group found in Sumatra and adjacent islands (*versus* keeled in *Cnemaspis aceh* Iskandar, McGuire & Amarasinghe, 2017, *Cnemaspis dezwaani* Das, 2005, *Cnemaspis jacobsoni* Das, 2005, *Cnemaspis minang* Iskandar, McGuire & Amarasinghe, 2017, *Cnemaspis modiglianii* Das, 2005, *Cnemaspis pagai* Iskandar, McGuire & Amarasinghe, 2017, *Cnemaspi tapanuli* Iskandar, McGuire & Amarasinghe, 2017 and *Cnemaspis whittenorum* Das, 2005 except for *C. andalas* Iskandar, McGuire & Amarasinghe, 2017. *C. tanintharyi* **sp. nov.** is distinguished from *C. andalas* by having 2–4 precloacal pores (*versus* six), 15–18 subdigital lamellae on the 4th toe (*versus* 18–20) and by four spine-like tubercles on the flank (*versus* six).

Etymology. The specific epithet refers to the type locality of this species situated in the Tanintharyi Region, Myanmar. We recommend the English common name "Tanintharyi Rock Gecko".

Distribution & natural history. *Cnemaspis tanintharyi* **sp. nov.** is known from just two localities in the proposed Lenya National Park and its proposed extension in the Tanintharyi Region, Myanmar. It may also exist in adjacent habitat in Southwest Thailand (see discussion). Both localities are situated near karst outcrops, with the surrounding habitat consisting of lowland tropical rainforest dominated by dipterocarp trees. Specimens were collected on karst outcrops and low down on the tree buttress of large dipterocarps. The immature specimen was found at dusk on a karst formation (G. Connette, pers. comm.). The type specimen was collected inside the margins of a cave during the day and the Nint Tenku specimen was collected during the morning from the buttress of a large dipterocarp tree, while running up the buttress after raking leaf litter. Like other species of the *Cnemaspis kandiana* group, this species probably uses caves, crevices, or leaf-litter as shelter. It is sympatric with *C. siamensis* at one locality (Nint Tenku).

Cnemaspis thayawthadangyi sp. nov.

Thayawthadangyi Islands Rock Gecko
Figs. 6–7.
urn:lsid:zoobank.org:act:8283FBDF-76A1-4F10-90CD-C26333EE2CAC

Holotype. USNM 595053 (GenBank accession no. MN104951), adult male collected by Daniel G. Mulcahy and Grant Connette on 12 May 2017, 2100–2230 h, from Za Let Aw (Escape Bay), southeast side of Linn Lune Kyun, Thayawthadangyi Kyun Group, Myeik Archipelago, Tanintharyi Region, Myanmar (12.30849°N, 98.0043°E; 80 m elevation).

Paratype. USNM 595052 (GenBank accession no. MN104950), adult male, same collection data as the holotype.

Diagnosis. *Cnemaspis thayawthadangyi* **sp. nov.** is a small diminutive member of the *C. kandiana* species group and can be distinguished from all other members of the group by a combination of the following morphological characters: 1) a maximum SVL of 29.9 mm; 2) each postmental bordered posteriorly by four scales; 3) four spine-like ventrolateral tubercles on flank; 4) gular scales keeled; 5) pectoral scales and abdominal scales keeled; 6) ventral scales keeled; 7) three precloacal pores; 8) four femoral pores on each leg; 9) subcaudal scales smooth, scales on median row enlarged and smooth; 10) coloration of the gular region silver with dark-gray irregularly shaped streaks; 11) 6–7 supralabials; 12) 6–7 infralabials; 13) 16–18 subdigital lamellae on the 4th toe; 14) 18–20 ventral scales at midbody.

Description of the holotype. Adult male (USNM 595053) in good condition with some skin missing from the dorsal surface at midbody. Left lateral incision for gonadal examination, testes pigmented marbled black. Summary of measurements: SVL 29.5 mm, TailL 38.7 mm, TailW 3.1 mm, BrachiumL 3.8 mm, ForearmL 4.5 mm, AxillaGroinL 12.6 mm, ThighL 5.7 mm, CrusL 6.0 mm, HeadL 9.0 mm, HeadW 4.9 mm, HeadD 3.1 mm, EyeD 1.6 mm, EyeEar 2.3 mm, SnEye 3.8 mm, NarEye 3.1, InterorbD 2.7 mm, EarL 0.5 mm, InternarD 1.1 mm, HeadL/SVL 30.5%, HeadW/SVL 16.6%, HeadD/HeadL 34.4%, SnEye/HeadL 42.2%, EyeD/HeadL 17.8%.

Head triangular, moderately oblong dorsally, slightly flattened, distinct from neck; snout moderately sized, flat in lateral view; rostral scale concave and partially divided by median groove dorsally, posteroventrally in contact with first supralabial; rostral contacted posteriorly by two supranasals, no medial internasal; nostrils round, dorsally oriented; scales along snout and occipital region granular, distinctly elevated, scales on snout larger than scales on occipital region; occipital scales small, granular and elevated; tubercles absent on snout but present on occipital region; seven supralabials; from eye approximately five or six scales blocking contact with supralabials; mental scale subtriangular, wider than long, in contact along its posterolateral edge with two large postmental scales and one smaller medial postmental scale blocking enlarged scales from contact; lateral postmental scales bordered posteriorly by four smooth scales; gular scales keeled; seven infralabials, both supra and infralabials decrease in size posteriorly.

FIGURE 6. *Cnemaspis thayawthadangyi* **sp. nov.** Holotype. USNM 595053. Dorsal (A) and Ventral (B) views of the after preservation. Scale Bar = 10 mm. Photographs by Esther M. Langan.

Body slender and elongate; ventrolateral furrow separating dorsal scales from ventral scales; dorsal tubercles slightly enlarged, mostly keeled, separated from one other by 2–6 scales; 15 paravertebral tubercles form a straight line; four ventrolateral spine-like tubercles; dorsal scales smooth, raised, granulate, smaller than ventral scales; pectoral scales keeled; ventral scales at midbody and abdominal region keeled; ventrolateral scales smooth, round, slightly elevated; 18 ventral scales at midbody; two precloacal pores, arranged in a small medial patch; four femoral pores on each side, in small singular row, separated from precloacal pores. Scales on underside of brachium smooth, weakly keeled under thigh; hindlimb digits slender, elongate, lacking webbing, bearing distinct recurved claws; 16 subdigital lamellae on 4th toe; relative length of fingers and toes 4 = 3 > 5 > 2 > 1; no significantly enlarged submetatarsal scale on toes.

Tail base swollen, complete two postcloacal openings, one on each side, presumably openings of hemipenial sheaths; longitudinal furrows present dorsally and ventrally; tail with two ventrolateral whorls of lateral tubercle rows each bordered by four to six scales; dorsal caudals keeled; dorsal scales on tail pointed; subcaudals smoth, medial scales enlarged, around 1.5–2.0x as large as surrounding scale rows.

Coloration in preservative. After formalin fixation and two years in ethanol the dorsum is gray-brown; a series of faint trapezoidal-shaped silver-gray blotches starting at nape and terminating posterior to hind limbs on anterior portion of the tail; midbody with scattered gray and white mottling concentrated on tubercles; area around eyelids blue; scattered broken dark-brown bands on limbs and toes. Top of head gray-brown, labial scales mainly gray-brown, edged with silver; dark-brown postorbital stripe starting at neck, continuing through eye and ending at nostril. Venter cream; median of pectoral and midbody region immaculate bordered laterally by gray-brown mottling; limbs and abdominal regions bear scattered gray-brown mottling and dark colored scale edges; subdigital lamellae gray-brown; gular region silver with scattered irregular-shaped dark-gray streaks. Coloration in life not recorded.

Description of the paratype. The male paratype has a broken tail, but in all other aspects of morphology, agrees with the holotype. A summary of differences is shown in Table 2.

Comparisons. We compare the species *Cnemaspis thayawthadangyi* **sp. nov.** to all other members of the *Cnemaspis kandiana* group from Southern Thailand, Sumatra and islands off its west coast and the Bay of Bengal. Further comparisons can be found in Table 3. *C. thayawthadangyi* **sp. nov.** is distinguished from *C. phuketensis* by having an enlarged medial subcaudal row (*versus* subcaudals equal in size), precloacal and femoral pores in males (*versus* both absent), smooth gular scales (*versus* keeled) and by four scales bounding each postmental scale (*versus* three). For distinctions between *C. tanintharyi* **sp. nov.** and *C. thayawthadangyi* **sp. nov.**, see the comparisons section in the species account for *C. tanintharyi* **sp. nov.** From the *Cnemaspis* found in the Bay of Bengal, *C. thayawthadangyi* **sp. nov.** is distinguished from *C. andersonii* by having four bounded scales bordering the postmental (*versus* three scales), ventral scales throughout belly keeled (*versus* all ventral scales smooth), the presence of enlarged medial subcaudal row (*versus* subcaudals equal sized) and a blotched color pattern (*versus* immaculate coloration) as well as *C. wicksi* by three precloacal pores (*versus* 4–5), 16–18 subdigital lamellae on 4th toe (*versus* 14), keeled abdominal scales (*versus* smooth), ventral scales on thigh weakly keeled (*versus* smooth), and a blotched color pattern (*versus* immaculate coloration).

The presence of keeled ventral scales on the thigh distinguishes *C. thayawthadangyi* **sp. nov.** from all members of the *C. kandiana* species group found in Sumatra and islands off its west coast (*C. aceh*, *C. andalas*, C. *phuketensis, C. minang,* and *C. tapanuli*) except for *C. dezwaani, C. jacobsoni*, *C. modiglianii*, *C. pagai* and *C. whittenorum*. *Cnemaspis thayawthadangyi* **sp. nov.** is distinguished from *C. dezwaani* by having three precloacal pores (*versus* 8–12) and the absence of a pale vertebral stripe (*versus* present), from *C. jacobsoni* by having femoral and precloacal pores (*versus* absent), 16–18 subdigital lamellae on 4th toe (*versus* 14), from *C. modiglianii* by having 18–20 ventral scales at midbody (*versus* 24–26); only four precloacal pores (*versus* 2–4), only four scales surrounding each postmental (*versus* 3–5) and by a gular coloration consisting of thick dark irregular stripes (*versus* unpatterned gular coloration), from *C. pagai* by having 16–18 subdigital lamellae on 4th toe (*versus* 20), three precloacal pores (*versus* two), four femoral pores (*versus* three) and four scales bordering each postmental (*versus* three), from *C. whittenorum* by having three precloacal pores (*versus* four), four femoral pores (*versus* six), 6–7 supralabials (*versus* 5–6), and the absence of a pale vertebral stripe (*versus* present).

Etymology. The specific epithet "*thayawthadangyi*" is a reference to the type locality of this species—the Thayawthadangyi Kyun (Island) group in the Myeik Archipelago. We recommend the common name "Thayawthadangyi Islands Rock Gecko" for this species, a reference to the island group in which it was first found.

Distribution & natural nistory. *Cnemaspis thayawthadangyi* **sp. nov.** is currently known from a single locality on Linn Lune Kyun, Thayawthadangyi Island Group, Myeik Archipelago, Tanintharyi Region, Myanmar, near the top of a waterfall in Za Let Aw (Escape Bay) on the southeast side of the island. The two specimens were collected on large tree trunks at night close to a stream. This species is probably more widely distributed than currently documented and likely inhabits similar microhabitats on this and other islands in the group.

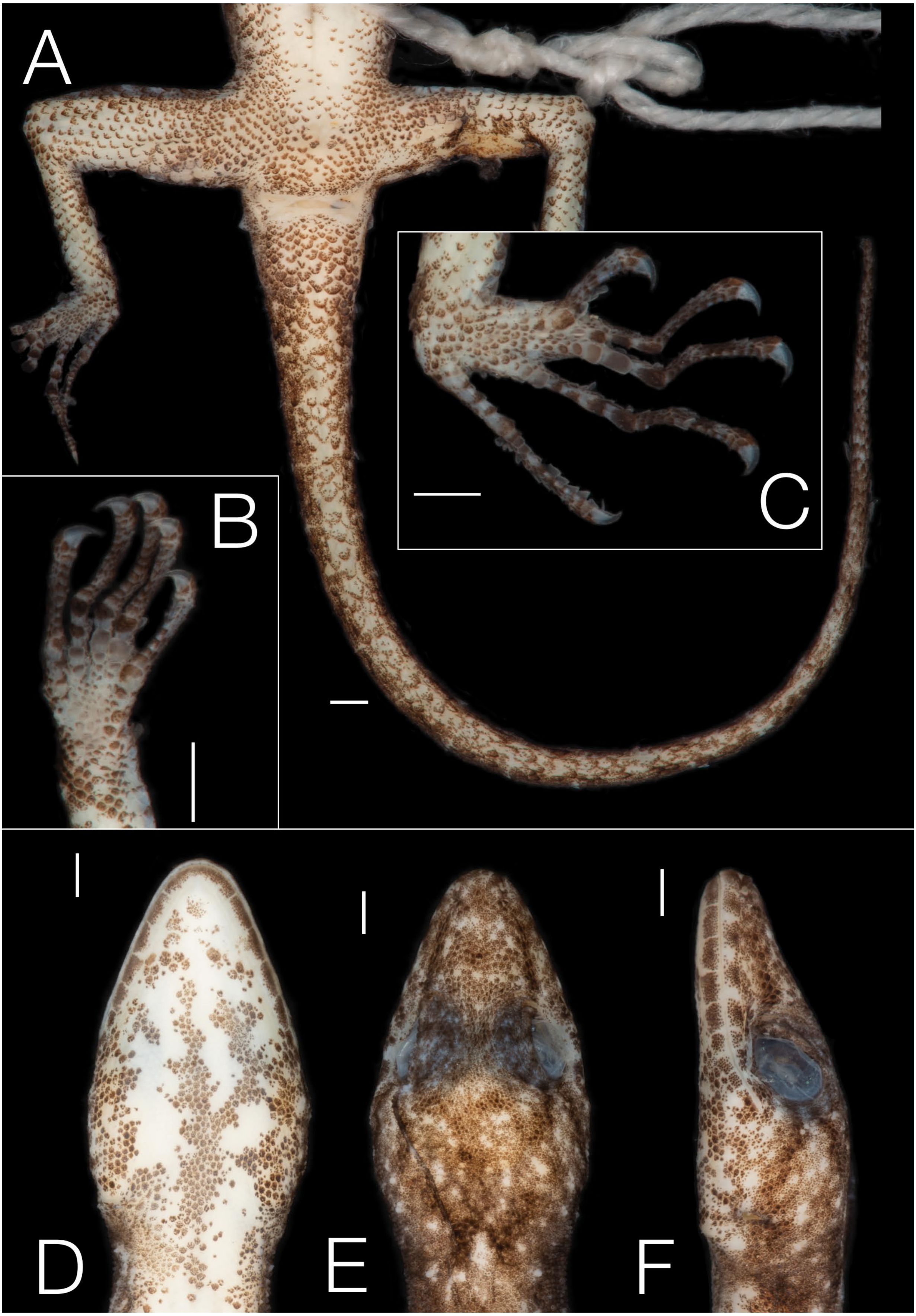

FIGURE 7. *Cnemaspis thayawthadawgyi* **sp. nov.** Holotype. USNM 595053. Ventral view of cloacal, femoral and caudal region (A), underside of forefoot (B), underside of hindfoot (C), ventral (D) dorsal (E) and lateral (F) views of the head. Scale bars = 1 mm. Photographs by Esther M. Langan.

TABLE 2. Summary of morphological variation of the holotype and paratypes of *Cnemaspis thayawthadangyi* **sp. nov.** Entry marked with a "–" represents a character not available for study.

	USNM 595053	**USNM 595052**
Status	Holotype	Paratype
Sex	Male	Male
Tail Broken (2) Regenerated (1) or original (0)	0	2
SVL	29.5	29.9
TailL	38.7	–
BrachiumL	3.8	3.3
ForearmL	4.5	4.7
AxillaGroinL	12.6	12.7
ThighL	5.7	5.9
CrusL	6.0	6.0
HeadL	9.0	8.5
HeadW	4.9	5.0
HeadD	3.1	3.1
EyeD	1.6	1.6
EyeEar	2.3	2.1
SnEye	3.8	3.6
NarEye	3.1	3.2
InterorbD	2.7	2.4
EarL	0.5	0.3
InternarD	1.1	0.9
Supralabials	6/7	6/6
Infralabials	6/7	7/7
Postmentals	3	3
Precloacal Pores	2	3
Femoral Pores	4	5
Paravertebral Tubercles	15	11
Ventral Scales at Midbody	18	20
Ventrolateral Caudal Tubercles Anteriorly	1	1
4th Toe Lamellae	16	18

Addition of *Cnemaspis siamensis* to the herpetofauna of Myanmar

The discovery of *Cnemaspis siamensis* in the Tanintharyi Region represents a country record for Myanmar. Two adult males were collected by Daniel G. Mulcahy, Myint Kyaw Thura and Thaw Zin on 20 May 2015 (USNM 587512; GenBank accession no. MN104943) and 30 May 2015 (USNM 587513) near Ma Noe Lone stream close to its confluence with the Lenya River, proposed Lenya National Park, Tanintharyi Region, Myanmar (11.06520°N 98.91556°E; 55 m elevation). The nearest record from this locality is approximately 40 km southwest at Kapoh Waterfall, Tha Sae District, Chumphon Province, Thailand (Grismer *et al.* 2010). Another male specimen (USNM 594370; GenBank accession no. MN104945) was collected on 19 May 2016 near Nint Tenku village, proposed Lenya National Park, Tanintharyi Region, Myanmar (11.45189°N 99.22590°E; 54 m elevation) by the same collectors. All specimens agree morphologically with *C. siamensis* by having a silver-gray dorsum with transverse bars and flanks, gular region white with dark black longitudinal stripes, subcaudal scales slightly enlarged, forearm, subtibials, ventrals, subcaudals, and dorsal tubercles keeled, gular scales smooth, 8–9 supralabials and 6–8 infralabials. These characters agree with literature descriptions provided by Taylor (1965) and Grismer *et al.* (2010).

TABLE 3. Diagnostic characters of *Cnemaspis tanintharyi* **sp. nov.** and *Cnemaspis thayawthadangyi* **sp. nov.** compared to other members of the *Cnemaspis kandiana* species group from Southeast Asia. Entries marked with a "–" represent characters not available for study. Data from other species comes from Das & Leong (2004), Manamendra-Arachchi *et al.* (2007), Iskandar *et al.* (2017).

	***thayawthadangyi* sp. nov.**	***tanintharyi* sp. nov.**	***phuketensis***	***aceh***	***andalas***	***andersonii***	***dezwaani***
Max SVL	29.9	29.6	29.1	30.7	33.8	31.5	31.3
Supralabials	6–7	6–7	6–7	7	6–7	7	5–7
Number of bounding scales of each postmental	4	2–4	3	4	4	3	4
Number of spine-like tubercles on flank	4	4	4	6	6	–	4
Precloacal Pores	3	2–4	0	–	6	3	8–12
Femoral Pores (on each side)	4	4–5	0	–	4	4	3–4
4th Toe Lamellae	16–18	15–18	16–17	18	18–20	–	16–19
Gular Scales Keeled (1) or Smooth (0)	1	0	1	1	0	–	1
Pectoral Scales Keeled (1) or Smooth (0)	1	1	1	1	0	0	1
Abdominal Scales Keeled (1) or Smooth (0)	1	0	0	1	0	0	1
Subtibial Scales Keeled (1) or Smooth (0)	1 (weak)	0	0	0	0	0	1
Subcaudals Keeled (1) or Smooth (0)	0	0	0	1	0	–	1
Median Subcaudal Row enlarged (1) or subequal (0)	1	1	0	1	1	0	1
Pale Vertebral Stripe Present (1) or Absent (0)	0	1	0	1	1	0	1

......*continued on the next page*

TABLE 3. (Continued)

	jacobsoni	*minang*	*modiglianii*	*pagai*	*tapanuli*	*whittenorum*	*wicksi*
Max SVL	30.5	31.3	33.6	31.9	32.1	32.0	28.6
Supralabials	6–7	8	6–7	7	6	5–6	5
Number of bounding scales of each postmental	4	3–4	3–5	3	3	4	3
Number of spine-like tubercles on flank	–	4	4	4	4	4	–
Precloacal Pores	0	4	2–4	2	4	4	4
Femoral Pores (on each side)	0	4	4–5	3	4–5	6	4–5
4th Toe Lamellae	14	18	16–18	20	18	18	14
Gular Scales Keeled (1) or Smooth (0)	1	1	1	1	1	1	1
Pectoral Scales Keeled (1) or Smooth (0)	1	0	1	1	1	1	–
Abdominal Scales Keeled (1) or Smooth (0)	1	0	1	1	0	1	0
Subtibial Scales on Thigh Keeled (1) or Smooth (0)	1	0	1	1	0	1	0
Subcaudals Keeled (1) or Smooth (0)	1	0	1	1	0	1	0
Median Subcaudal Row enlarged (1) or subequal (0)	1	1	1	1	1	1	1
Pale Vertebral Stripe Present (1) or Absent (0)	1	0	0	0	1	1	0

Discussion

The discovery of the genus *Cnemaspis* in mainland Myanmar is not surprising because they are known from adjacent Thailand. Part of the reason why they remained undetected for so long was due to a lack of surveys in proper habitat. The discovery of *Cnemaspis siamensis* in the Tanintharyi Region, Myanmar fills a predictable sampling gap in its distribution. The closest records to the two Tanintharyi localities are approximately 40 km southeast at Kapoh Waterfall, Tha Sae District, Chumphon Province, Thailand and approximately 45 km west from Thap Sakae District, Prachuap Khiri Khan Province, Thailand (Grismer *et al.* 2010). Interestingly, we discovered high intraspecific divergences (5.1% uncorrected p-distance) within samples, signifying that this group may merit further molecular phylogenetic and morphological investigation and might contain unrecognized microendemic diversity. However, the large sequence divergence could also be caused by poor dispersal rates typical in small, low motile gecko species.

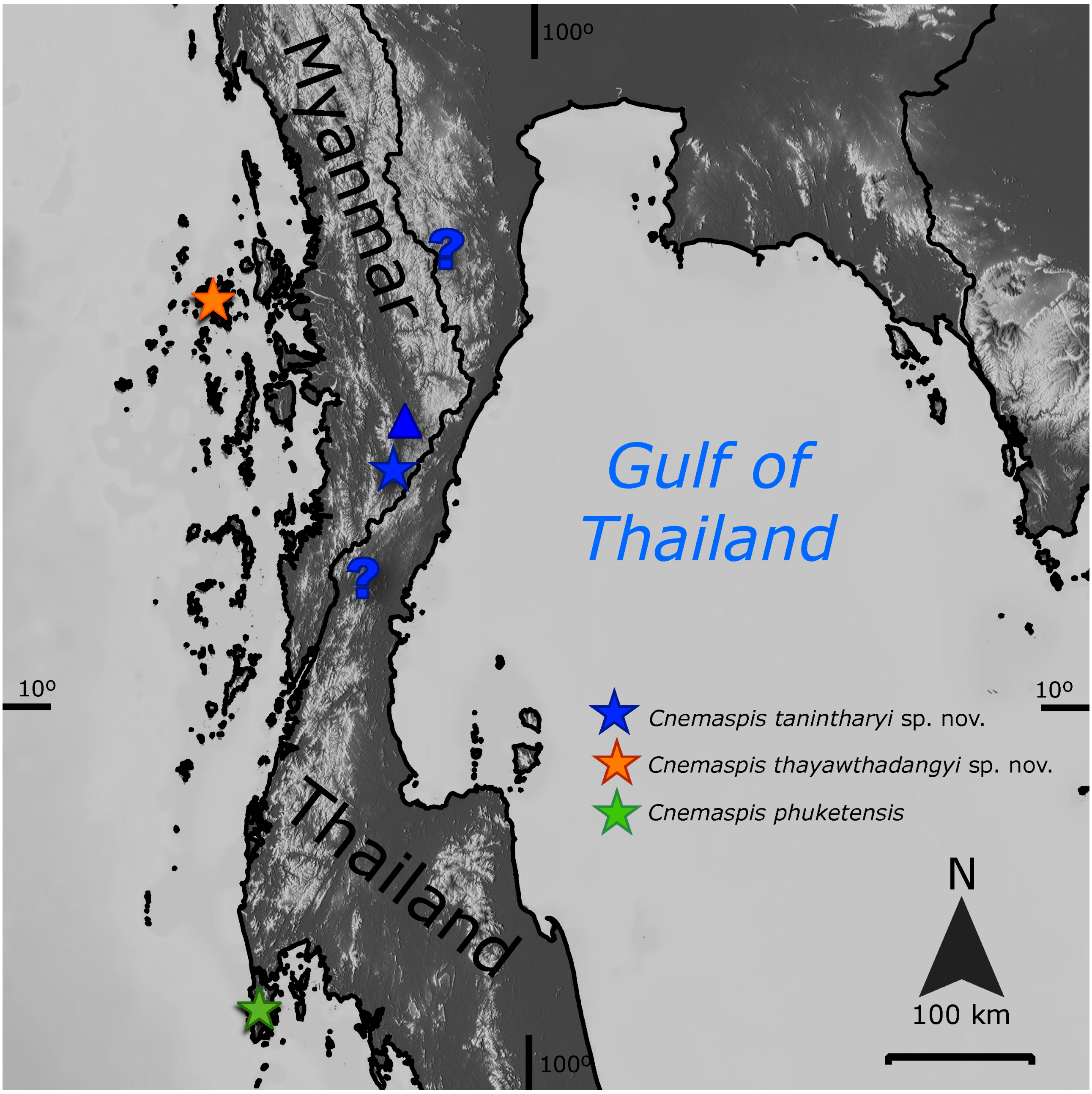

FIGURE 8. Distribution of the two new *Cnemaspis* from Myanmar, showing the distribution of *Cnemaspis tanintharyi* **sp. nov.** (Blue), *Cnemaspis thayawthadangyi* **sp. nov.** (Orange) and nearby *Cnemaspis phuketensis* (Green). Stars represent type localities. Records identified as *Cnemaspis* cf. *tanintharyi* from Thailand are represented by blue question marks.

The status of remaining *C. kandiana* populations from Thailand reported by Taylor (1963), Dring (1979) and later authors (Pauwels *et al.* 2003; Chan-ard *et al.* 2015) have remained unresolved until now. These populations, when first recognized by Taylor (1963), were referred to *Cnemaspis mysoriensis* (Jerdon, 1853), an Indian species; yet Taylor acknowledged they may be conspecific with *C. kandiana*. Dring (1979) followed this by recognizing peninsular Thailand and Sumatran populations as *C. kandiana*. The Sumatran populations were subsequently described as distinct species (Das 2005; Manamendra-Arachchi *et al.* 2007), and *C. mysoriensis* was later restricted to India (Giri *et al.* 2010), leaving peninsular Thailand populations as '*C. kandiana*', except for populations on Phuket Island, which are now known as *C. phuketensis*. The morphological description provided by Taylor (1963) matches the description of *C. tanintharyi* **sp. nov.** in several characters, mainly the number of femoral and precloacal pores and number of supralabials. However, his description lacks other pertinent characters that could confirm the identification of these specimens. Because we have not directly examined these specimens, we conservatively identify these populations as *Cnemaspis* cf. *tanintharyi.* The occurrence of *kandiana* group members in Southeast Asia is interesting, as the only other locations in Southeast Asia besides the Isthmus of Kra region where this group persists include Sumatra, adjacent islands on its western coast and the Andaman & Nicobar Island archipelagos in the Bay of Bengal (Das 2005; Manamendra-Arachchi *et al.* 2007; Harikrishnan *et al.* 2010; Iskandar *et al.* 2017). However, the distribution of the clade matches many biogeographic scenarios of other amphibians and reptiles that have sister populations in South Asia and Sundaland (Gower *et al.* 2005; Klaus *et al.* 2010; Harikrishnan *et al.* 2012; Grismer *et al.* 2016). The Southeast Asian clade of *Cnemaspis* dominates the rest of mainland Southeast Asia, including most of Sundaland (Grismer *et al.* 2014).

FIGURE 9. Adult male *Cnemaspis siamensis* (USNM 594370) from Nint Tenku, Tanintharyi Region, Myanmar. Photograph by Daniel G. Mulcahy.

The biogeographic origins of the South Asian *Cnemaspis* are uncertain, but the group likely arose on the Indian subcontinent given the high species diversity in this region (Agarwal *et al.* 2017). As the Indian Subcontinent drifted northward after its detachment from Gondwana, faunal exchange pathways opened up between the subcontinent and Southeast Asia (Klaus *et al.* 2010; Li *et al.* 2013; Grismer *et al.* 2016). Grismer *et al.* (2016) noted two invasions between India and Southeast Asia for agamid lizards, one of them allowing colonization from India to Sundaland and vice versa. A similar scenario was proposed for the swamp-dwelling clade of *Cyrtodactylus* (Grismer & Davis 2018). In their phylogenetic analysis, Agarwal *et al.* (2017) estimated that the Sumatran *Cnemaspis modigliani* split from its Indian congeners during the Miocene. Based on our phylogenetic data, the clade containing both *Cnemaspis tanintharyi* **sp. nov.** and *Cnemaspis thayawthadangyi* **sp. nov.** is sister to *C. modigliani*. This relationship suggests that the South Asian *Cnemaspis* found in Myanmar and Thailand are relicts of a northward expansion from Sundaland. However, this hypothesis needs further testing and appropriate genetic samples of the other *Cnemaspis* found in Sumatra, as well as subsequent sampling of *C.* cf. *tanintharyi* from peninsular Thailand (*sensu* Taylor 1963 and Dring 1979), *C. phuketensis, C. andersonii*, and *C. wicksi*. Samples of the latter two species will be difficult to obtain because both species have not been detected since their discovery in the late 19th century (Manamendra-Arachchi *et al.* 2007; Meiri *et al.* 2018). However, given the paucity of herpetological expeditions to the Andaman & Nicobar Islands, it is possible these species may not be rare. Future surveys in Myanmar may find additional species of *Cnemaspis*, but researchers should be mindful that these new populations may not represent members of the nominal Southeast Asian *Cnemaspis* clade, but could be related to South Asian *Cnemaspis* such as in the new species described herein.

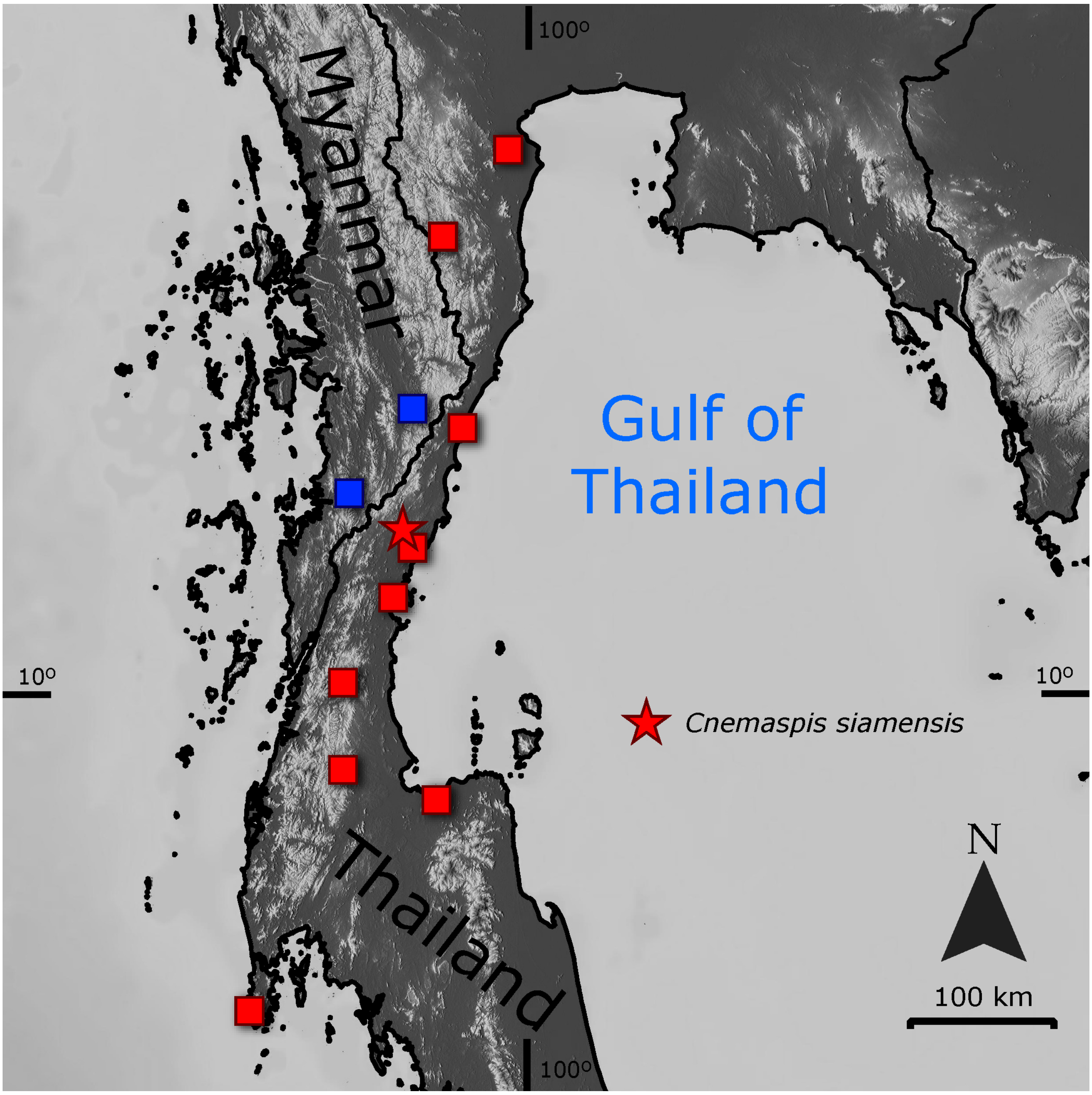

FIGURE 10. Distribution map of *Cnemaspis siamensis* (Red) showing new records from the Tanintharyi Region (Blue). Star represents type locality.

The localities of both new *Cnemaspis* species in the Tanintharyi Region may be under threat from habitat loss. Destruction of karstic habitats will affect the populations of *C. tanintharyi* **sp. nov.** and other karst-associated lizards (Grismer *et al.* 2017). In addition, since some specimens of *C. tanintharyi* **sp. nov.** were collected from forested areas, clear cutting of rainforests may negatively affect this species amongst other native herpetofauna (Connette *et al.* 2017). *Cnemaspis thayawthadangyi* **sp. nov.** is known from one locality in the Thayawthadangyi Kyun Island Group and has not been detected elsewhere. Given that there have been few herpetological surveys of the Myeik Archipelago, it is possible that *C. thayawthadangyi* **sp. nov.** is more widely distributed than currently understood because it is a forest-dwelling species and similar habitat exists throughout the island. Nevertheless, efforts should still be made to preserve the type localities of both species. If they are endemic to their surroundings, the destruction of these sites could cause their extinction. In conclusion, the addition of *Cnemaspis* to the Tanintharyi adds to a growing number of known endemic amphibians and reptiles from the Isthmus of Kra region, further supporting the idea that its herpetofaunal diversity is still severely underestimated.

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