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A new rock gecko in the *Cnemaspis siamensis* group (Reptilia, Gekkonidae) from Kanchanaburi Province, western Thailand

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Abstract

We describe a new species of the gekkonid genus *Cnemaspis* from Erawan National Park in Kanchanaburi Province of western Thailand. Molecular phylogenetic analyses, based on the mitochondrial NADH dehydrogenase subunit 2 gene and flanking tRNAs, revealed that *Cnemaspis auriventralis* **sp. nov.** is nested within the *C. siamensis* group and is closely related to *C. huaseesom*, but has uncorrected pairwise genetic divergences of 12.12–27.92% from all other species in the *C. siamensis* group. The new species is also distinguished from other species in the *C. siamensis* group by having the combination of snout-vent length 36.7–38.6 mm in males (N = 3), 32.9–36.9 mm in females (N = 2); eight to ten supralabials; seven to nine infralabials; ventral scales smooth; six or seven precloacal pores in males; 16–17 paravertebral tubercles linearly arranged; tubercles on the lower flanks present; lateral caudal furrows present; no caudal tubercles in the lateral furrows; ventrolateral caudal tubercles present anteriorly; caudal tubercles not encircling tail; subcaudals smooth bearing a single median row of enlarged smooth scales; two postcloacal tubercles on each side; no shield-like subtibial scales; subtibial scales smooth; no enlarged submetatarsal scales; 23–27 subdigital lamellae on the fourth toe; sexually dimorphic for dorsal and ventral colour pattern; prescapular marking absent; gular marking absent; and yellow colouration in life of all ventral surfaces of head, body and tail in adult males. The new species is currently known only from upland karst habitat at its type locality.

Key Words

Cnemaspis auriventralis, Erawan National Park, karst formations, molecular phylogenetics, morphology

Introduction

The Southeast Asian Rock Gecko genus *Cnemaspis* Strauch, 1887 comprises a monophyletic clade of approximately 66 recognised species that are distributed from Laos, southern Vietnam westwards through southern Indochina, southwards through the Thai-Malay Peninsula, Sumatra, Java and eastwards to Borneo (Grismer 2010; Grismer et al. 2014, 2020; Wood et al. 2017; Riyato et al. 2019; Ampai et al. 2020; Quah et al. 2020; Nashriq et al. 2022; Uetz et al. 2022). Based on molecular and morphological data, Southeast Asian *Cnemaspis* are recovered in four major monophyletic clades that contain six species groups (Grismer et al. 2014). The *Cnemaspis siamensis* group is distributed across the Thai-Malay Peninsula and northwards to Kanchanaburi Province, western Thailand (Grismer et al. 2014, 2020; Ampai et al. 2019). This group currently contains 13 named species (Grismer et al. 2010, 2014, 2020; Wood et al. 2017; Ampai et al. 2019, 2020) including *C. adangrawi* Ampai, Rujirawan, Wood, Stuart & Aowphol, 2019, *C. chanardi* Grismer, Sumontha, Cota, Grismer, Wood, Pauwels & Kunya, 2010, *C. huaseesom* Grismer, Sumontha, Cota, Grismer, Wood, Pauwels & Kunya, 2010, *C. kamolnorranathi* Grismer, Sumontha, Cota, Grismer, Wood, Pauwels & Kunya, 2010, *C. lineatubercularis* Ampai, Wood, Stuart & Aowphol, 2020, *C. omari* Grismer, Wood, Anuar, Riyanto, Ahmad, Muin, Sumontha, Grismer, Chan, Quah & Pauwels, 2014, *C. phangngaensis* Wood, Grismer, Aowphol, Aguilar, Cota, Grismer, Murdoch & Sites, 2017, *C. punctatonuchalis* Grismer, Sumontha, Cota, Grismer, Wood, Pauwels & Kunya, 2010, *C. roticanai* Grismer & Chan, 2010, *C. selenolagus* Grismer, Yushchenko, Pawangkhanant, Nazarov, Naiduangchan, Suwannapoom & Poyarkov, 2020, *C. siamensis* (Smith, 1925), *C. thachanaensis* Wood, Grismer, Aowphol, Aguilar, Cota, Grismer, Murdoch & Sites, 2017 and *C. vandeventeri* Grismer, Sumontha, Cota, Grismer, Wood, Pauwels & Kunya, 2010. Ecologically, many species of this genus are substrate or microhabitat specialists (e.g. granite, karst, vegetation or terrestrial) and restricted to activity periods (diurnal or nocturnal) and elevational zonation (lowlands or uplands) (Grismer et al. 2014; Wood et al. 2017; Ampai et al. 2020). In Kanchanaburi Province of western Thailand, *C. huaseesom* was discovered from Sai Yok National Park, Sai Yok District, based on specimens that were commonly found on hillsides in lowland areas having karst boulders (Grismer et al. 2010, 2014).

During recent herpetological surveys in Kanchanaburi Province of western Thailand, we collected five specimens of *Cnemaspis* from the karst formations in Erawan National Park. Molecular and morphological analyses revealed that the Erawan *Cnemaspis* were members of the *C. siamensis* group, but differed from all other recognised species. Herein, we describe it as a new species.

Materials and methods

Field collection of specimens

Field surveys were conducted at Erawan National Park, Tha Kradan Subdistrict, Si Sawat District, Kanchanaburi Province, Thailand, in November 2019 and November 2021 (Fig. 1). Direct observations were made during the day (09:00–17:00 h) and at night (19:00–22:00 h) and *Cnemaspis* specimens were collected by hand. Captured specimens were humanely euthanised using tricaine methanesulphonate (MS-222) within 24 hours of collection (Simmons 2015). Liver or muscle tissues were immediately removed from euthanised individuals, preserved in 95% ethyl alcohol and stored at -20 °C for molecular analysis. Euthanised specimens were fixed in 10% formalin and later transferred to 70% ethyl alcohol for permanent storage. Specimens and tissues were deposited in the herpetological collection of the Zoological Museum, Kasetsart University, Thailand (**ZMKU**). Geographic coordinates and elevations were recorded using a Garmin GPSMAP 64s with WGS84 datum. Ambient air temperature and relative humidity were collected with a Kestrel 4000 Weather Meter. Live animals and preserved specimens were photographed using a Nikon D700 or Z50 digital camera with an AF-S Micro Nikkor 60-mm f/2.8G ED lens and external flashes.

Morphology

Morphological characters taken and their abbreviations were modified from recent studies of the genus *Cnemaspis* (Wood et al. 2017; Ampai et al. 2020; Grismer et al. 2020). Morphological measurements were taken with digital calipers to the nearest 0.1 mm. Scalation and other aspects of external morphology were examined using a Nikon SMZ745 stereomicroscope. Measurements were taken on the left side of the body, while scale counts were taken on both right and left sides (R/L) when possible. Measurements and meristic characters are shown in Table 1 and qualitative observations of external morphology evaluated are described below.

Additional character states evaluated were the general size (i.e. strong, moderate, weak) and arrangement (i.e. random or linear) of the dorsal body tubercles; the orientation and shape of precloacal pores; the number of precloacal scales lacking pores separating the left and right series of pore-bearing precloacal scales; the degree and arrangement of body and tail tuberculation; the relative size and morphology of the subcaudal scales, subtibial scales and submetatarsal scales beneath the first metatarsal. Sex and maturity were determined by the presence of secondary sexual characteristics, such as the presence of hemipenes or pore-bearing precloacal scales in males, the presence of calcium glands or eggs in females or sexually dimorphic colour patterns. Morphological data for comparisons were obtained from the original and expanded descriptions of other species in the *C. siamensis* group (Smith 1925; Grismer and Chan 2010; Grismer et al. 2010, 2014, 2020; Wood et al. 2017; Ampai et al. 2019, 2020).

DNA extraction and PCR amplification

We extracted genomic DNA from the liver tissue of five individuals of *Cnemaspis* from Erawan National Park, Kanchanaburi Province (Table 2) using the DNeasy Blood and Tissue Kit (Qiagen, Germany) according to the manufacturer's protocol. A portion of the mitochondrial NADH dehydrogenase subunit 2 gene (ND2) and its flanking tRNAs was amplified via a double-stranded polymerase chain reaction (PCR), using the light strand primer L4437b (5'-AAGCAGTTGGGCCCATACC-3'; Macey et al. 1997) and heavy strand primer H5934 (5' AGRGTGCCAATGTCTTTGTGRTT-3'; Macey et al. 1997). PCR reactions were executed in an Eppendorf Mastercycler gradient thermocycler under the following conditions: initial denaturation at 95 °C for 2 min, followed

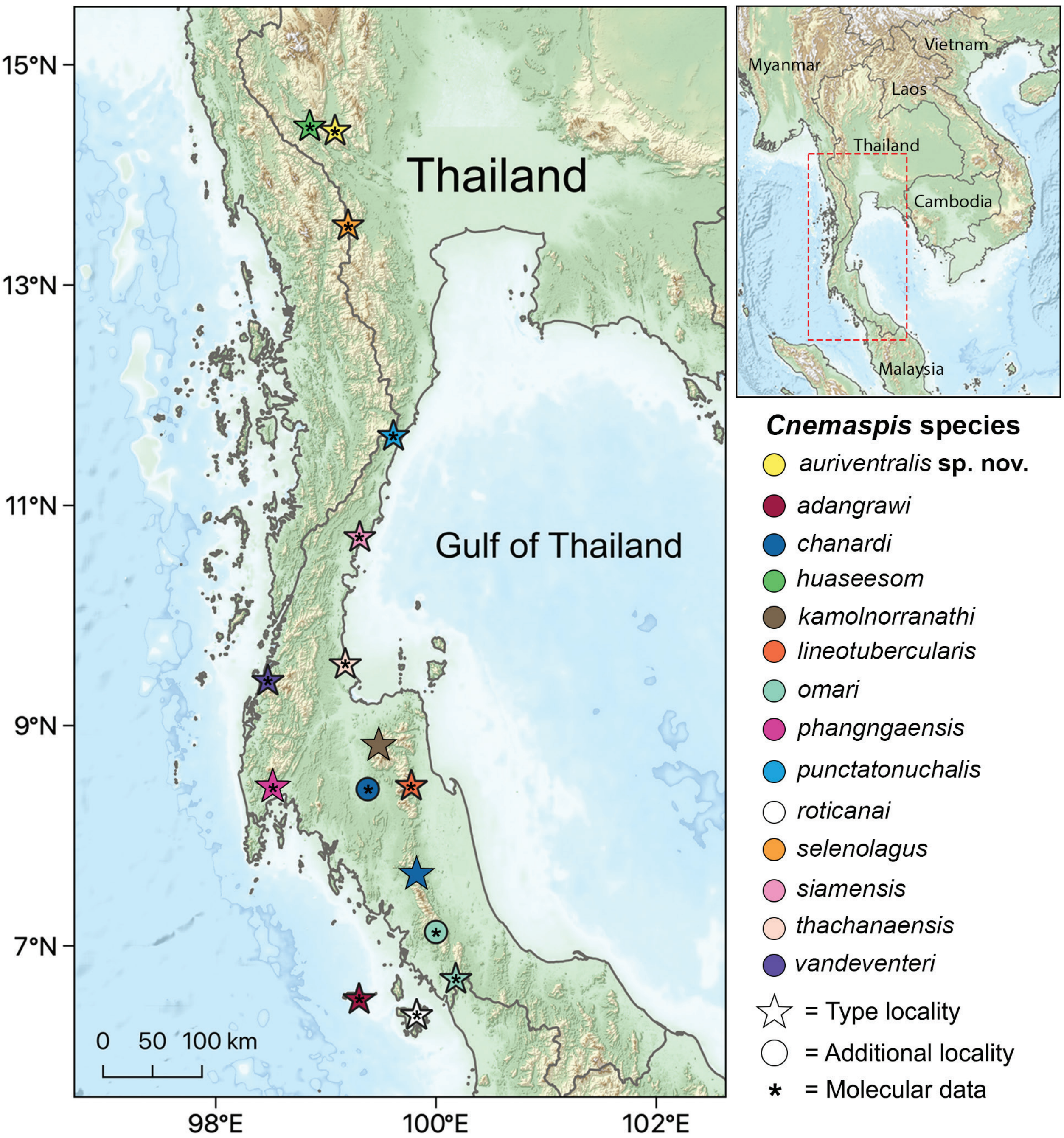

Figure 1. Map illustrating the type locality (yellow star) of *Cnemaspis auriventralis* sp. nov. at Erawan National Park, Si Sawat District, Kanchanaburi Province, Thailand and the *Cnemaspis siamensis* group samples used in the molecular analyses (asterisk) given in Table 2. Stars indicate type localities and circles represent additional localities.

by a second denaturation at 95 °C for 35 s, annealing at 55 °C for 35 s, followed by a cycle extension at 72 °C for 35 s, for 33–40 cycles with a final extension at 72 °C for 10 min. PCR products were purified using a QIAquick PCR Purification Kit (Qiagen, Germany). PCR products were sequenced in both forward and reverse directions using the same amplifying primers at Biobasic Asia Inc. (Singapore) on an ABI 3730XL automatic sequencer (Applied Biosystems, CA, USA). Sequences were visually checked and edited in Geneious R11 (Biomatters Ltd, Auckland, New Zealand). The protein-coding region of ND2 was translated to amino acids and checked to confirm the lack of premature stop codons. All new sequences were deposited in GenBank under accession numbers OP093974–OP093978 (Table 2).

Phylogenetic analyses

Additional homologous sequences of 68 individuals belonging to the *C. affinis* group, *C. boulengerii* group, the *C. argus* group, the *C. chanthaburiensis* group, the

Table 1. Morphological characters and abbreviations used in this study.

Abbreviations	Characters
Measurement	
SVL	Snout-vent length, taken from tip of snout to the anterior margin of vent
TW	Tail width at the base of the tail immediately posterior to the postcloacal swelling
TL	Tail length, as distance from the vent to the tip of the tail, whether original, broken or regenerated
FL	Forearm length, taken on the dorsal surface from the posterior margin of the elbow while flexed 90° to the inflection of the flexed wrist
TBL	Tibia length, taken on the ventral surface from the posterior surface of the knee while flexed 90° to the base of the heel
HL	Head length, as distance from the posterior margin of the retroarticular process of the lower jaw to the tip of the snout
HW	Head width at the angle of the jaws
HD	Head depth, as the maximum height of head from the occiput to the throat
AG	Axilla-groin length, taken from the posterior margin of the fore-limb at its insertion point on the body to the anterior margin of the hind-limb at its insertion point on the body
ED	Eye diameter, as the maximum horizontal diameter of the eyeball
EE	Eye-ear distance, measured from the anterior margin of the ear opening to the posterior edge of the eyeball
EL	Ear length, taken from the greatest vertical distance of the ear opening
EN	Eye-nostril distance, measured from the anterior most margin of the eyeball to the posterior margin of the external nares
ES	Eye-snout distance, measured from the anterior margin of the eyeball to the tip of snout
IO	Inner orbital distance, as the width of the frontal bone at the level of the anterior edges of the orbit
IN	Internarial distance, measured between the medial margins of the nares across the rostrum
Scalation	
SL	Supralabial scales, counted from below the middle of the orbit to the rostral scale
IL	Infralabial scales, counted from below the middle of the orbit to the mental scale
PVT	The number of paravertebral tubercles between limb insertions, counted in a straight line immediately left of the vertebral column
4TL	The number of subdigital lamellae beneath the fourth toe, counted from the base of the first phalanx to the claw
PP	The total number of pore-bearing precloacal scales in males
PPS	The number of postcloacal tubercles on each side of tail base

C. kumpoli group, the *C. siamensis* group and outgroups were downloaded from GenBank. *Cyrtodactylus bokorensis* Murdoch, Grismer, Wood, Neang, Poyarkov, Tri, Nazarov, Aowphol, Pauwels, Nguyen & Grismer, 2019 and *Hemidactylus garnotii* Duméril & Bibron, 1836 were selected as outgroups to root the tree following Ampai et al. (2020) and Quah et al. (2020). The five newly-generated and downloaded *Cnemaspis* sequences were aligned using the default options in the MUSCLE (Edgar 2004) plug-in in Geneious R11 (Biomatters Ltd, Auckland, New Zealand). The aligned dataset was partitioned into four partitions consisting of 1st–3rd ND2 codon positions and tRNAs.

Maximum Likelihood (ML) and Bayesian Inference (BI) were used to estimate phylogenetic relationships. Best-fit models of evolution for each partition was determined using the Bayesian information criterion (BIC) implemented in ModelFinder (Kalyaanamoorthy et al. 2017). The best-fit evolutionary models were TPM2u+F+I+G4 for tRNAs and TVM+F+I+G4, TIM3+F+G4 and GTR+F+G4 for ND2 codon positions 1, 2 and 3, respectively. The ML analysis was performed using the IQ-TREE webserver 1.6.12 (Trifinopoulos et al. 2016) with 1,000 bootstrap pseudo-replicates using the ultrafast bootstrap analysis (Minh et al. 2013; Hoang et al. 2018). The BI analysis was implemented in MrBayes v.3.2 (Ronquist et al. 2012) on the CIPRES Science Gateway V.3.3 (Miller et al. 2010) using default priors and models of evolution that were selected by the BIC and used in the ML analysis. Two independent runs, each with three heated and one cold chain, were performed using Markov Chain Monte Carlo (MCMC). The MCMC chains were run for 10,000,000 generations and trees sampled every 1,000 generations with the first 25% of each run discarded as burn-in. Stationarity was evaluated by ensuring effective sample sizes (ESS) were above 200 for all parameters in Tracer v. 1.7 (Rambaut et al. 2018). The phylogenetic trees from the ML and BI analyses were visualised using FigTree v. 1.4.4 (http://tree.bio.ed.ac.uk/software/figtree/). Nodes having ultrafast bootstrap support values (UFB) ≥ 95 and Bayesian posterior probabilities (BPP) ≥ 0.95 were considered highly supported (Huelsenbeck and Ronquist 2001; Wilcox et al. 2002; Minh et al. 2013). Uncorrected pairwise sequence divergences (*p*-distances) were calculated in MEGA 11 (Tamura et al. 2021) using the pairwise deletion option to remove gaps and missing data from the alignment prior to analysis.

Results

The final alignment of ND2 and flanking tRNAs contained 1,327 characters of 71 individuals of *Cnemaspis* and two individuals of outgroup species (Table 2). The average standard deviation of split frequencies was 0.000732 and the ESS of all parameters were ≥ 5,153 for all parameters in the BI analysis. The best tree in the ML analysis had a Maximum Likelihood value (lnL) of -22,848.995. The ML and BI analyses recovered trees with topologies similar to each other and to those recovered by Ampai et al. (2020) (Fig. 2). The five samples from Erawan National Park formed a strongly supported monophyletic lineage (≥ 95 UFB, ≥ 0.95 BPP) within the *C. siamensis* group. The Erawan National Park population was strongly supported (≥ 95 UFB, ≥ 0.95 BPP) to be the sister taxon of *C. huaseesom* from Sai Yok National Park, Sai Yok District, Kanchanaburi Province. Uncorrected pairwise genetic divergences (*p*-distances) within the Erawan

Table 2. Samples used in the molecular analyses, including their locality, voucher number and GenBank accession number. Voucher abbreviations are the School of Agriculture and Natural Resources, University of Phayao (AUP), Monte L. Bean Life Science Museum at Brigham Young University (BYU), California Academy of Sciences (CAS), the Field Museum of Natural History, Chicago, Illinois, USA (FMNH), La Sierra University Herpetological Collection (LSUHC), Universiti Sains Malaysia Herpetological Collection at the Universiti Sains Malaysia, Penang, Malaysia (USMHC), Zoological Museum of Kasetsart University (ZMKU) and the Zoological Museum of Moscow University (ZMMU).

Species	Locality	Voucher	GenBank accession no.	Reference
Outgroup				
Cyrtodactylus bokorensis	Cambodia, Kampot	FMNH 263228	KT013107	Grismer et al. (2015b)
Hemidactylus garnotii	Myanmar, Mon State, Kyaihto Township,	CAS 222276	EU68364	Bauer et al. (2008)
Ingroup				
Cnemaspis adangrawi	Thailand, Satun Province, Mueang Satun District, Adang Island	ZMKU R 00767	MK862112	Ampai et al. (2019)
Cnemaspis adangrawi	Thailand, Satun Province, Mueang Satun District, Adang Island	THNHM 28207	MK862113	Ampai et al. (2019)
Cnemaspis adangrawi	Thailand, Satun Province, Mueang Satun District, Adang Island	ZMKU R 00770	MK862114	Ampai et al. (2019)
Cnemaspis affinis	Malaysia, Penang, Pulau Pinang	LSUHC 6787	KM024682	Grismer et al. (2014)
Cnemaspis argus	Malaysia, Terengganu, Gunung Lawit	LSUHC 8304	KM024687	Grismer et al. (2014)
Cnemaspis argus	Malaysia, Terengganu, Gunung Lawit	LSUHC 10834	KM024688	Grismer et al. (2014)
Cnemaspis aurantiacopes	Vietnam, Kien Giang Province, Hon Dat Hill	LSUHC 8610	KM024692	Grismer et al. (2014)
Cnemaspis aurantiacopes	Vietnam, Kien Giang Province, Hon Dat Hill	LSUHC 8611	KM024693	Grismer et al. (2014)
Cnemaspis auriventralis sp. nov.	Thailand, Kanchanaburi Province, Si Sawat District, Tha Kradan Subdisctrict, Erawan National Park	ZMKU R 00999	OP093974	This study
Cnemaspis auriventralis sp. nov.	Thailand, Kanchanaburi Province, Si Sawat District, Tha Kradan Subdisctrict, Erawan National Park	ZMKU R 01000	OP093975	This study
Cnemaspis auriventralis sp. nov.	Thailand, Kanchanaburi Province, Si Sawat District, Tha Kradan Subdisctrict, Erawan National Park	ZMKU R 01001	OP093976	This study
Cnemaspis auriventralis sp. nov.	Thailand, Kanchanaburi Province, Si Sawat District, Tha Kradan Subdisctrict, Erawan National Park	ZMKU R 01002	OP093977	This study
Cnemaspis auriventralis sp. nov.	Thailand, Kanchanaburi Province, Si Sawat District, Tha Kradan Subdisctrict, Erawan National Park	ZMKU R 01003	OP093978	This study
Cnemaspis biocellata	Malaysia, Perlis, Kuala Perlis	LSUHC 8817	KM024707	Grismer et al. (2014)
Cnemaspis biocellata	Malaysia, Perlis, Kuala Perlis	LSUHC 8817	KM024708	Grismer et al. (2014)
Cnemaspis boulengerii	Vietnam, Ca Mau Province, Con Dao Archipelago	LSUHC9278	KM024710	Grismer et al. (2014)
Cnemaspis boulengerii	Vietnam, Ca Mau Province, Con Dao Archipelago	LSUHC9279	KM024711	Grismer et al. (2014)
Cnemaspis caudanivea	Vietnam, Kien Giang Province, Hon Tre Island	LSUHC 8582	KM024714	Grismer et al. (2014)
Cnemaspis chanardi	Thailand, Nakhon Si Thammarat Province, Tham Thong Panra	LSUHC 9567	KM024715	Grismer et al. (2014)
Cnemaspis chanthaburiensis	Cambodia, Pursat Province, Phnom Dalai	LSUHC 9338	KM024716	Grismer et al. (2014)
Cnemaspis grismeri	Malaysia, Perak, Lenggong	LSUHC 9969	KM024722	Grismer et al. (2014)
Cnemaspis hangus	Malaysia, Pahang, Bukit Hangus	LSUHC 9358	KM024728	Grismer et al. (2014)
Cnemaspis harimau	Malaysia, Kedah, Gunung Jeri	LSUHC 9665	KM024730	Grismer et al. (2014)
Cnemaspis huaseesom	Thailand, Kanchanaburi Province, Sai Yok National Park	LSUHC 9455	KM024733	Grismer et al. (2014)
Cnemaspis huaseesom	Thailand, Kanchanaburi Province, Sai Yok National Park	LSUHC 9457	KM024734	Grismer et al. (2014)
Cnemaspis huaseesom	Thailand, Kanchanaburi Province, Sai Yok National Park	LSUHC 9458	KM024735	Grismer et al. (2014)
Cnemaspis karsticola	Malaysia, Kelantan, Gunung Reng	LSUHC 9054	KM024736	Grismer et al. (2014)
Cnemaspis karsticola	Malaysia, Kelantan, Gunung Reng	LSUHC 9055	KM024737	Grismer et al. (2014)
Cnemaspis kumpoli	Malaysia, Perlis, Perlis State Park	LSUHC 8847	KM024745	Grismer et al. (2014)
Cnemaspis kumpoli	Malaysia, Perlis, Perlis State Park	LSUHC 8848	KM024746	Grismer et al. (2014)
Cnemaspis lineatubercularis	Thailand, Nakhon Si Thammarat Province, Lan Saka District, Wang Mai Pak Waterfall	ZMKU R 00825	MT112890	Ampai et al. (2020)
Cnemaspis lineatubercularis	Thailand, Nakhon Si Thammarat Province, Lan Saka District, Wang Mai Pak Waterfall	ZMKU R 00828	MT112891	Ampai et al. (2020)
Cnemaspis lineatubercularis	Thailand, Nakhon Si Thammarat Province, Lan Saka District, Wang Mai Pak Waterfall	ZMKU R 00829	MT112892	Ampai et al. (2020)
Cnemaspis lineogularis	Thailand, Prachuap Khiri Khan Province, Kui Buri District, Wat Khao Daeng	BYU 62535	KY091231	Wood et al. (2017)
Cnemaspis lineogularis	Thailand, Prachuap Khiri Khan Province, Kui Buri District, Wat Khao Daeng	ZMKU R 00728	KY091233	Wood et al. (2017)
Cnemaspis mahsuriae	Malaysia, Kedah, Pulau Langkawi,Gunung Raya	LSUHC 11829	KT250634	Grismer et al. (2015a)
Cnemaspis mcguirei	Malaysia, Perak, Bukit Larut	LSUHC 8853	KM024751	Grismer et al. (2014)
Cnemaspis monachorum	Malaysia, Kedah, Langkawi Archipelago, Pulau Langkawi	LSUHC 9114	KM024754	Grismer et al. (2014)
Cnemaspis monachorum	Malaysia, Kedah, Langkawi Archipelago, Pulau Langkawi	LSUHC 10807	KM024755	Grismer et al. (2014)
Cnemaspis narathiwatensis	Malaysia, Perak, Belum-Temengor, Sungai Enam	USMHC 1347	KM024762	Grismer et al. (2014)
Cnemaspis narathiwatensis	Malaysia, Perak, Belum-Temengor, Sungai Enam	USMHC 1348	KM024763	Grismer et al. (2014)
Cnemaspis neangthyi	Cambodia, Pursat Province, O'Lakmeas	LSUHC 8515	KM024767	Grismer et al. (2014)
Cnemaspis neangthyi	Cambodia, Pursat Province, O'Lakmeas	LSUHC 8516	KM024768	Grismer et al. (2014)
Cnemaspis niyomwanae	Thailand, Trang Province, Tham Khao Ting	LSUHC 9568	KM024773	Grismer et al. (2014)

Species	Locality	Voucher	GenBank accession no.	Reference
Cnemaspis niyomwanae	Thailand, Trang Province, Tham Khao Ting	LSUHC 9571	KM024774	Grismer et al. (2014)
Cnemaspis nuicamensis	Vietnam, An Giang Province, Nui Cam Hill	LSUHC 8646	KM024775	Grismer et al. (2014)
Cnemaspis nuicamensis	Vietnam, An Giang Province, Nui Cam Hill	LSUHC 8647	KM024776	Grismer et al. (2014)
Cnemaspis omari	Thailand, Satun Province, Phuphaphet Cave	LSUHC 9565	KM024780	Grismer et al. (2014)
Cnemaspis omari	Malaysia, Perlis, Perlis State Park	LSUHC 9978	KM024779	Grismer et al. (2014)
Cnemaspis perhentianensis	Malaysia, Terengganu, Pulau Perhentian Besar	LSUHC 8699	KM024820	Grismer et al. (2014)
Cnemaspis phangngaensis	Thailand, Phangnga Province, Mueang Phangnga District, Khao Chang, Phung Chang Cave	BYU 62537	KY091234	Wood et al. (2017)
Cnemaspis phangngaensis	Thailand, Phangnga Province, Mueang Phangnga District, Khao Chang, Phung Chang Cave	BYU 62538	KY091235	Wood et al. (2017)
Cnemaspis punctatonuchalis	Thailand, Prachaup Khiri Khan Province, Thap Sakae	BYU 62539	KY091236	Wood et al. (2017)
Cnemaspis punctatonuchalis	Thailand, Prachaup Khiri Khan Province, Thap Sakae	BYU 62540	KY091237	Wood et al. (2017)
Cnemaspis roticanai	Malaysia, Kedah, Pulau Langkawi, Gunung Raya	LSUHC 9430	KM024829	Grismer et al. (2014)
Cnemaspis roticanai	Malaysia, Kedah, Pulau Langkawi, Gunung Raya	LSUHC 9431	KM024830	Grismer et al. (2014)
Cnemaspis selenolagus	Thailand, Ratchaburi Province, Suan Phueng District	ZMMU R-16391	MW051887	Grismer et al. (2020)
Cnemaspis selenolagus	Thailand, Ratchaburi Province, Suan Phueng District	AUP-00767	MW051888	Grismer et al. (2020)
Cnemaspis siamensis	Thailand, Chumpon Province, Pathio District	LSUHC 9474	KM024838	Grismer et al. (2014)
Cnemaspis siamensis	Thailand, Chumpon Province, Pathio District	LSUHC 9485	KM024839	Grismer et al. (2014)
Cnemaspis tarutaoensis	Thailand, Satun Province, Mueang Satun District, Tarutao Island	ZMKU R 00761	MK862117	Ampai et al. (2019)
Cnemaspis tarutaoensis	Thailand, Satun Province, Mueang Satun District, Tarutao Island	ZMKUR 00763	MK862118	Ampai et al. (2019)
Cnemaspis tarutaoensis	Thailand, Satun Province, Mueang Satun District, Tarutao Island	ZMKU R 00764	MK862119	Ampai et al. (2019)
Cnemaspis thachanaensis	Thailand, Surat Thani Province, Tha Chana District, Tham Khao Sonk Hill	BYU 62542	KY091239	Wood et al. (2017)
Cnemaspis thachanaensis	Thailand, Surat Thani Province, Tha Chana District, Tham Khao Sonk Hill	BYU 62543	KY091243	Wood et al. (2017)
Cnemaspis thachanaensis	Thailand, Surat Thani Province, Tha Chana District, Tham Khao Sonk Hill	BYU 62544	KY091244	Wood et al. (2017)
Cnemaspis tubaensis	West Malaysia, Kedah, Langkawi Archipelago, Tuba Island	USMHC 2527	MT028175	Quah et al. (2020)
Cnemaspis tubaensis	West Malaysia, Kedah, Langkawi Archipelago, Tuba Island	USMHC 2528	MT028176	Quah et al. (2020)
Cnemaspis tucdupensis	Vietnam, An Giang Province, Tuc Dup Hill	LSUHC 8631	KM024852	Grismer et al. (2014)
Cnemaspis tucdupensis	Vietnam, An Giang Province, Tuc Dup Hill	LSUHC 8632	KM024853	Grismer et al. (2014)
Cnemaspis vandeventeri	Thailand, Ranong Province, Suk Saran District, Naka	BYU 62541	KY091238	Wood et al. (2017)

National Park population were 0.00–0.65%. The Erawan National Park population had uncorrected *p*-distances of 12.12–12.55% from *C. huaseesom* and 15.15–27.92% from the other species in the *siamensis* group. The *p*-distances amongst species in the *C. siamensis* group ranged from 8.23–29.00% (Table 3).

Taxonomic hypotheses

Cnemaspis samples from Erawan National Park, Tha Kradan Subdistrict, Si Sawat District, Kanchanaburi Province differed from congeners in mtDNA analyses and diagnostic morphological characters (see "Comparisons"). Based on these corroborating lines of evidence, we hypothesise that the Erawan National Park population represents a previously unnamed species, which is described below.

Taxonomy

Cnemaspis auriventralis sp. nov.

https://zoobank.org/899EA1FF-67AC-453A-87A0-31E55C4A242D

Figs 3–8

Cnemaspis huaseesom Yodthong, Rujirawan, Stuart, Grismer, Aksornneam, Termprayoon, Ampai & Aowphol, 2022: 160.

Holotype. (Figs 3–6). ZMKU R 01001, adult male from Thailand, Kanchanaburi Province, Si Sawat District, Tha Kradan Subdistrict, Erawan National Park, Tham Phra That Protection Unit (14.39730N, 99.0818E; 747 m elevation), collected 18 November 2021 by Attapol Rujirawan, Siriporn Yodthong, Natee Ampai and Akrachai Aksornneam.

Paratypes. (Figs 7, 8). Two adult males and two adult females. ZMKU R 01002 (adult female), same collection data as the holotype. ZMKU R 01003 (adult female), same collection data as the holotype, except collected 20 November 2021. ZMKU R 00999–01000 (two adult males) same collection data as the holotype, except collected 26 November 2019 by Attapol Rujirawan, Siriporn Yodthong, Korkhwan Termprayoon and Akrachai Aksornneam.

Diagnosis. *Cnemaspis auriventralis* sp. nov. can be distinguished from all other species in the *C. siamensis* group by having the following combination of morphological and colour pattern characters: SVL 36.7–38.6 mm in adult males (N = 3), 32.9–36.9 mm in adult females (N = 2); eight to ten supralabials; seven to nine infralabials; ventral scales smooth; six or seven precloacal pores in males; 16–17 paravertebral tubercles linearly arranged; tubercles on the lower flanks present; lateral caudal furrows present; no caudal tubercles in the lateral furrows; ventrolateral caudal tubercles present anteriorly; caudal tubercles not encircling tail; subcaudals smooth bearing a single median row of enlarged smooth scales; two post-

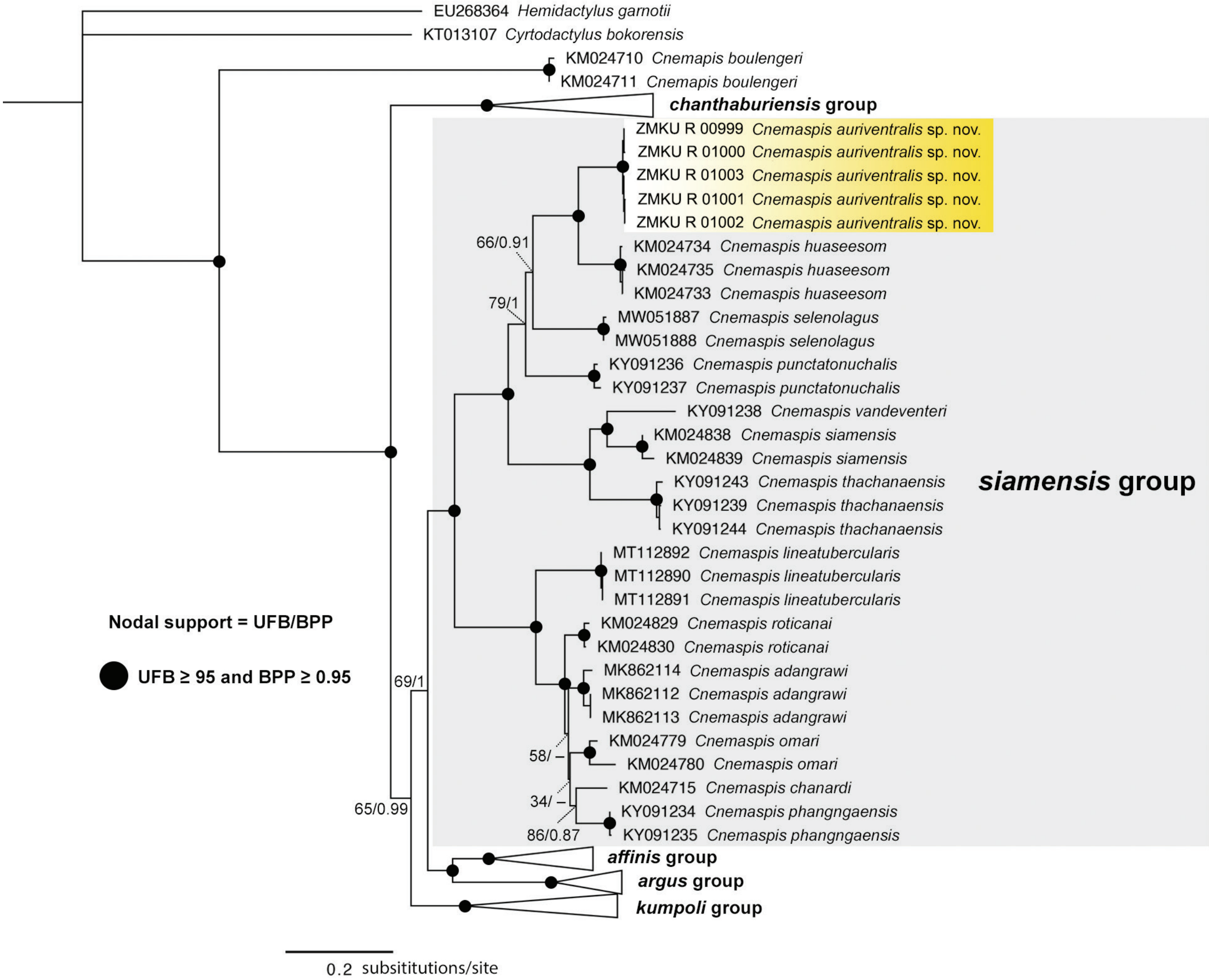

Figure 2. The best tree resulting from Maximum Likelihood analysis of 1,327 aligned characters of the mitochondrial NADH dehydrogenase subunit 2 gene and flanking tRNAs of *Cnemaspis* species. Nodal support is indicated by Ultrafast bootstrap (UFB) values and Bayesian posterior probabilities (BPP) from a separate Bayesian Inference analysis, respectively. GenBank accession numbers and locality data for sequenced samples are provided in Table 2.

cloacal tubercles on each side; no shield-like subtibial scales; subtibial scales smooth; no enlarged submetatarsal scales; 23–27 subdigital lamellae on the fourth toe; sexually dimorphic in dorsal and ventral colour pattern; prescapular marking absent; gular marking absent; and yellow colouration in life on all ventral surfaces of head, body and tail in adult males.

Description of holotype. Adult male; SVL 38.0 mm; head oblong in dorsal profile, moderate in size (HL/SVL 0.28), somewhat narrow (HW/SVL 0.19), flat (HD/HL 0.40), distinct from neck; snout moderate (ES/HL 0.42), snout slightly concave in lateral profile; postnasal region concave medially; scales of rostrum round, weakly keeled, raised, larger than similarly-shaped scales on occiput; weak supraorbital ridges; weak frontorostral sulcus; canthus rostralis smoothly rounded; eye large (ED/HL 0.24); extra-brillar fringe scales small in general, but slightly larger anteriorly; pupil round; ear opening oval, taller than wide; rostral concave dorsally, dorsal 80% divided by longitudinal groove; rostral bordered posteriorly by supranasals, one small azygous internasal and nostrils; bordered laterally by first supralabials; 8R/9L (right/left) raised supralabials of similar size, but smallest posteriorly; 8R/8L infralabials, decreasing gradually in size posteriorly; nostrils small, elliptical, orientated dorsolaterally; bordered posteriorly by single, flat, enlarged postnasal scales; mental large, triangular, flat, extending to level of second infralabials, bordered posteriorly by three postmentals, medial postmental smaller than laterals; gular scales smooth, flat, round or oval, juxtaposed; throat scales smooth, raised, round, juxtaposed to subimbricate.

Body slender, elongate (AG/SVL 0.42); small, raised, weakly keeled, dorsal scales generally equal in size throughout body, intermixed with numerous, large, multi-keeled, linearly arranged tubercles; enlarged, multi-keeled, conical tubercles on flanks; tubercles extend from the occiput to base of the tail and continue on tail in whorls; body tubercles slightly smaller anteriorly; 17 paravertebral tubercles; pectoral and abdominal scales smooth, flat, imbricate; abdominal scales larger than pectoral and dorsal scales; seven contiguous, pore-bearing, precloacal scales; precloacal pores round to elongate.

Fore-limbs moderately long, slender; dorsal scales raised, weakly keeled, juxtaposed; ventral scales of

Table 3. Mean (minimum-maximum) percentages of uncorrected pairwise sequence divergences (*p*-distances) of *Cnemaspis* species in the *C. siamensis* group compared to *C. auriventralis* sp. nov., based on 1,327 aligned characters of the mitochondrial NADH dehydrogenase subunit 2 gene and flanking tRNAs. Intraspecific *p*-distances are in bold font.

Species	*N*	*C. auriventralis* sp. nov.	*C. adangrawi*	*C. chanardi*	*C. huaseesom*	*C. lineatubercularis*	*C. omari*	*C. phangngaensis*	*C. punctatonuchalis*	*C. roticanai*	*C. selenolagus*	*C. siamensis*	*C. thachanaensis*	*C. vandeventeri*
C. auriventralis sp. nov.	5	**0.30 (0.00–0.65)**												
C. adangrawi	3	25.57 (25.11–25.97)	**3.03 (0.00–4.55)**											
C. chanardi	1	26.23 (25.97–26.41)	11.40 (11.02–12.12)	–										
C. huaseesom	3	12.29 (12.12–12.55)	26.26 (26.19–26.41)	26.62 (26.62–26.62)	**0.43 (0.00–0.65)**									
C. lineatubercularis	3	25.19 (24.89–25.54)	17.97 (17.32–19.05)	17.32 (17.10–17.53)	27.95 (27.71–28.35)	**0.29 (0.22–0.43)**								
C. omari	2	27.68 (27.27–27.92)	9.63 (8.23–10.39)	11.90 (11.69–12.12)	28.57 (28.14–29.00)	19.05 (18.61–19.48)	**4.11 (4.11–4.11)**							
C. phangngaensis	2	23.94 (23.81–24.03)	10.57 (9.74–11.04)	11.58 (11.47–11.69)	24.13 (24.03–24.24)	17.93 (17.75–18.18)	11.26 (11.04–11.47)	**0.22 (0.22–0.22)**						
C. punctatonuchalis	2	15.54 (15.37–15.80)	24.68 (24.03–25.97)	25.54 (25.54–25.54)	16.81 (16.67–16.88)	25.97 (25.76–26.19)	26.30 (26.19–26.41)	25.00 (24.89–25.11)	**0.00 (0.00–0.00)**					
C. roticanai	2	26.39 (26.19–26.62)	9.05 (8.66–9.74)	12.01 (11.90–12.12)	28.03 (27.92–28.14)	16.13 (15.80–16.45)	9.09 (8.66–9.52)	9.09 (8.87–9.31)	25.65 (25.54–25.76)	**0.22 (0.22–0.22)**				
C. selenolagus	2	15.54 (15.15–16.02)	26.01 (25.54–26.62)	26.73 (26.41–27.06)	18.40 (18.18–18.61)	26.73 (26.19–27.27)	27.06 (26.62–27.49)	24.68 (24.24–25.11)	15.91 (15.58–16.23)	25.97 (25.54–26.41)	**0.65 (0.65–0.65)**			
C. siamensis	2	18.92 (18.61–19.26)	25.61 (25.54–25.76)	25.32 (25.32–25.32)	19.05 (19.05–19.05)	27.56 (27.49–27.71)	27.49 (27.49–27.49)	24.78 (24.68–24.89)	18.61 (18.61–18.61)	28.03 (27.92–28.14)	20.67 (20.56–20.78)	**0.00 (0.00–0.00)**		
C. thachanaensis	3	19.71 (19.26–20.56)	25.18 (24.89–25.54)	23.95 (23.81–24.24)	20.49 (20.13–21.21)	27.13 (26.84–27.71)	27.81 (27.49–28.35)	25.72 (25.32–26.41)	20.20 (20.13–20.35)	27.31 (27.06–27.71)	23.48 (22.94–24.24))	13.35 (12.99–14.07)	**0.72 (0.00–1.08)**	
C. vandeventeri	1	19.13 (18.61–19.48)	24.10 (24.03–24.24)	23.81 (23.81–23.81)	19.84 (19.70–19.91)	25.40 (25.32–25.54)	26.30 (25.76–26.84)	25.00 (24.89–25.11)	20.35 (20.35–20.35)	26.73 (26.62–26.84)	22.19 (22.08–22.29)	12.55 (12.55–12.55)	14.29 (14.07–14.72)	–

brachia smooth, raised, juxtaposed; scales beneath forearm smooth, slightly raised, subimbricate; digits long with an inflected joint; claws recurved; subdigital lamellae unnotched; subdigital lamellae wide throughout length of digits, bearing a larger scale at digital inflections; interdigital webbing absent; fingers increase in length from first to fifth, with fourth and fifth nearly equal in length; relative length of fingers I < II < III < V ≤ IV; total subdigital lamellae on fingers I–V: 12–18–21–25–22 (right), 12–18–22–broken-broken (left). Hind-limbs slightly longer and thicker than fore-limbs; dorsal scales keeled, raised, juxtaposed; ventral scales of thigh and subtibial scales smooth, flat, imbricate; plantar scales smooth, raised, subimbricate; enlarged submetatarsal scales beneath first toes absent; digits elongate with an inflected joint; claws recurved; subdigital lamellae unnotched; lamellae wide throughout length of digits; enlarged scales at digital inflections; interdigital webbing absent; toes increase in length from first to fourth and fifth nearly equal in length; relative length of toes I < II < III < V ≤ IV; total subdigital lamellae on toes I–V: 11–18–22–23–22 (right), 11–17–21–24–21 (left).

Tail original (broken at tip), long, slender, TL = 45.9 mm (TL/SVL 1.21); dorsal, caudal scales arranged in segmented whorls; caudal scales keeled, raised, juxtaposed; mid-dorsal and lateral, caudal furrows present; subcaudals smooth; median row of enlarged subcaudal scales present; paravertebral, dorsolateral and lateral rows of large, keeled, caudal tubercles extend length of tail; ventrolateral rows of tubercles present only anteriorly; caudal tubercle rows do not en-

Figure 3. Adult male holotype of *Cnemaspis auriventralis* sp. nov. (ZMKU R 01001) in life.

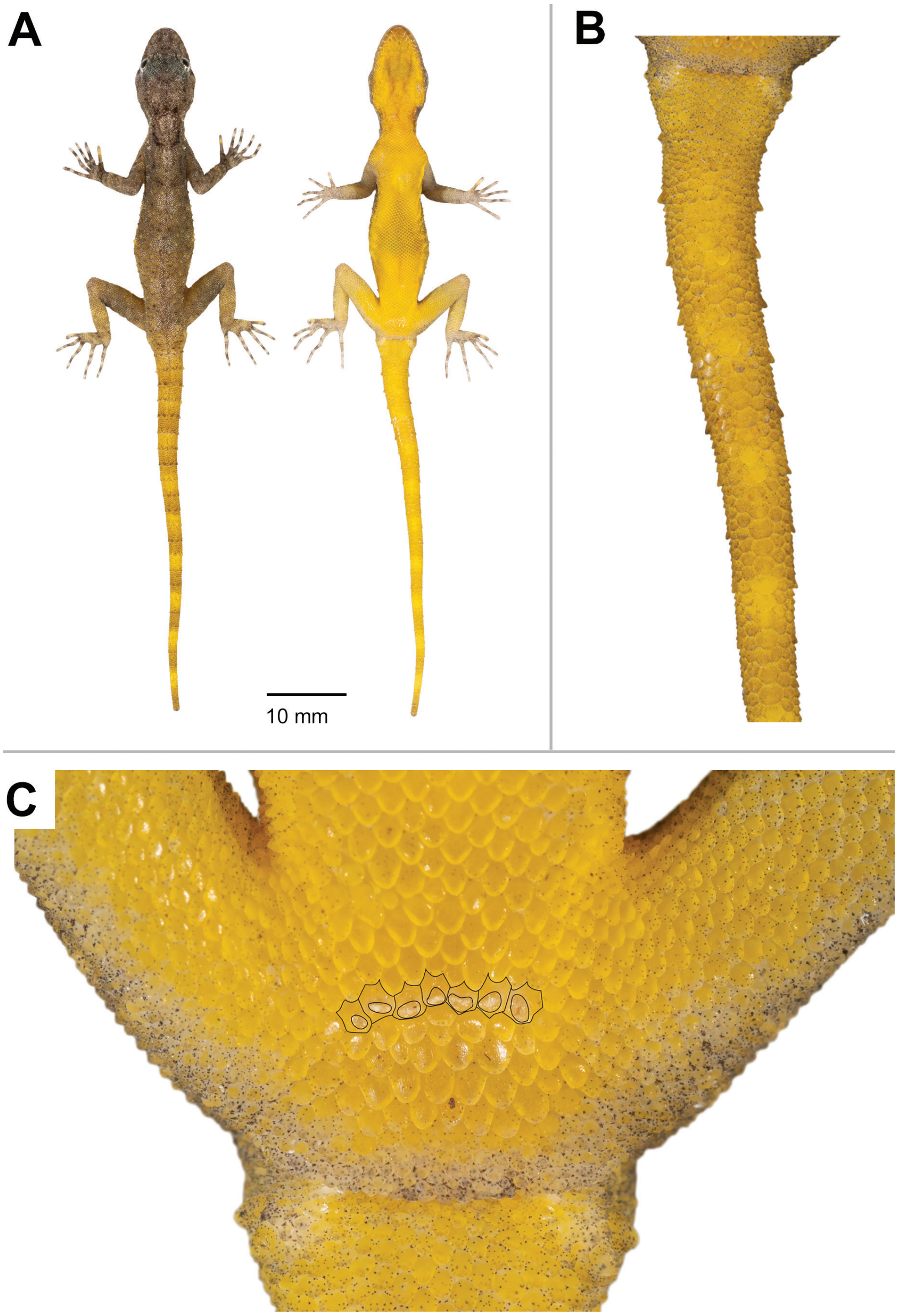

Figure 4. Adult male holotype of *Cnemaspis auriventralis* sp. nov. (ZMKU R 01001) immediately after euthanasia. **A.** Dorsal and ventral views; **B.** Subcaudal region and **C.** Precloacal region with precloacal pores (outlined in black).

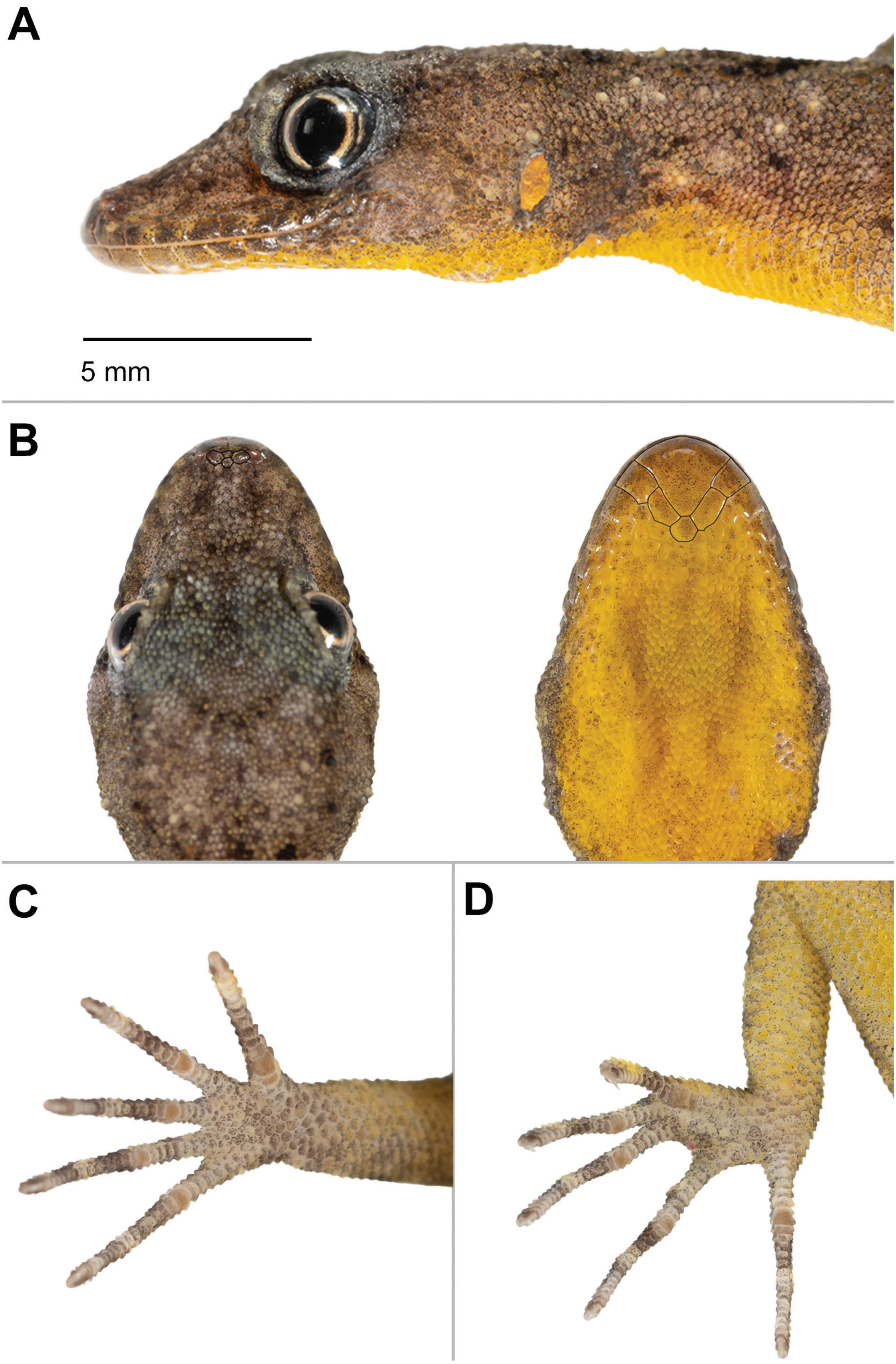

Figure 5. Adult male holotype of *Cnemaspis auriventralis* sp. nov. (ZMKU R 01001) immediately after euthanasia. **A.** Lateral view of head; **B.** Dorsal and ventral views of head (supranasal and internasal scales in dorsal view and mental, postmental and first infralabial scales in ventral view; outlined in black); **C.** Palmar view of the right manus; **D.** Plantar view of the right pes.

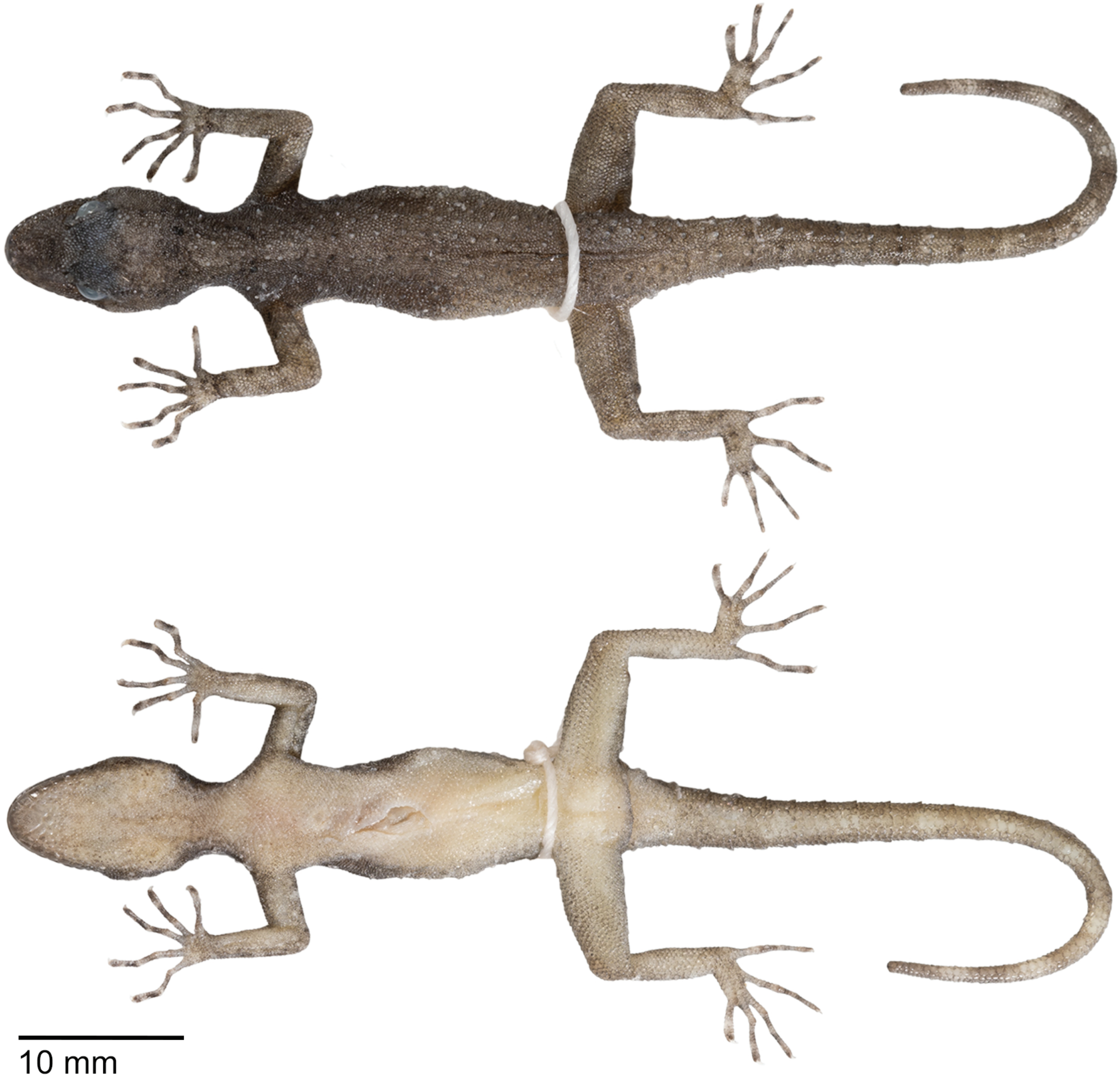

Figure 6. Dorsal and ventral views of adult male holotype of *Cnemaspis auriventralis* sp. nov. (ZMKU R 01001) in preservative.

circle tail; tubercles absent from lateral caudal furrow; enlarged postcloacal tubercles 2R/2L on lateral surface of hemipenial swellings at base of tail.

Colouration in life. (Figs 3–5). Dorsal ground colour of head, nape and fore-limbs grey; dorsal ground colour of trunk and hind-limbs yellowish-grey; dorsal ground colour of tail yellow; top of head bearing small, diffuse, faint, dark and light markings; dark postorbital stripes faint extending to occiput; pair of dark, diffuse, blotches on nape; large, light, irregularly-shaped, vertebral blotches extend from nape to base of tail, continuing on to tail as light yellow caudal bands; small, light, irregularly-shaped blotches in shoulder regions and flanks; limbs mottled with small, diffuse light and dark blotches; digits light grey bearing thin, dark bands; all ventral surfaces of head, body and tail yellow; ventral surfaces of limbs light grey with yellow speckling.

Colouration in preservative. (Fig. 6). Dorsal and lateral surfaces of head, body, limbs and tail darker grey than in life, with some fading of markings. Ventral surfaces of head, body, limbs and tail creamy-white, with minute dark speckling on gular region, limbs and tail regions.

Variation. *Cnemaspis auriventralis* sp. nov. shows significant sexual dimorphism in colour pattern. All female paratypes lack yellow colouration on the tail and ventral surfaces. Female paratype ZMKU R 01003 was darker coloured in life than other members of the type series. Two male paratypes ZMKU R 00999–01000 were lighter coloured than the holotype in life. Dark markings on the dorsum of all paratypes are more prominent than the holotype. The female paratypes (ZMKU R 01002–01003) lack precloacal pores and have postcloacal tubercles that are relatively smaller than those in males. One male paratype (ZMKU R 01000) has six (2R/4L) pore-bearing pre-

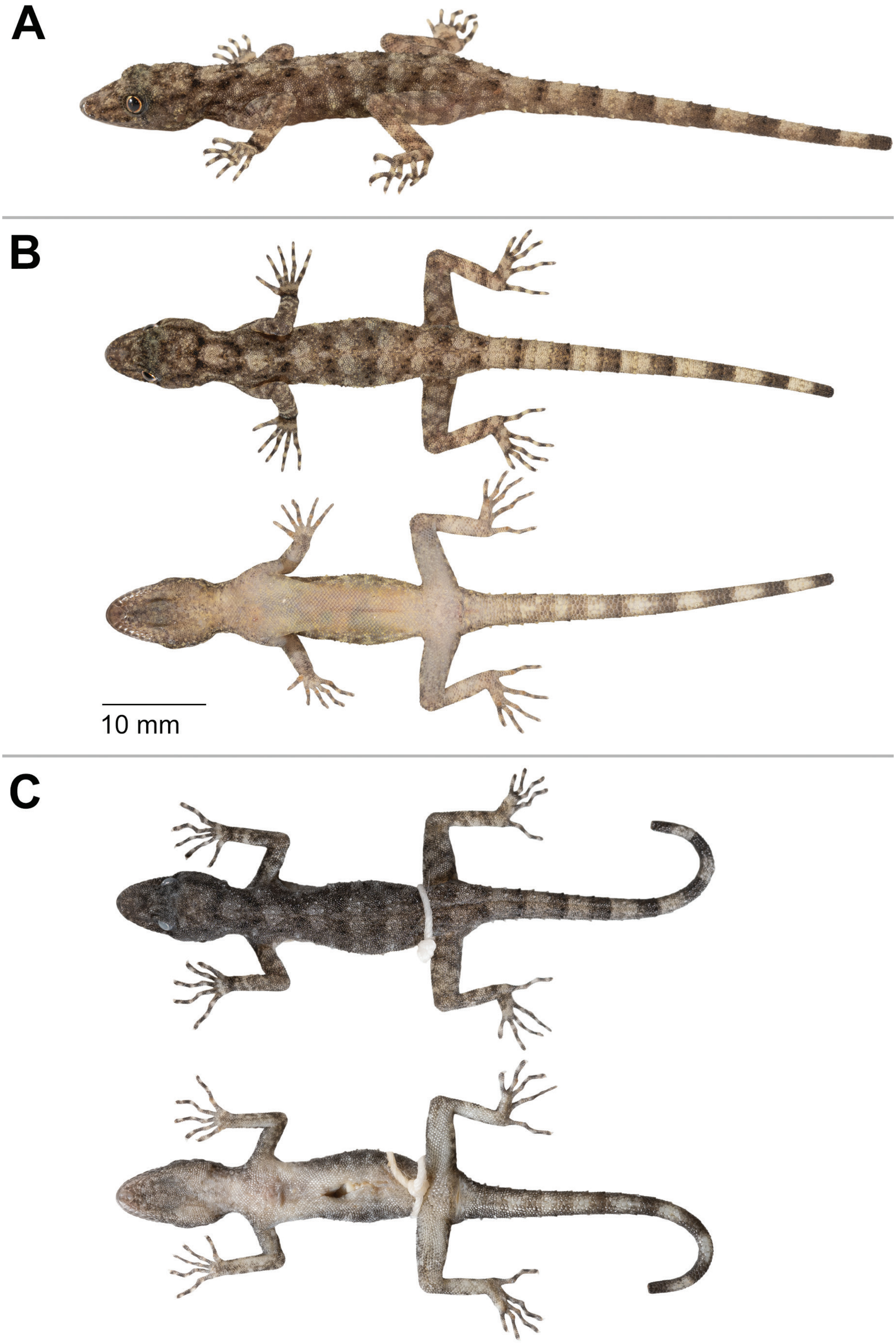

Figure 7. Adult female paratype of *Cnemaspis auriventralis* sp. nov. (ZMKU R 01002). **A.** Dorsolateral view in life; **B.** Dorsal and ventral views immediately after euthanasia; **C.** Dorsal and ventral views in preservative.

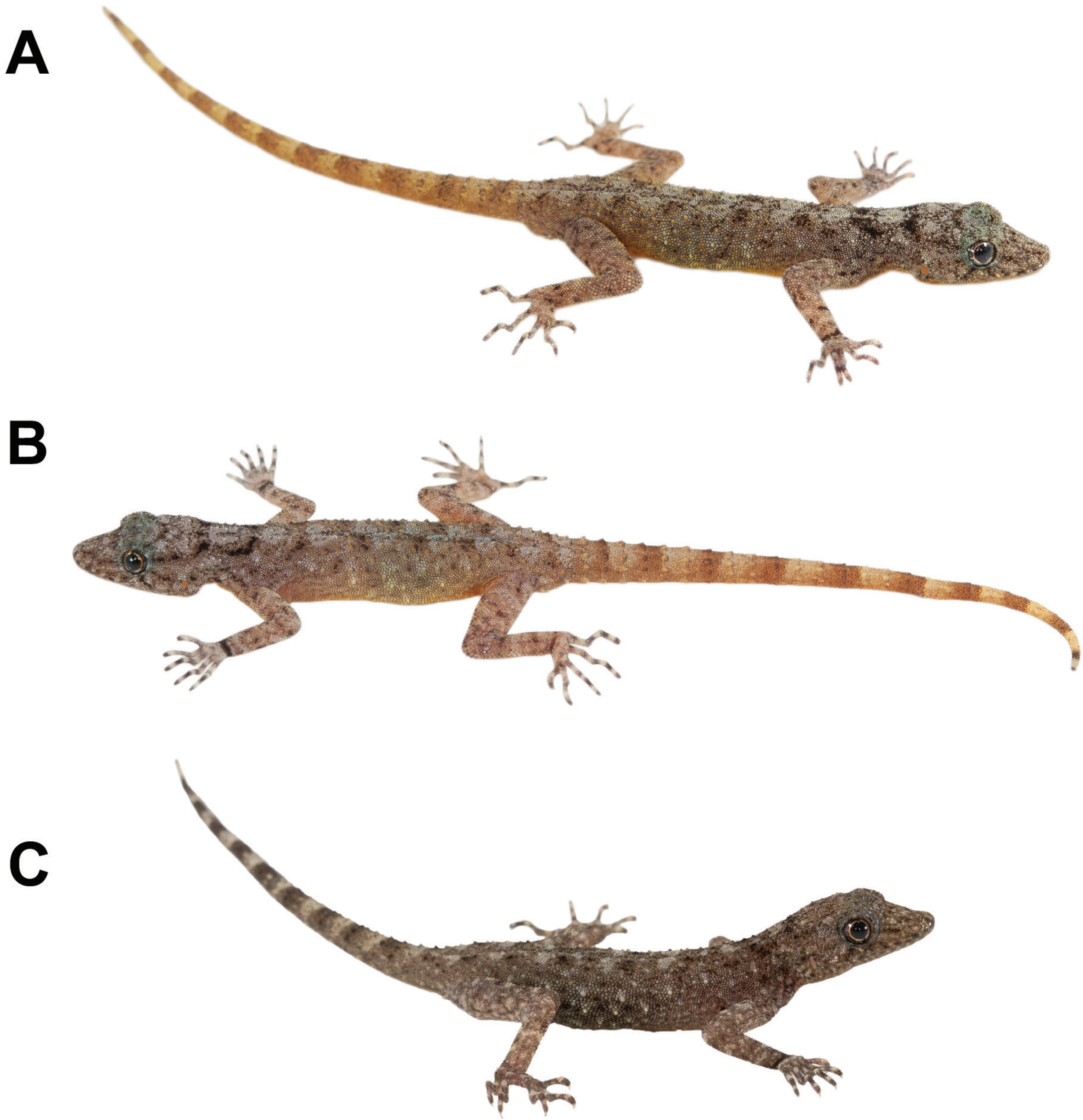

Figure 8. *Cnemaspis auriventralis* sp. nov. paratypes in life. **A.** Adult male ZMKU R 00999; **B.** Adult male ZMKU R 01000; **C.** Adult female ZMKU R 01003.

cloacal scales separated by a single scale lacking pore. Variation in morphometric and meristic data amongst specimens in the type series are presented in Table 4.

Distribution. This species is known only from the type locality. The type series was collected from a karst formation that is part of the Tenasserim Mountain Range in Erawan National Park, Tha Kradan Subdistrict, Si Sawat District, Kanchanaburi Province, Thailand (Figs 1, 9).

Natural history. The type locality of *Cnemaspis auriventralis* sp. nov. is a karst forest at 747 m elevation. The type series was collected in November 2019 at 14:00–14:30 h with temperature 25.4 °C and relative humidity 62.1% and in November 2021 at 16:00–20:00 h with temperature 25.3–26.8 °C and relative humidity 79.9–88.0%. All specimens were found on karst boulders along the nature trail to the Tham (= cave) Phra That. Most were observed clinging upside down to the undersides of large boulders (around 1–3 m^2) or in narrow crevices of the boulders. Four individuals (ZMKU R 00999–01002) were found during the daytime (14:00–16:30 h) and one individual (ZMKU R 01003) was found at night (20:30 h). Most observed individuals were found during the daytime and they were active and rapidly escaped from disturbances. The one individual found at night was relatively inactive (slow-moving). At night, the new species was found to co-occur with five other species of gekkonid lizards, *Cyrtodactylus monilatus* Yodthong, Rujirawan, Stuart, Grismer,

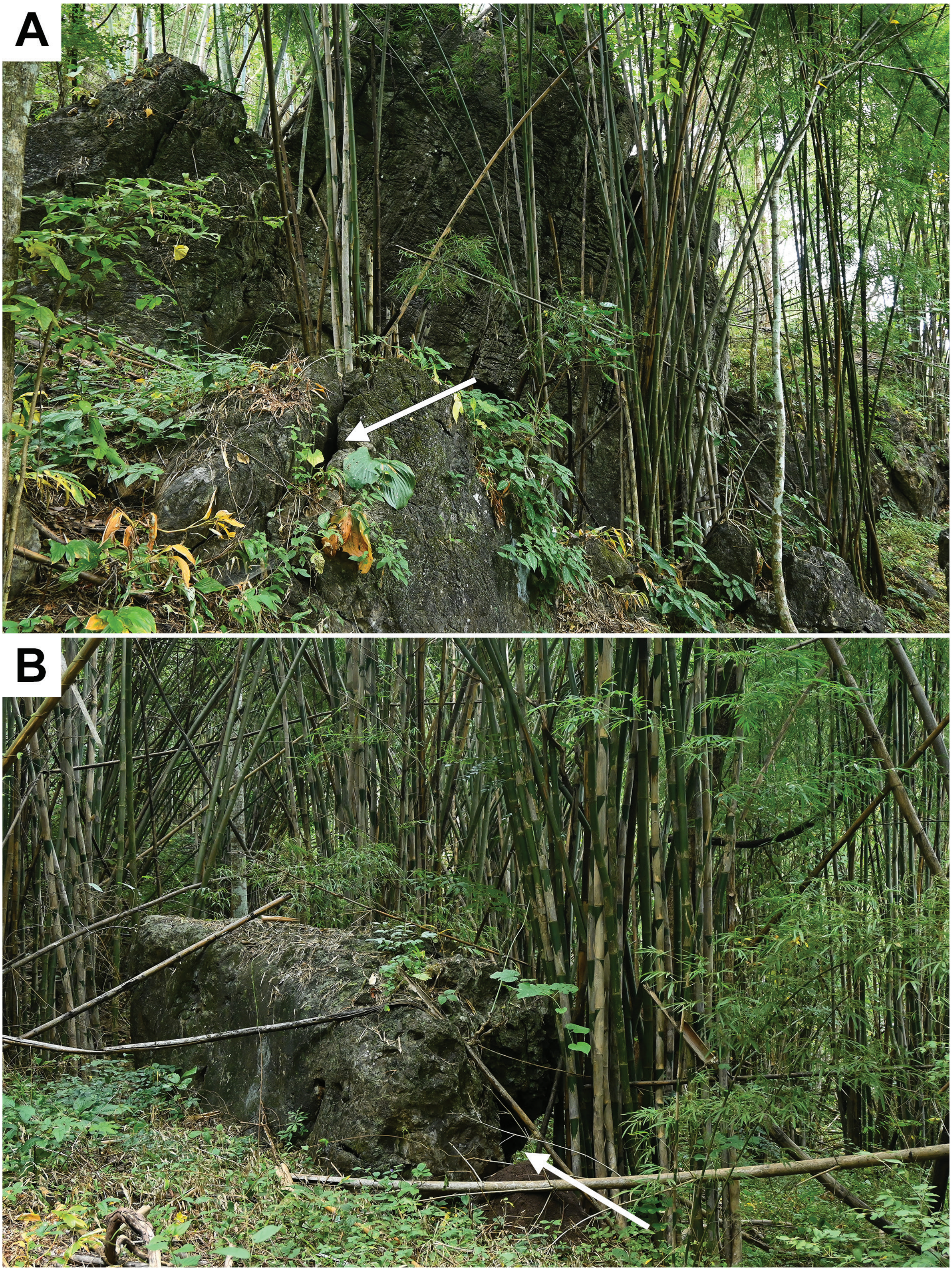

Figure 9. Habitat of *Cnemaspis auriventralis* sp. nov. at the type locality at Erawan National Park, Si Sawat District, Kanchanaburi Province, Thailand. **A.** Microhabitat in karst boulder crevice (white arrow); **B.** Microhabitat on undersides of karst boulder (white arrow).

Aksornneam, Termprayoon, Ampai & Aowphol, 2022, *Cyrtodactylus tigroides* Bauer, Sumontha & Pauwels, 2003, *Gehyra mutilata* (Wiegmann, 1834), *Dixonius hangseesom* Bauer, Sumontha, Grossmann, Pauwels & Vogel, 2004 and *Dixonius siamensis* (Boulenger, 1899).

Etymology. The species epithet *auriventrali*s is derived from *aurum* (L.) for gold and *ventralis* (L.) for venter in reference to the new species having distinct yellow colouration on all ventral surfaces of the head, body and tail in adult males. We propose "Erawan Rock Gecko" for the common

Table 4. Descriptive measurements (millimetres) and meristics (right/left) of the type series of *Cnemaspis auriventralis* sp. nov. Key: M = adult male; F = adult female; Cont. = continuous; Sep. = separated; NA = data unavailable or not applicable. Morphological abbreviations are defined in Table 1.

Museum number	ZMKU R 01001	ZMKU R 00999	ZMKU R 01000	ZMKU R 01002	ZMKU R 01003	All males	All females
Type	**holotype**	**paratype**	**paratype**	**paratype**	**paratype**	***N* = 3**	***N* = 2**
Sex	**M**	**M**	**M**	**F**	**F**	**Mean ± SD (min-max)**	**Mean ± SD (min-max)**
SVL	38.0	38.6	36.7	32.9	36.9	37.8 ± 0.97 (36.7–38.6)	34.9 ± 2.83 (32.9–36.9)
TW	3.3	3.1	3.4	3.3	3.0	3.3 ± 0.15 (3.1–3.4)	3.2 ± 0.21 (3.0–3.3)
TL	45.9	45.6	48.1	36.3	50.0	46.5 ± 0.21 (45.6–48.1)[a]	50.0[b]
Tail condition	broken	original	original	broken	original	NA	NA
FL	6.4	6.4	6.2	5.8	6.3	6.3 ± 0.12 (6.2–6.4)	6.1 ± 0.35 (5.8–6.3)
TBL	8.3	8.2	8.0	7.3	8.7	8.2 ± 0.15 (8.0–8.3)	8.0 ± 0.99 (7.3–8.7)
HL	10.5	10.9	10.4	10.2	11.2	10.6 ± 0.26 (10.4–10.9)	10.7 ± 0.71 (10.2–11.2)
HW	7.2	7.3	7.2	6.3	7.3	7.2 ± 0.06 (7.2–7.3)	6.8 ± 0.71 (6.3–7.3)
HD	4.2	4.1	3.9	4.0	4.1	4.1 ± 0.15 (3.9–4.2)	4.1 ± 0.07 (4.0–4.1)
AG	16.1	16.0	16.2	15.7	16.4	16.1 ± 0.10 (16.0–16.2)	16.1 ± 0.49 (15.7–16.4)
ED	2.5	2.5	2.2	2.0	2.2	2.4 ± 0.17 (2.2–2.5)	2.1 ± 0.14 (2.0–2.2)
EE	2.8	3.0	2.8	2.7	3.1	2.9 ± 0.12 (2.8–3.0)	2.9 ± 0.28 (2.7–3.1)
EL	1.3	0.9	1.1	1.2	1.1	1.1 ± 0.20 (0.9–1.3)	1.2 ± 0.07 (1.1–1.2)
EN	3.7	3.7	3.6	3.3	3.4	3.7 ± 0.06 (3.6–3.7)	3.4 ± 0.07 (3.3–3.4)
ES	4.4	4.8	4.6	4.6	4.5	4.6 ± 0.20 (4.4–4.8)	4.6 ± 0.07 (4.5–4.6)
IO	2.3	2.4	2.5	2.2	2.2	2.4 ± 0.10 (2.3–2.5)	2.2 ± 0.00 (2.2–2.2)
IN	1.1	1.1	1.0	0.9	1.0	1.1 ± 0.06 (1.0–1.1)	1.0 ± 0.07 (0.9–1.0)
HL/SVL	0.28	0.28	0.28	0.31	0.30	0.28 ± 0.00 (0.28–0.28)	0.31 ± 0.00 (0.30–0.31)
HW/SVL	0.19	0.19	0.20	0.19	0.20	0.19 ± 0.00 (0.19–0.20)	0.19 ± 0.00 (0.19–0.20)
HD/HL	0.40	0.38	0.38	0.39	0.37	0.38 ± 0.01 (0.38–0.40)	0.38 ± 0.02 (0.37–0.39)
ES/HL	0.42	0.44	0.44	0.45	0.40	0.43 ± 0.01 (0.42–0.44)	0.43 ± 0.03 (0.40–0.45)
ED/HL	0.24	0.23	0.21	0.20	0.20	0.23 ± 0.01 (0.21–0.24)	0.20 ± 0.00 (0.20–0.20)
AG/SVL	0.42	0.41	0.44	0.48	0.44	0.43 ± 0.01 (0.41–0.44)	0.46 ± 0.02 (0.44–0.48)
TL/SVL	1.21	1.18	1.31	1.10	1.36	1.23 ± 0.07 (1.18–1.31)	1.23 ± 0.18 (1.10–1.36)
Scalation						**Min-max**	
SL	8R/9L	9R/9L	9R/9L	10R/9L	8R/8L	8–10	
IL	8R/8L	9R/7L	8R/8L	9R/8L	7R/7L	7–9	
PVT	17	17	16	16	16	16–17	
4TL	23R/24L	25R/26L	26R/27L	26R/27L	27R/27L	23–27	
PP	7	7	6 (2R/4L)	absent	absent	6–7	
Pore arrangement	Cont.	Cont.	Sep.	NA	NA	NA	
PPS	2R/2L	2R/2L	2R/2L	2R/2L	2R/2L	2	

[a] Data of original tails from two males.
[b] Data of original tail from one female.

English name and "จิ้งจกนิ้วยาวเอราวัณ" (Jing Jok Niew Yao Erawan) for the common Thai name of the new species.

Comparisons. *Cnemaspis auriventralis* sp. nov. is distinguishable from all other members of the *C. siamensis* group by a combination of morphological and colour pattern characteristics (see Table 5 for additional comparisons).

Cnemaspis auriventralis sp. nov. differs from *C. adangrawi* by having a smaller maximum SVL of 38.6 mm (vs. 44.9 mm); ventral scales smooth (vs. keeled); 16–17 paravertebral tubercles (vs. 23–25); paravertebral tubercles linearly arranged (vs. randomly); tubercles on lower flanks present (vs. absent); caudal tubercles in lateral furrow absent (vs. present); enlarged median subcaudal scales row present (vs. absent); subcaudal scales smooth (vs. keeled); single median row of subcaudals smooth (vs. keeled); two postcloacal tubercles on each side in males (vs. one); subtibial scales smooth (vs. keeled); sexual dimorphism of dorsal colour pattern present (vs. absent); light or yellowish prescapular crescent absent (vs. present); yellow colouration on original tail in males present (vs. absent); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. yellowish colouration only on gular region, abdominal region and caudal region).

Cnemaspis auriventralis sp. nov. differs from *C. chanardi* by having ventral scales smooth (vs. keeled); 16–17 paravertebral tubercles (vs. 20–30); paravertebral tubercles linearly arranged (vs. randomly); ventrolateral caudal tubercles anteriorly present (vs. absent); subcaudal scales smooth (vs. keeled); two postcloacal tubercles on each side in males (vs. one); subtibial scales smooth (vs. keeled); sexual dimorphism of dorsal colour pattern present (vs. absent); light or yellowish prescapular crescent absent (vs. present); yellow colouration on original tail in males present (vs. absent); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. yellow colouration only on gular region, belly, underside of hind-limbs and subcaudal region).

Cnemaspis auriventralis sp. nov. is most closely related in mitochondrial DNA to *C. huaseesom* (Fig. 2), but differs in morphology from *C. huaseesom* by having a smaller maximum SVL of 38.6 mm (vs. 43.5 mm); 16–17 paravertebral tubercles (vs. 18–24); caudal tubercles in lateral furrow absent (vs. present); ventrolateral caudal tubercles anteriorly present (vs. absent); enlarged median subcaudal scales row present (vs. absent); yellow dorsal colouration on fore-limbs in males absent (vs. present); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. yellow colouration only on gular region, throat, pectoral region, underside of fore-limbs and subcaudal region).

Cnemaspis auriventralis sp. nov. differs from *C. kamolnorranathi* by having 16–17 paravertebral tubercles (vs. 19–24); caudal tubercles in lateral furrow absent (vs. present); ventrolateral caudal tubercles anteriorly present (vs. absent); subcaudal scales smooth (vs. keeled); single median row of subcaudals smooth (vs. keeled); sexual dimorphism of dorsal colour pattern present (vs. absent); yellow colouration on original tail in males present (vs. absent); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. lacking yellow colouration on ventral surfaces).

Cnemaspis auriventralis sp. nov. differs from *C. lineatubercularis* by having ventral scales smooth (vs. keeled); 16–17 paravertebral tubercles (vs. 19–21); enlarged median subcaudal scales row present (vs. absent); subcaudal scales smooth (vs. keeled); single median row of subcaudals smooth (vs. keeled); two postcloacal tubercles on each side in males (vs. one); subtibial scales smooth (vs. keeled); sexual dimorphism of dorsal colour pattern present (vs. absent); light or yellowish prescapular crescent absent (vs. present); yellow colouration on original tail in males present (vs. absent); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. yellowish colouration only on anterior gular, abdominal and subcaudal regions).

Cnemaspis auriventralis sp. nov. differs from *C. omari* by having ventral scales smooth (vs. keeled); 6–7 precloacal pores in males (vs. 4); 16–17 paravertebral tubercles (vs. 22–29); ventrolateral caudal tubercles anteriorly present (vs. absent); enlarged median subcaudal scales row present (vs. absent); caudal tubercles not encircling the tail (vs. encircling); two postcloacal tubercles on each side in males (vs. one); subtibial scales smooth (vs. keeled); sexual dimorphism of dorsal colour pattern present (vs. absent); light or yellowish prescapular crescent absent (vs. present); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. yellow colouration only on gular region, belly, underside of hind-limbs, and subcaudal region).

Cnemaspis auriventralis sp. nov. differs from *C. phangngaensis* by having 7–9 infralabials (vs. 10); ventral scales smooth (vs. keeled); 6–7 precloacal pores in males (vs. 4); 16–17 paravertebral tubercles (vs. 22); tubercles on lower flanks present (vs. absent); enlarged median subcaudal scales row present (vs. absent); subcaudal scales smooth (vs. keeled); single median row of subcaudals smooth (vs. keeled); subtibial scales smooth (vs. keeled); 23–27 subdigital lamellae on the fourth toe (vs. 29); light or yellowish prescapular crescent absent (vs. present); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. yellow colouration only on anterior gular region, abdomen and subcaudal region).

Cnemaspis auriventralis sp. nov. differs from *C. punctatonuchalis* by having a smaller maximum SVL of 38.6 mm (vs. 49.6 mm); 6–7 precloacal pores in males (vs. 0); 16–17 paravertebral tubercles (vs. 24–27); 23–27 subdigital lamellae on the fourth toe (vs. 29–31); ocelli on brachium and side of neck in males absent (vs. present); yellow colouration on original tail in males present (vs. absent); and yellow colouration on all ventral surfaces of body and tail in males (vs. orange colouration on throat and subcaudal region).

Cnemaspis auriventralis sp. nov. differs from *C. roticanai* by having a smaller maximum SVL of 38.6 mm (vs. 47.0 mm); ventral scales smooth (vs. keeled); 16–17 paravertebral tubercles (vs. 25–27); paravertebral tubercles linearly arranged (vs. randomly); ventrolateral caudal tubercles anteriorly present (vs. absent); subcaudal scales smooth (vs. keeled); single median row of subcaudals smooth (vs. keeled); subtibial scales smooth (vs. keeled); light or yellowish prescapular crescent absent (vs. present); yellow colouration on original tail in males present (vs. absent); and yellow colouration on regenerated tail absent (vs. present).

Cnemaspis auriventralis sp. nov. differs from *C. selenolagus* by having 7–9 infralabials (vs. 10); paravertebral tubercles linearly arranged (vs. randomly); tubercles on lower flanks present (vs. absent); lateral caudal furrow present (vs. absent); ventrolateral caudal tubercles anteriorly present (vs. absent); enlarged median subcaudal scales row present (vs. absent); caudal tubercles not encircling the tail (vs. encircling); enlarged submetatarsal scales on the first toe absent (vs. present); 23–27 subdigital lamellae on the fourth toe (vs. 22); orange-yellow colouration on anterior 1/2 of body in males absent (vs. present); ocelli on brachium and side of neck in males absent (vs. present); light or yellowish prescapular crescent absent (vs. present); yellow dorsal colouration on fore-limbs in male absent (vs. present); yellow colouration on original tail in males present (vs. absent); and having yellow colouration on all ventral surfaces of head, body and tail in males (vs. yellow colouration only on anterior part of body).

Cnemaspis auriventralis sp. nov. differs from *C. siamensis* by having ventral scales smooth (vs. keeled); 6–7 precloacal pores in males (vs. 0); 16–17 paravertebral tubercles (vs. 19–25); paravertebral tubercles linearly arranged (vs. randomly); ventrolateral caudal tubercles anteriorly present (vs. absent); subcaudal scales smooth (vs. keeled); single median row of subcaudals smooth (vs. keeled); subtibial scales smooth (vs. keeled); sexual dimorphism of dorsal colour pattern present (vs. absent); lineate gular marking absent (vs. present); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. yellow colouration only on gular region, throat and pectoral region).

Cnemaspis auriventralis sp. nov. differs from *C. thachanaensis* by having ventral scales smooth (vs. keeled); 6–7 precloacal pores in males (vs. 0); enlarged median subcaudal scales row present (vs. absent); subcaudal scales smooth (vs. keeled); single median row of subcaudals

Table 5. Diagnostic morphological and colour pattern characteristics distinguishing *Cnemaspis auriventralis* sp. nov. from other species of the *C. siamensis* group. Grey highlight indicates differences with the new species. Key: Cont. = continuous; Sep. = separated; NA = data unavailable or not applicable.

Characters	*C. auriventralis* sp. nov.	*C. adangrawi*	*C. chanardi*	*C. huaseesom*	*C. kamolnorranathi*	*C. lineatubercularis*	*C. omari*	*C. phangngaensis*	*C. punctatonuchalis*	*C. roticanai*	*C. selenolagus*	*C. siamensis*	*C. thachanaensis*	*C. vandeventeri*
Morphology														
Max SVL	38.6	44.9	40.1	43.5	37.8	41.8	41.3	42.0	49.6	47.0	36.2	39.7	39.0	44.7
Supralabial	8–10	10	7–10	7–10	8–9	8–9	8–9	10	8	8–9	10–11	8–9	10–11	8–9
Infralabial	7–9	9	6–8	6–9	7–8	8–9	7–8	10	7–8	7–8	10	6–8	9–11	7–9
Ventral scales	smooth	keeled	keeled	smooth	weakly keeled or smooth	keeled	keeled	keeled	smooth	keeled	smooth	keeled	keeled	keeled
No. of precoacal pores	6–7	6–8	6–8	5–8	7	4–7	4	4	0	3–6	6–7	0	0	4
Precloacal pores arrangement	Cont. or Sep.	Sep.	Sep.	Cont.	Cont.	Sep.	Sep.	Cont.	NA	Sep.	Cont.	NA	NA	Sep.
No. of paravertebral tubercles	16–17	23–25	20–30	18–24	19–24	19–21	22–29	22	24–27	25–27	16–18	19–25	15–19	25–29
Tubercles arranged	linearly	randomly	randomly	weakly linear or randomly	semi-linearly	linearly	semi-linearly or randomly	linearly	semi-linearly	randomly	randomly	randomly	linearly	randomly
Tubercles on lower flanks	present	absent	present	present	present	present	generally present	absent	present	present	absent	present	generally present	absent
Lateral caudal furrows	present	present	present	present	present	present	present	present	present	present	absent	present	present	present
Caudal tubercles in lateral furrow	absent	present	absent	present	present	absent	absent	absent	absent	absent	NA	absent	absent	absent
Ventrolateral caudal tubercles anteriorly	present	present	absent	absent	absent	present	absent	present	present	absent	absent	absent	present	absent
Enlarged median subcaudal scale row	present	absent	present	absent	weak	absent	absent	absent	present	present	absent	present	absent	present
Subcaudals	smooth	keeled	keeled	smooth	keeled	keeled	keeled or smooth	keeled	smooth	keeled	smooth	keeled	keeled	keeled
Single median row of subcaudals	smooth	keeled	smooth	smooth	keeled	keeled	smooth	keeled	smooth	keeled	NA	keeled	keeled	weakly keeled
Caudal tubercles encircle tail	no	no	no	no	no	no	yes	no	no	no	yes	no	no	no
No. of postcloacal tubercles in males	2	1	1	1 or 2	1 or 2	1	1	2	1–3	1 or 2	2	1 or 2	0	1–3
Subtibial scales	smooth	keeled	keeled	smooth	keeled or smooth	keeled	keeled	keeled	smooth	keeled	smooth	keeled	keeled	keeled
Shield-like subtibial scales	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent
Enlarged submetatarsal scales on 1st toe	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent	present	absent	present	absent
No. of 4th toe lamellae	23–27	26–28	25–30	21–31	24–28	27–29	25–28	29	29–31	26–29	22	24–26	23–25	24–28
Colouration and pattern														
Dorsal colour pattern sexually dimorphic	yes	no	no	yes	no	no	no	yes	yes	yes	NA	no	yes	no
Ventral pattern sexually dimorphic	yes	yes	yes	yes	NA	yes	yes	yes	yes	yes	NA	yes	yes	yes
Anterior 1/2 of body orange-yellow, posterior 1/2 grey	no	no	no	no	no	no	no	no	no	no	yes	no	no	no
Ocelli on brachium and side of neck	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no
Light or yellowish, prescapular crescent	no	yes	yes	no	variable	yes	yes	yes	no	yes	yes	no	no	yes

Characters	*C. auriventralis* sp. nov.	*C. adangrawi*	*C. chanardi*	*C. huaseesom*	*C. kamolnorranathi*	*C. lineatubercularis*	*C. omari*	*C. phangngaensis*	*C. punctatonuchalis*	*C. roticanai*	*C. selenolagus*	*C. siamensis*	*C. thachanaensis*	*C. vandeventeri*
Fore-limbs yellow in males	no	no	no	yes	no	no	no	no	no	no	yes	no	no	no
Original tail yellow in males	yes	no	no	yes	no	no	no	no	no	no	no	no	no	no
Regenerated tail yellow	no	no	no	no	no	no	no	no	NA	yes	no	no	no	no
Lineate gular markings	no	no	no	no	no	no	no	no	no	no	no	yes	yes	no
All ventral surfaces of head, body and tail yellow in males	yes	no	no	no	no	no	no	no	no	yes	no	no	no	no

smooth (vs. keeled); two poscloacal tubercles on each side in males (vs. 0); subtibial scales smooth (vs. keeled); lineate gular marking absent (vs. present); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. yellowish-orange colouration only on gular region).

Cnemaspis auriventralis sp. nov. differs from *C. vandeventeri* by having a smaller maximum SVL of 38.6 (vs. 44.7 mm); ventral scales smooth (vs. keeled); 6–7 precloacal pores in males (vs. 4); 16–17 paravertebral tubercles (vs. 25–29); paravertebral tubercles linearly arranged (vs. randomly); tubercles on lower flanks present (vs. absent); ventrolateral caudal tubercles anteriorly present (vs. absent); subcaudal scales smooth (vs. keeled); single median row of subcaudals smooth (vs. weakly keeled); subtibial scales smooth (vs. keeled); sexual dimorphism of dorsal colour pattern present (vs. absent); light or yellowish prescapular crescent absent (vs. present); and yellow colouration on all ventral surfaces of head, body and tail in males (vs. orange colouration on gular region, throat, pectoral region, underside of limbs, belly and subcaudal region).

Discussion

Our phylogenetic analyses indicated that *Cnemaspis auriventralis* sp. nov. belongs to the *C. siamensis* group and is closely related to *C. huaseesom* from Sai Yok National Park, Kanchanaburi Province, approximately 25 km to the west. Ecologically, the new species and its close relative *C. huaseesom* occur in similar habitats and substrates (karst associated areas). However, the new species was found at 747 m elevation, whereas *C. huaseesom* was found in lowland areas (Grismer et al. 2010, 2014). Therefore, the geographic boundaries of these two species could be separated by elevation zonation (upland [> 600 m] and lowland [< 600 m] species; Grismer et al. 2014). The description of *C. auriventralis* sp. nov. brings the total number of Thai *Cnemaspis* to 21 species (Grismer et al. 2014; Uetz et al. 2022). *Cnemaspis auriventralis* sp. nov. is the seventh new Thai *Cnemaspis* species described in the last five years (Ampai et al. 2020; Grismer et al. 2020; Uetz et al. 2022). The number of known Thai *Cnemaspis* species continues to increase, likely as a result of new field research in poorly known areas and the use of integrative taxonomic approaches to delimit species in this genus (Wood et al. 2017; Ampai et al. 2019, 2020; Grismer et al. 2020). Additional field surveys and further taxonomic investigations using multiple lines of evidence in western Thailand are needed to determine the extent of the geographic range of the new species and to improve documentation of the herpetofaunal diversity in Thailand.

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