



# A multitude of spots! Five new microendemic species of the *Cnemaspis gracilis* group (Squamata: Gekkonidae) from massifs in the Shevaroy landscape, Tamil Nadu, India

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## Abstract

South Asian *Cnemaspis* are one of the most diverse clades of gekkonids in South Asia with their highest diversity in the Western Ghats and Sri Lanka. These geckos include only a few nocturnal species and are largely diurnal or cathemeral and restricted to relatively cool habitats. One of the prominently diurnal subgroups in South Asian *Cnemaspis* is the *gracilis* clade, which includes six species distributed in southern India on the eastern slopes of the Western Ghats, the southern Eastern Ghats and Palghat Gap. In this paper, we describe five more species of the *gracilis* clade from the Shevaroyan landscape, including three from Kollimalai and one each from Yercaud and Pachaimalai, all in Tamil Nadu. These new species show 4.6–19.7 % uncorrected sequence divergence on the mitochondrial ND2 gene from each other and known species of the *gracilis* clade and are morphologically diagnosable in body size, the number of paravertebral tubercles between limb insertions, the number of dorsal tubercle rows, the number of ventral scale rows across the belly, the number of femoral and precloacal pores and poreless scales separating these series, and aspects of colouration. The discovery of these five new species adds to the growing discoveries of cool-adapted species in southern India outside the Western Ghats and highlights the role of sky-islands in diversification. The Shevaroyan landscape shows high levels of microendemism with eight species distributed in an area of < 2000 km<sup>2</sup>, and all these species restricted to much smaller areas of actual distribution. With an area of < 500 km<sup>2</sup> respectively, the massif of Pachaimalai has a single endemic and the massifs of Yercaud and Kollimalai have three endemic *Cnemaspis* species each.

## Keywords

Endemic species, integrative taxonomy, microendemism, mountains, southern India, species radiation, taxonomy

## Introduction

Diurnality has evolved multiple times within the ancestrally nocturnal Gekkonidae, including numerous reversals (Gamble et al. 2016). Among the most diverse genera

of chiefly diurnal gekkonids is the South Asian clade of the paraphyletic *Cnemaspis* Strauch, 1887 that includes over 100 described species with a disjunct distribution

across parts of peninsular India, Sri Lanka and northeast India in the Indian subcontinent, as well as eastern South-east Asia (Iskandar et al. 2017; Lee et al. 2019; Agarwal et al. 2020a, 2021a; Amarasinghe et al. 2021; Pal et al. 2021; Uetz et al. 2022). Most species of South Asian *Cnemaspis* are diurnal or crepuscular/ cathemeral, apart from the largely nocturnal *wynadensis* clade and some species of the *beddomei* clade (Pal et al. 2021).

South Asian *Cnemaspis* originated in the Western Ghats in the Paleocene-Eocene and are largely restricted to cool habitats (Agarwal et al. 2020b), 10 of the 13 broad clades within the group endemic to peninsular India and seven of these to the Western Ghats (Pal et al. 2021; Khandekar et al. 2022a). Of the three clades that are distributed outside the Western Ghats, the *bangara* and *mysoriensis* clades with four and seven species, respectively, are restricted to the southern edge of the Mysore Plateau and associated hills; and only the *C. gracilis* clade with six species is distributed in both the Western Ghats and other parts of peninsular India (Agarwal et al. 2021b; Pal et al. 2021; Khandekar et al. 2022a, 2022b).

*Cnemaspis gracilis* (Beddome) was described by Beddome (1870) from the 'Palghat Hills' and the species was thought to be widely distributed in southern India (Smith 1935; Srinivasulu and Srinivasulu 2013). Manamendra-Arachchi et al. (2007) designated a lectotype for *C. gracilis* and redescribed the species, which is now known with certainty from three localities in Kerala and Tamil Nadu in the vicinity of the Palghat Gap (Khandekar et al. 2022b). The additional five species of the complex have been described in the last three years, each known only from the vicinity of their respective type localities (Khandekar 2019; Khandekar et al. 2019, 2022b; Pal et al. 2021). *Cnemaspis jackieii* Pal, Mirza, Dsouza & Shanker and *C. mundanthuraiensis* Khandekar, Thackeray & Agarwal are distributed on the eastern slopes of the Western Ghats, *C. shevaroyensis* Khandekar, Gaitonde & Agarwal and *C. thackerayi* Khandekar, Gaitonde & Agarwal in the Shevaroy Hills (Yercaud; along with an additional unnamed lineage *C. cf. gracilis*), and *C. agarwali* Khandekar from an isolated hillock just south of the Mysore Plateau, beside *C. gracilis* from the Palghat Gap (Fig. 1).

The highest diversity within the *gracilis* clade is in Yercaud, an isolated massif with a plateau above 1000 m asl. and a maximum elevation of 1623 m asl., on which two named species and one unnamed species occur (Khandekar et al. 2019). Yercaud forms a part of the broader Shevaroy Group or Shevaroyan landscape (sensu Raheem et al. 2014), which includes a number of smaller hills and the major ranges with maximum elevations of > 1000 m asl. of Sitteri and Kalrayan Hills to the east of Yercaud, and Kollimalai and Pachaimalai hills to the south and southeast (Fig. 1). We sampled the Shevaroyan landscape as part of an ongoing project on the systematics and taxonomy of peninsular Indian lizards and discovered multiple unidentified *Cnemaspis* spp. of the *gracilis* clade. In this paper, we describe five new species from the Yercaud-Kollimalai-Pachaimalai Hill complex using morphological data and mitochondrial sequence data to demonstrate the uniqueness of these lineages.

## Materials and Methods

### Taxon sampling

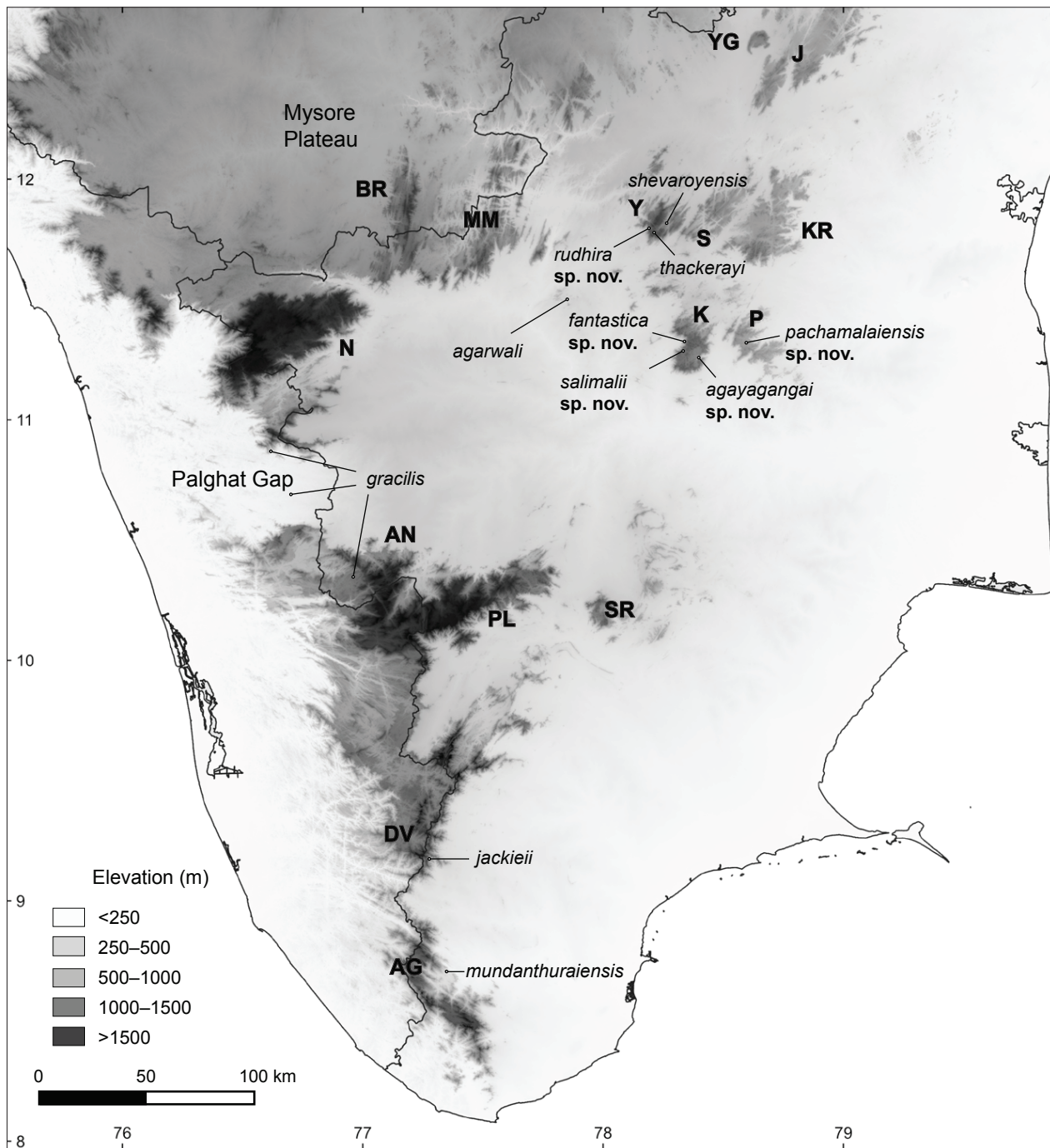
Surveys were conducted in both day and night time, specimens were spotted on rocks, building walls, sometimes on tree trunks, and collected by hand, followed by euthanasia using isoflurane after taking colour photos in life. Liver tissues of at least three individuals of each new species were collected in molecular grade ethanol and subsequently stored at  $-20^{\circ}\text{C}$  for genetic analysis. Specimens were fixed in 8% formalin for  $\sim 12\text{--}24$  hours, washed and kept in tap water for  $\sim 24$  hours, and transferred to 70% ethanol for long-term storage. Specimens are deposited in the museum and research collection facility at the National Centre for Biological Sciences, Bengaluru (NCBS/NRC).

### Molecular data

Total genomic DNA was extracted from tail/ liver tissues using the Qiagen DNeasy Blood & Tissue extraction kit for the new species and some individuals of *Cnemaspis gracilis* (Table 1). The primers L4437 and H5934 (Macey et al. 1997) were used to amplify the protein coding ND2 gene, and L4437 was used to sequence a partial fragment of ND2. Both PCR and sequencing were outsourced to Medauxin (Bangalore, India). We added published sequences of the *Cnemaspis gracilis* clade and used *C. australis* Manamendra-Arachchi, Batuwita & Pethiyagoda and *C. monticola* Manamendra-Arachchi, Batuwita & Pethiyagoda as outgroups (Table 1; after Khandekar et al. 2019, 2022a, 2022c; Pal et al. 2021). We used MEGA 5.2 (Tamura et al. 2011) for sequence alignment using default settings in ClustalW (Thompson et al. 1994), translation to amino acids to check for erroneous stop codons, and to calculate uncorrected pairwise p-distance with the partial deletion option.

The best fit models of sequence evolution and partitions were selected using the Bayesian Information Criteria in Partitionfinder 2 (Lanfear et al. 2012) which selected partitions by codon position and the HKY + I model for codon position (cp) 1, HKY + G for cp 2 and GTR + G for cp 3. We reconstructed a Maximum Likelihood (ML) phylogeny with the GTR + G model applied for each codon partition in RAXML HPC 8.2.10 (Stamatakis 2014) (since RAXML allows only a single model across partitions) as implemented in raxmlGUI 2.0.9 (Edler et al. 2020) with 10 independent ML runs and support assessed with 500 rapid bootstraps. A partitioned Bayesian analysis was carried out in MrBayes 3.2.7 (Ronquist and Huelsenbeck 2003) with model parameters unlinked across partitions. The final analysis was run for 2,000,000 generations sampling every 200 generations, implementing two parallel runs with four chains each (one cold and three hot) and convergence was determined based on standard deviation of split frequencies ( $<0.01$ ) and ESS ( $>>200$ ). A Maximum Clade Credibility tree was built us-





**Figure 1.** Elevation map showing the distribution of members of the *Cnemaspis gracilis* clade in peninsular India. Major hill ranges are marked by bold text, within the Western Ghats: AG, Agasthyamalai; AN, Anaimalai; DV, Devarmalai; N, Nilgiris; PL, Palani; and outside the Western Ghats: BR, Biligirangan; J, Jawadhu; K, Kollimalai; KR, Kalrayan; MM, Male Mahadeshwara; P, Pachaimalai; S, Sitteri; SR, Sirumalai; Y, Yercaud; YL, Yelagiri. The Mysore Plateau and Palghat Gap are also marked.

ing TreeAnnotator 1.10.4 (Drummond et al. 2012) after discarding the first 25% of trees as burn-in.

## Morphological and meristic data

Morphological data were collected from a total of 44 specimens of the five new species. We restricted morphological comparisons to the *gracilis* clade (see Results). Comparative morphological data of four of six members of the *gracilis* clade included the type series; topotypic

as well as additional specimens were used for *C. gracilis* (Beddome) (all listed in Appendix 1); and comparative morphological data for the most recently described species — *C. jackieii* was obtained from the original description (Pal et al. 2021). Meristic counts and measurements were taken under a ZEISS Stemi 305 stereo dissecting microscope and on the right side of the body where possible. Colour pattern was recorded from photographs taken in life and specimens in case no photographs were available. We use ocelli to refer to the distinct, dark spots on head and forebody. All measurements were taken with a

**Table 1.** List of *Cnemaspis* sequences used in this study. Museum and voucher abbreviations as follows: AK, Akshay Khandekar field series; CES G (Karanth lab field series) and CES L (Centre for Ecological Sciences, Bangalore); NCBS and NRC (National Centre for Biological Sciences, Bangalore); ZM, Zeeshan Mirza field series.

Species	Voucher	Locality	GenBank Accession number
<i>Cnemaspis agarwali</i>	BNHS 2336 (AK 107)	India, Tamil Nadu, Salem District, Sankari	MK792466
<i>Cnemaspis agarwali</i>	NCBS-AU485 (AK 108)	India, Tamil Nadu, Salem District, Sankari	MK792467
<i>Cnemaspis agayagangai</i> <b>sp. nov.</b>	NRC-AA-1215 (AK 267)	India, Tamil Nadu, Namakkal District, Agaya Gangai Waterfalls	OP709694
<i>Cnemaspis agayagangai</i> <b>sp. nov.</b>	NRC-AA-1214 (AK 268)	India, Tamil Nadu, Namakkal District, Agaya Gangai Waterfalls	OP709695
<i>Cnemaspis australis</i>	ZM003	India, Kerala, Peppara	MZ701834
<i>Cnemaspis gracilis</i>	AK 135	India, Tamil Nadu, Coimbatore District, Valparai	MK792470
<i>Cnemaspis gracilis</i>	CES L 606	India, Tamil Nadu, Palakkad District, Chennathanair RF	OP709696
<i>Cnemaspis gracilis</i>	CES L 607	India, Tamil Nadu, Palakkad District, Chennathanair RF	OP709697
<i>Cnemaspis gracilis</i>	CES G 385	India, Kerala, Palakkad District, near Chittur river	MK7924
<i>Cnemaspis jackieii</i>	CES L 192	India, Tamil Nadu, Vairavankulam RF, near Karuppan-adhi dam	MZ701804
<i>Cnemaspis fantastica</i> <b>sp. nov.</b>	NRC-AA-1223 (AK 284)	India, Tamil Nadu, Namakkal District, Kollimalai ghat	OP709698
<i>Cnemaspis fantastica</i> <b>sp. nov.</b>	NRC-AA-1224 (AK 285)	India, Tamil Nadu, Namakkal District, Kollimalai ghat	OP709699
<i>Cnemaspis fantastica</i> <b>sp. nov.</b>	CES G 131	India, Tamil Nadu, Namakkal District, Kollimalai ghat	OP709700
<i>Cnemaspis monticola</i>	CES L 044	India, Kerala, Wayanad District, Manikunjmalai	MZ701803
<i>Cnemaspis mundanthuraiensis</i>	NRC-AA-1176 (AKR 443)	India, Tamil Nadu, Tirunelveli District, Mundanthurai forest range	ON494557
<i>Cnemaspis mundanthuraiensis</i>	NRC-AA-1177 (AKR 445)	India, Tamil Nadu, Tirunelveli District, Mundanthurai forest range	ON494558
<i>Cnemaspis pachaimalaiensis</i> <b>sp. nov.</b>	NRC-AA-1231 (AK 708)	India, Tamil Nadu, Tiruchirapalli District, Pachaimalai	OP709701
<i>Cnemaspis pachaimalaiensis</i> <b>sp. nov.</b>	NRC-AA-1232 (AK 709)	India, Tamil Nadu, Tiruchirapalli District, Pachaimalai	OP709702
<i>Cnemaspis rudhira</i> <b>sp. nov.</b>	NRC-AA-1239 (AK 208)	India, Tamil Nadu, Salem District, Yercaud	MK792461
<i>Cnemaspis rudhira</i> <b>sp. nov.</b>	NRC-AA-1240 (AK 209)	India, Tamil Nadu, Salem District, Yercaud	MK792462
<i>Cnemaspis rudhira</i> <b>sp. nov.</b>	NRC-AA-1241 (AK 212)	India, Tamil Nadu, Salem District, Yercaud	MK792463
<i>Cnemaspis rudhira</i> <b>sp. nov.</b>	NRC-AA-1242 (AK 213)	India, Tamil Nadu, Salem District, Yercaud	MK792464
<i>Cnemaspis salimalii</i> <b>sp. nov.</b>	NRC-AA-1205 (AK 257)	India, Tamil Nadu, Namakkal District, Kollimalai	OP709703
<i>Cnemaspis salimalii</i> <b>sp. nov.</b>	NRC-AA-1206 (AK 258)	India, Tamil Nadu, Namakkal District, Kollimalai	OP709704
<i>Cnemaspis shevaroyensis</i>	NCBS-BH675 (AK 205)	India, Tamil Nadu, Salem District, Yercaud	MK792468
<i>Cnemaspis shevaroyensis</i>	NCBS-BH674 (AK 204)	India, Tamil Nadu, Salem District, Yercaud	MK792469
<i>Cnemaspis thackerayi</i>	CES G 143	India, Tamil Nadu, Salem District, Yercaud	MK792471

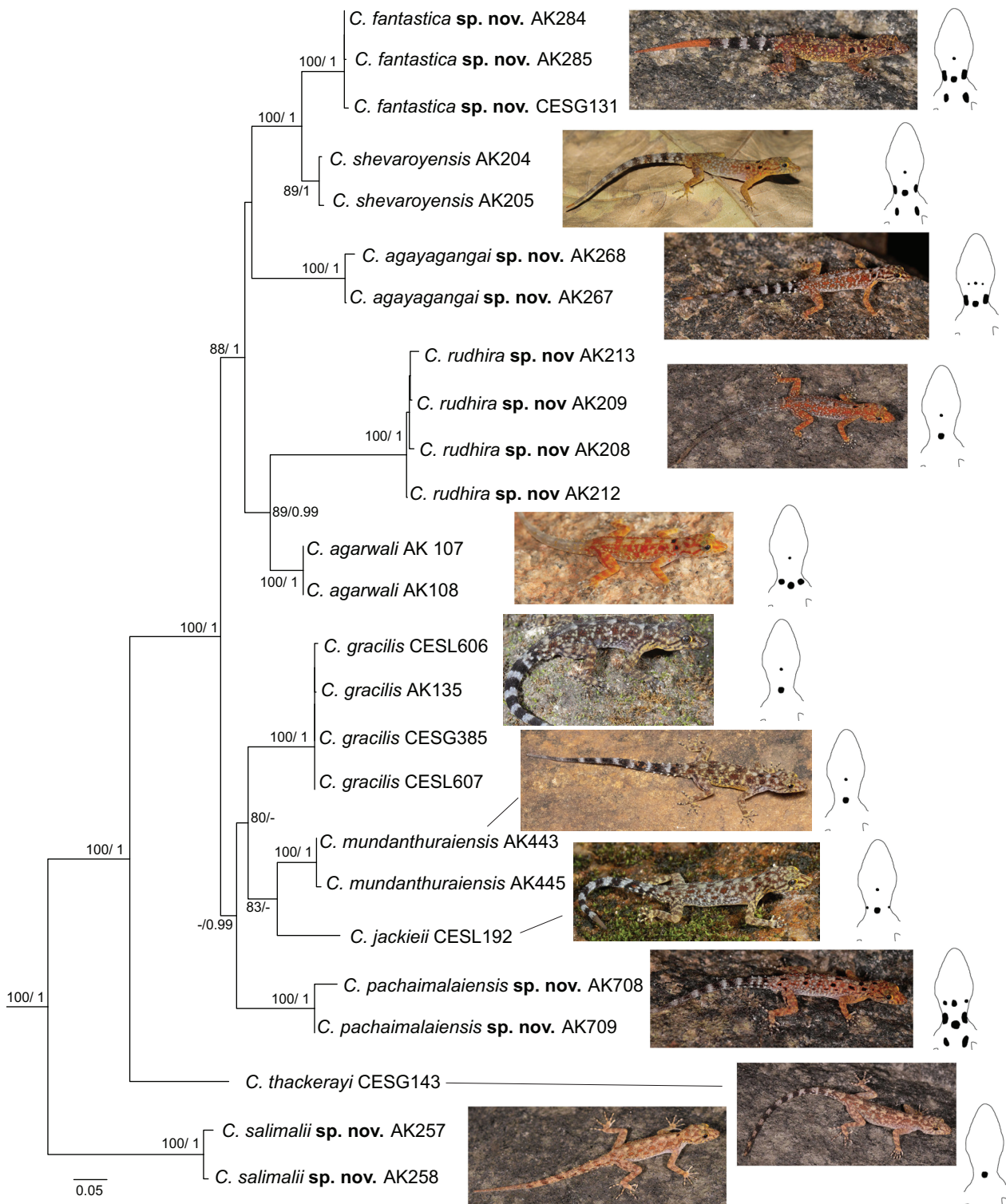
Mitutoyo digital vernier calliper (to the nearest 0.1 mm). We follow Agarwal et al. (2020a) for body size categories for South Asian *Cnemaspis*; mensural, meristic and additional morphological character states evaluation is in accordance with Khandekar et al. (2019): snout vent length (SVL), axilla to groin length (AGL), body height (BH), body width (BW), forearm length (FL), crus length (CL), tail length (TL), tail width (TW), head length (HL), head width (HW), head depth (HD), eye diameter (ED), eye to nares distance (EN), eye to snout distance (ES), eye to ear distance (EE), ear length (EL), internarial distance (IN), interorbital distance (IO); meristic data recorded for all specimens were number of supralabials (SL), infralabials (IL), supralabials at midorbital position (SL M), infralabials at midorbital position (IL M), dorsal tubercle rows including longitudinal rows of spine-like scales on lower flank (DTR), paravertebral tubercles (PVT), ventral scales (VS), mid-body scale rows across the belly (MVS), precloacal pores (PP), femoral pores (FP), poreless scales between precloacal and femoral pores

(SB PP&FP), poreless scales between precloacal pores (SB PP), poreless scales between femoral pores (SB FP), postcloacal tubercles (PCT), transverse subdigital lamellae on finger 1 (LamF1), finger 4 (LamF4), toe 1 (LamT1), toe 4 (LamT4), toe 5 (LamT5).

## Results

### Phylogenetic relationships

The partial ND2 sequences for the new species ranged from 325–851 nucleotides. The monophyly of the *gracilis* clade is well supported (bootstrap support 100, Posterior Probability 1.0), within which a basal split separates *Cnemaspis salimalii* **sp. nov.** (see description below) from the remaining lineages in the clade, with a subsequent divergence separating *C. thackerayi* from the remaining



**Figure 2.** Maximum likelihood tree of the *gracilis* clade of South Asian *Cnemaspis* based on a partial fragment of ND2 with photographs of the species in life (not to scale) and sketches showing dorsal colour pattern of head and forebody (not to scale); note that *C. salimalii* **sp. nov.** and *C. thackerayi* have the same pattern. Bootstrap support and Posterior Probability (only values  $\geq 65\%$  and 0.99 shown) depicted at nodes, outgroups not shown.

lineages (Fig. 1). These nine lineages fall into two broad clades, the first including *C. gracilis* as the sister taxon to *C. mundanthuraiensis* + *C. jackieii*, these three taxa collectively the sister taxon to *Cnemaspis pachimalaiensis* **sp. nov.** (see description below). The second clade includes one subclade with *Cnemaspis agayagangai* **sp. nov.** (see description below) sister to *C. shevaroyensis*

+ *Cnemaspis fantastica* **sp. nov.** (see description below) and the other subclade with *C. agarwali* sister to *C. rudhira* **sp. nov.** (see description below) (referred to as *C. cf. gracilis* by Khandekar et al. 2019).

Uncorrected pairwise sequence divergence within previously named species of the *gracilis* clade ranges from 6.1–19.7% (Table 2). Of the five new species, *Cnemaspis*



**Table 2.** Pairwise uncorrected ND2 sequence divergence between members of the *Cnemaspis gracilis* clade of South Asian *Cnemaspis*, numbers in bold along diagonal represent intraspecific diversity.

	Species	1	2	3	4	5	6	7	8	9	10
1	<i>C. agarwali</i>	<b>0.0</b>									
2	<i>C. agayagangai</i> <b>sp. nov.</b>	7.8	<b>1.0</b>								
3	<i>C. fantastica</i> <b>sp. nov.</b>	8.2	9.8	<b>0.4</b>							
4	<i>C. gracilis</i>	8.7	10.4	11.3	0.2						
5	<i>C. jackieii</i>	9.0	9.8	10.4	7.8	-					
6	<i>C. mundanthuraiensis</i>	8.8	10.7	10.6	7.6	6.1	<b>0.4</b>				
7	<i>C. pachaimalaiensis</i> <b>sp. nov.</b>	9.9	10.5	12.0	9.1	8.5	8.9	<b>1.8</b>			
8	<i>C. rudhira</i> <b>sp. nov.</b>	11.0	12.8	13.2	13.8	11.1	13.6	14.2	<b>1.0</b>		
9	<i>C. salimalii</i> <b>sp. nov.</b>	17.2	16.4	17.3	15.8	18.2	16.8	14.3	19.7	<b>1.1</b>	
10	<i>C. shevaroyensis</i>	7.9	9.5	4.6	10.2	9.7	10.3	10.6	13.3	17.8	<b>0.7</b>
11	<i>C. thackerayi</i>	13.2	14.4	14.1	12.9	12.3	13.3	13.5	16.6	14.3	13.6

*salimalii* **sp. nov.** shows  $\geq 14.3$  % divergence from other members of the clade, *Cnemaspis rudhira* **sp. nov.**  $\geq 11.0$  %, *Cnemaspis pachaimalaiensis* **sp. nov.**  $\geq 8.5$  %, *Cnemaspis agayagangai* **sp. nov.**  $\geq 7.8$  %, and *Cnemaspis fantastica* **sp. nov.**  $\geq 4.6$  % divergence. We describe these five divergent lineages as new species using morphological data.

## Systematics

### *Cnemaspis salimalii* **sp. nov.**

<https://zoobank.org/3499f0b8-6189-4ef8-9ed0-1cfcb11b840b>

Figs 3–5, 6A, 7A, 8A; Tables 3–5

**Holotype.** NRC-AA-1204 (AK 683), adult male, from the vicinity of Nallathambi resort, (11.2865°N, 78.3381°E; ca. 1150 m asl.), Semmedu, Kolli hills, Namakkal district, Tamil Nadu state, India; collected by Akshay Khandekar, Swapnil Pawar and Tejas Thackeray on 28<sup>th</sup> May 2019.

**Paratypes.** NRC-AA-1205 (AK 257), NRC-AA-1206 (AK 258), subadult males, NRC-AA-1207 (AK 259), NRC-AA-1208 (AK 261), NRC-AA-1209 (AK 263), adult males, NRC-AA-1210 (AK 265), adult female, same locality as holotype except collected by Akshay Khandekar, Ishan Agarwal, Nikhil Gaitonde, Varad Giri, Chaitanya R, and Aniruddha Dutta-Roy on 20<sup>th</sup> December 2018; NRC-AA-1212 (AK690), adult male, NRC-AA-1211 (AK 689), adult female, same data as holotype.

**Etymology.** The specific epithet is a patronym honouring the eminent ornithologist Dr. Salim Ali (1896–1987) for his immense contributions to field research and conservation in India.

**Suggested Common Name.** Salim Ali's dwarf gecko.

**Diagnosis.** A medium-sized *Cnemaspis*, snout to vent length up to 41.3 mm ( $n = 9$ ). Dorsal pholidosis heterogeneous; weakly keeled granular scales intermixed with irregularly arranged rows of enlarged, strongly keeled, conical tubercles; last one or two rows of enlarged tubercles on flank weakly keeled, short and spine-like; 11–13 rows of dorsal tubercles at mid-body, 16–18 tubercles in paravertebral rows, paravertebral rows rarely irregular ( $n = 1/7$ ); ventral scales smooth, subcircular, subimbricate, subequal from chest to vent, 30–33 scales across belly at mid-body, 109–128 longitudinal scales from mental to cloaca; subdigital scensors smooth, unpaired, unnotched; 10–12 lamellae under digit I of manus and pes, 15–18 lamellae under digit IV of manus and 20–24 lamellae under digit IV of pes; males with 3–5 femoral pores on each thigh separated by 5–7 poreless scales from series of 2–4 precloacal pores, precloacal pores separated medially by three or four poreless scales ( $n = 7/9$ ); tail with enlarged, strongly keeled, pointed, and spine-like tubercles forming whorls; median row of subcaudals smooth, roughly pentagonal, and distinctly enlarged. Dorsum with diffuse light tan blotches including some in a vertebral row and numerous smaller orange blotches; a single black dorsal ocellus on neck, venter off-white with black speckles; original tail in males with eight or nine faint bands, regenerated tail brown.

**Comparison with members of *C. gracilis* clade.** *Cnemaspis salimalii* **sp. nov.** is a member of the *gracilis* clade and can be easily distinguished from all six members of the clade by a combination of the following differing or non-overlapping characters: medium sized *Cnemaspis*, SVL up to 41 mm (versus small *Cnemaspis* SVL < 35 mm in *C. agarwali*, *C. gracilis*, *C. jackieii*, *C. mundanthuraiensis*, and *C. shevaroyensis*); 16–18 tubercles in paravertebral rows (versus only a few irregularly arranged tubercles in paravertebral region in *C. mundanthuraiensis*, 10–14 in *C. gracilis*; 11 or 12 in *C. jackieii*, 12–14 in *C. thackerayi*); 11–13 rows of dorsal tubercles at mid-body (versus eight or nine rows of dorsal tubercles at mid-body in *C. jackieii*, 6–8 rows of dorsal tubercles at mid-body in *C. mundanthuraiensis*); short spine-like tubercles present on flanks (versus spine-like tubercles



**Table 3.** Mensural (mm) data for the type series of *Cnemaspis salimalii* **sp. nov.**. Abbreviations are listed in Materials and Methods. \* = incomplete tail.

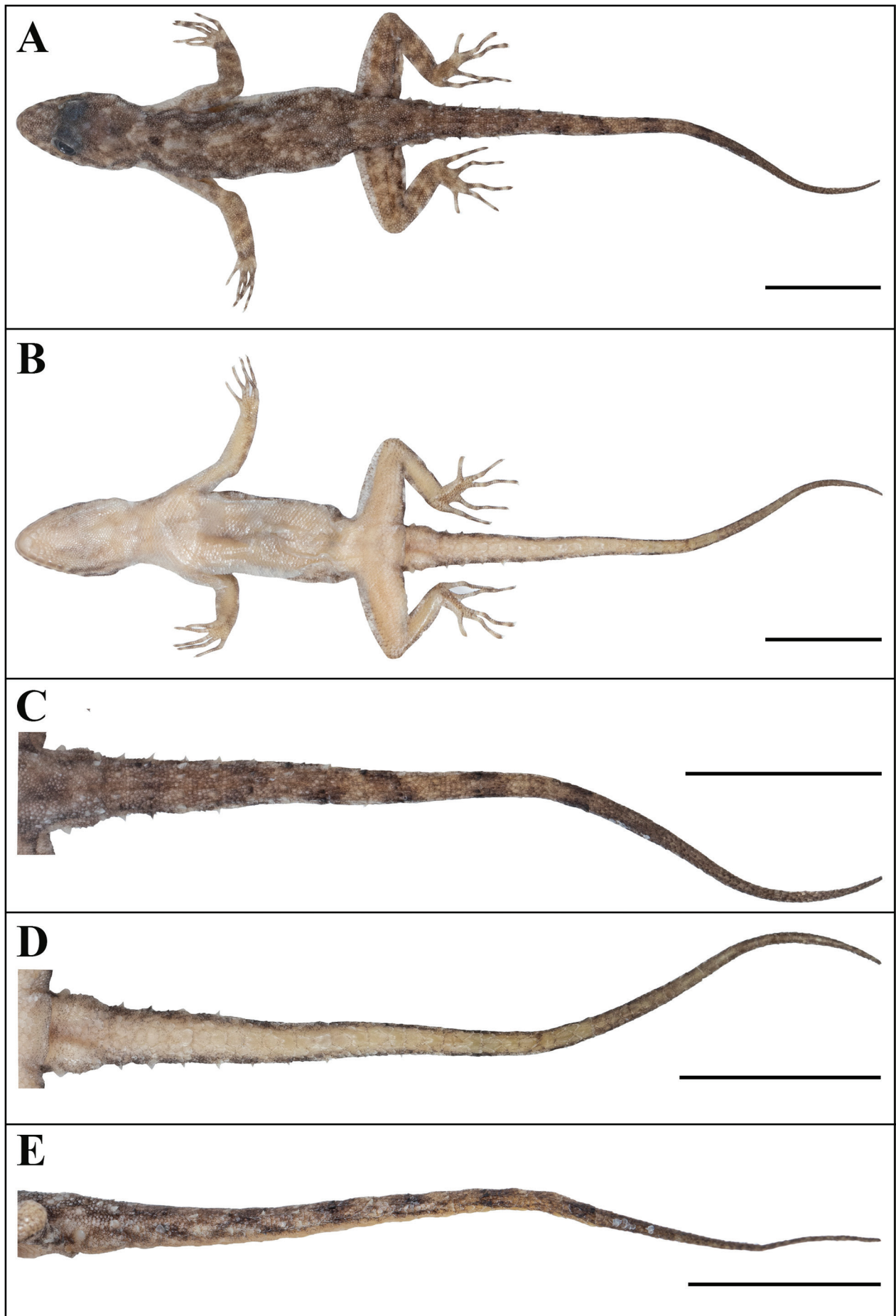
Type	Holotype	Paratypes							
museum number	NRC-AA-1204	NRC-AA-1205	NRC-AA-1206	NRC-AA-1207	NRC-AA-1208	NRC-AA-1209	NRC-AA-1210	NRC-AA-1211	NRC-AA-1212
Sex	Male	Male	Male	Male	Male	Male	Female	Female	Male
SVL	35.0	31.3	31.6	36.8	36.5	37.6	41.1	41.3	36.4
TL	45.0	2.7*	6.7*	14.0*	48.5	48.6	45.2	50.6	49.2
TW	3.5	3.0	2.7	3.5	3.8	3.7	3.5	4.0	3.4
LAL	5.1	4.6	4.6	5.6	5.2	5.6	6.1	5.8	5.6
CL	6.7	5.5	5.2	7.1	6.4	6.6	7.5	7.0	6.7
AGL	13.3	12.6	12.9	15.7	15.0	15.6	18.8	17.8	14.3
BH	3.3	2.8	2.6	3.4	3.7	4.3	3.5	4.1	3.6
BW	5.8	5.5	4.6	6.7	6.3	7.4	7.0	8.3	6.4
HL	8.9	7.7	7.5	9.1	8.8	8.9	9.8	9.7	9.2
HW	6.0	5.4	5.1	6.0	6.0	6.4	6.6	6.6	6.2
HD	3.7	2.7	3.0	3.4	4.2	3.5	3.4	4.0	3.8
ED	1.8	1.6	1.6	2.1	1.8	1.9	2.0	1.9	1.9
EE	2.7	2.5	2.5	2.6	2.9	2.8	3.0	3.0	2.8
ES	4.2	3.9	3.7	4.5	4.4	4.5	4.9	4.9	4.7
EN	3.4	3.1	2.9	3.4	3.5	3.5	4.1	3.9	3.5
IN	1.2	1.0	0.9	1.1	1.1	1.1	1.1	1.3	1.2
IO	1.5	1.3	0.8	1.6	1.4	1.4	1.6	1.6	1.5
EL	0.6	0.5	0.4	0.7	0.6	0.6	0.8	0.7	0.5

**Table 4.** Meristic data for the type series of *Cnemaspis salimalii* **sp. nov.**. Abbreviations are listed in Materials and Methods except for: L&R = Left & Right; irr = irregular; \* = paravertebral tubercles and lamellae incomplete; / = not available; abs. = absent;.

Type	Holotype	Paratypes							
Museum number	NRC-AA-1204	NRC-AA-1205	NRC-AA-1206	NRC-AA-1207	NRC-AA-1208	NRC-AA-1209	NRC-AA-1210	NRC-AA-1211	NRC-AA-1212
Sex	Male	Male	Male	Male	Male	Male	Female	Female	Male
SL (L&R)	10&10	8&9	8&8	9&9	9&8	9&9	9&10	8&7	9&9
IL (L&R)	8&8	7&8	7&7	8&9	9&9	9&8	9&9	8&8	9&8
SL M (L&R)	6&6	6&6	7&6	5&6	7&7	6&6	5&5	5&5	5&5
IL M (L&R)	6&6	5&6	6&5	5&6	6&6	6&5	5&5	5&6	5&6
PVT (L&R)	irr	/	/	18&18	18&18	*&17	18&18	16&17	18&17
DTR	12	11	/	11	12	12	12	13	12
MVSR	30	33	30	30	33	32	33	32	31
VS	109	114	113	118	116	128	117	114	117
LamF1 (L&R)	12&12	11&12	10&10	11&11	11&11	11&11	11&11	10&11	11&11
LamF4 (L&R)	16&17	15&16	18&16	18&18	16&17	17&17	16&16	18&18	18&18
LamT1 (L&R)	12&12	11&11	10&10	10&11	10&10	11&10	10&10	11&11	10&11
LamT4 (L&R)	22&22	21&22	22&22	21&22	21&21	21&20	22&22	15*&22	24&23
LamT5 (L&R)	19&19	15*&19	18&18	19&20	19&18	19&19	18&18	18&19	20&21
PP L&R	1&1	1&1	1&1	1&1	2&2	1&1	abs.	abs.	1&2
SBPP	3	3	3	3	3	4	abs.	abs.	3
SB PP&FP (L&R)	7&6	6&6	7&6	7&6	7&6	6&6	abs.	abs.	6&5
FP (L&R)	5&4	4&4	4&4	4&3	3&4	4&3	abs.	abs.	5&5
SBFP	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.
PCT (L&R)	1&1	1&1	1&1	1&1	1&1	1&1	1&1	1&1	1&1

absent on flanks in *C. agarwali*, *C. jackieii*, *C. shevaroyensis*, and *C. thackerayi*; 30–33 ventral scales across belly at mid-body (versus 24–26 ventral scales across belly at mid-body in *C. agarwali*, 26–29 (rarely 30) in

*C. gracilis*, 21–24 in *C. shevaroyensis*, and 22–25 in *C. thackerayi*); single dorsal ocellus on occiput absent, single dorsal ocellus on neck present (versus a single dorsal ocellus each on occiput and neck, two pairs on either side



**Figure 3.** *Cnemaspis salimalii* sp. nov. (holotype, NRC-AA-1204): **A** dorsal aspect of body; **B** ventral aspect of body; **C** dorsal aspect of tail; **D** ventral aspect of tail; **E** lateral aspect of tail. Scale bars 10 mm; photos by Akshay Khandekar.

of neck and just posterior to forelimb insertions in *C. shevaroyensis*; a single dorsal ocellus present on occiput and neck, two pairs on either side just anterior and sometimes posterior to forelimb insertions in *C. agarwali*). *Cnemaspis salimalii* **sp. nov.** is diagnosed against *Cnemaspis agayagangai* **sp. nov.**, *Cnemaspis fantastica* **sp. nov.**, *Cnemaspis pachaimalaiensis* **sp. nov.**, and *Cnemaspis rudhira* **sp. nov.** as part of their respective descriptions below.

**Description of the holotype.** Adult male in good state of preservation except regenerated portion of tail tip slightly bent towards right (Fig. 3A–E). SVL 35.0 mm, head short (HL/SVL 0.25), wide (HW/HL 0.67), not strongly depressed (HD/HL 0.41), distinct from neck. Loreal region marginally inflated, canthus rostralis not distinct. Snout almost half of head length (ES/HL 0.47), nearly 2.5 times eye diameter (ES/ED 2.33); scales on snout and canthus rostralis subcircular, subequal, smooth anteriorly, becoming weakly keeled, and conical posteriorly; much larger than those on forehead and interorbital region; scales on forehead similar to those on snout and canthus rostralis except smaller and weakly conical; scales on interorbital region even smaller, granular and smooth to weakly keeled; scales on occipital and temporal region heterogeneous, slightly enlarged, weakly keeled, conical tubercles intermixed with smaller, weakly keeled and weakly conical granular scales (Fig. 4A). Eye small (ED/HL 0.20) with round pupil; supraciliaries short, larger anteriorly; seven interorbital scale rows across narrowest point of frontal bone; 30–32 scale rows between left and right supraciliaries at mid-orbit (Fig. 4A, C). Ear-opening deep, oval, small (EL/HL 0.06); eye to ear distance greater than diameter of eye (EE/ED 1.50) (Fig. 4C). Rostral more than 2× wider (1.86 mm) than high (0.80 mm), incompletely divided dorsally by a strongly developed rostral groove and internasal scale for more than half of its height; a single enlarged supranasal on each side, marginally larger than postnasals, separated from each other by a much smaller, elongated internasal scale; two postnasals, upper postnasal marginally larger than lower; rostral in contact with supralabial I, nostril, supranasal, and lower postnasal on either side; nostrils oval, surrounded by two postnasals, supranasal, and rostral on either side; two rows of scales separate orbit from supralabials (Fig. 4C). Mental enlarged, subtriangular, slightly wider (2.01 mm) than high (1.54 mm); two pairs of postmentals, inner pair roughly rectangular, much shorter (0.77 mm) than mental, separated from each other below mental by a single enlarged median chin shield; inner pair bordered by mental, infralabial I, outer postmental, enlarged median chin shield and two enlarged chin shield on either side; outer postmentals roughly subcircular, even smaller (0.63 mm) than inner pair, bordered by inner postmentals, infralabial I and II, and four enlarged chin shields on either side; four enlarged gular scales between left and right outer postmentals; all chin scales bordering postmentals more or less flat, subcircular, smooth, and much smaller than outermost postmentals; scales on rest of throat, even smaller, subequal, and smooth (Fig. 4B). Infralabials bordered be-

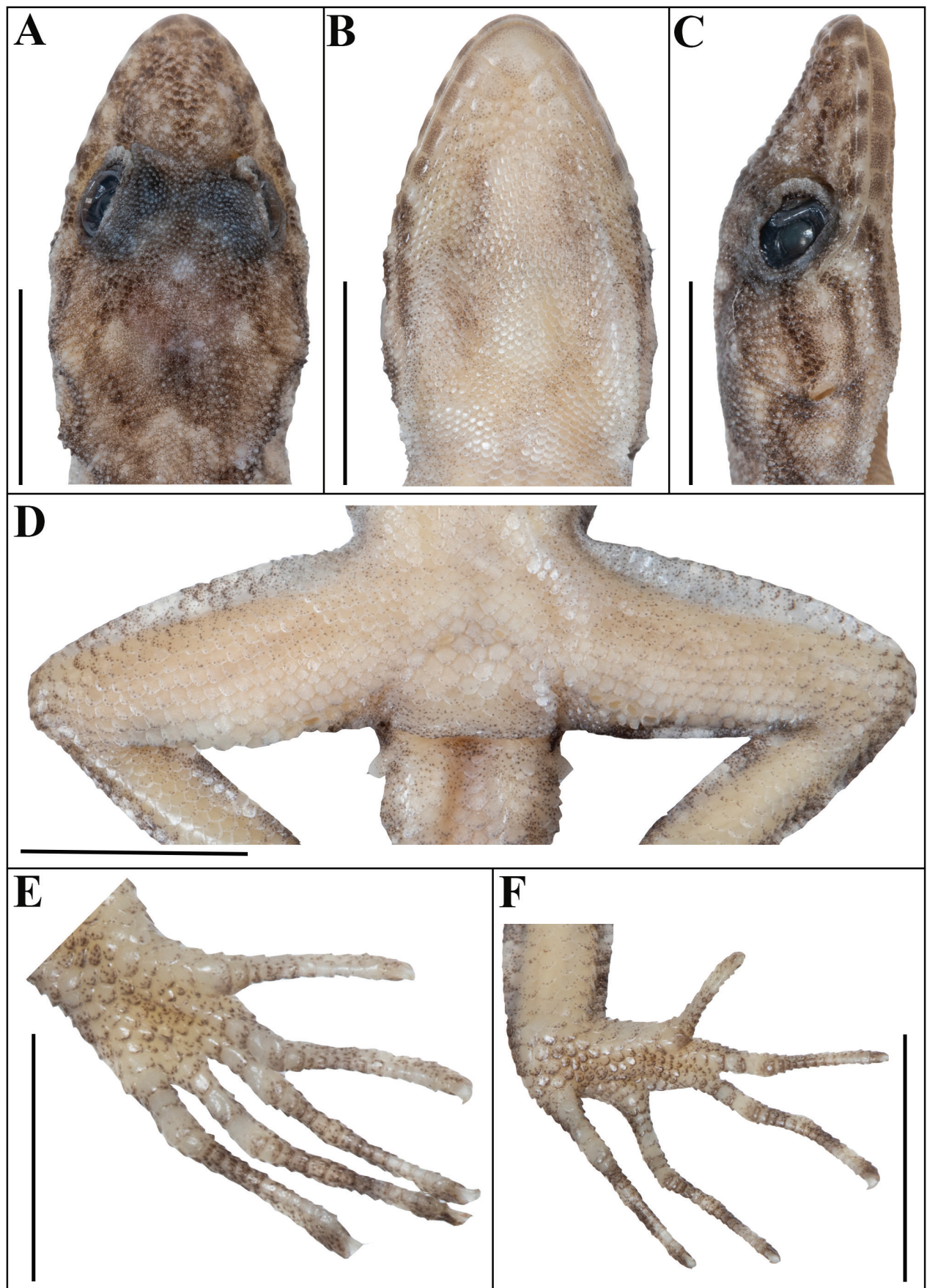
low by a row or two of slightly enlarged, much elongated scales, decreasing in size posteriorly. Ten supralabials up to angle of jaw and six at midorbital position on either side; supralabial I largest, rest of the series gradually decreasing in size posteriorly; eight infralabials up to angle of jaw and six at midorbital position on either side; infralabial I largest, gradually decreasing in size posteriorly (Fig. 4C).

Body relatively slender (BW/AGL 0.43), trunk less than half of SVL (AGL/SVL 0.38) without ventrolateral folds; short spine-like scales on flank present (Fig. 5A–C). Dorsal pholidosis heterogeneous; weakly keeled granular scales intermixed with irregularly arranged rows of enlarged, strongly keeled, conical tubercles; tubercles in approximately 12 longitudinal rows at mid-body including short spine-like scales at lower flank; tubercles in paravertebral rows irregular (Fig. 5A, C). Ventral scales much larger than granular scales on dorsum, smooth, subcircular, subimbricate, subequal from chest to vent; mid-body scale rows across belly 30; 109 scales from mental to anterior border of cloaca (Fig. 5B). Scales on base of neck similar to those on belly; gular region with much smaller, subequal, smooth, flattened scales, those bordering postmentals enlarged, smooth, subcircular, and more or less flattened (Fig. 4B). Five femoral pores on left thigh and four on right, separated by seven poreless scales on left and six on right side from two precloacal pores, precloacal pores separated medially by three poreless scales (Fig. 4D).

Scales on palms and soles small, smooth, rounded, and flattened; scales on dorsal aspects of limbs heterogeneous in shape and size; mixture of small granular, weakly keeled, imbricate scales that are twice the size of granules on body dorsum, largest on anterolateral aspect of hands and feet; scales on upper arm larger than lower; posterolateral aspect of limbs with small weakly keeled to smooth granular scales; ventral aspect of forelimbs with small, smooth, subimbricate scales, larger on lower arm than upper arm; ventral aspect of hindlimb with enlarged, smooth, flattened, subimbricate scales, slightly larger than body ventrals (Fig. 3A, B). Forelimbs and hindlimbs moderately long, slender (LAL/SVL 0.14; CL/SVL 0.19); digits long, with strong, recurved claw, distinctly inflected, distal portions laterally compressed conspicuously. Digits with unpaired lamellae, separated into a basal and narrower distal series by single enlarged lamella at inflection; basal lamellae series: (1-3-4-4-4 right manus, 1-4-5-8-5 right pes), (1-3-3-4-4 left manus, Fig. 4E; 1-4-5-8-5 left pes, Fig. 4F); distal lamellae series: (11-12-13-13-11 right manus, 11-12-14-14-14 right pes), (11-12-13-12-11 left manus, Fig. 4E; 11-12-14-14-14 left pes, Fig. 4F). Relative length of digits (measurements in mm in parentheses): IV (3.8) > III (3.5) > V (3.3) > II (3.1) > I (2.6) (left manus); IV (4.9) > V (4.2) = III (4.2) > II (3.7) > I (2.5) (left pes).

Tail original except tip (15.1 mm) which is regenerated, entire, subcylindrical, slender, slightly longer than snout-vent length (TL/SVL 1.28; Fig. 3C–E). Dorsal scales on tail base weakly keeled, granular, similar in size and shape to granular scales on mid-body dorsum,





**Figure 4.** *Cnemaspis salimalii* sp. nov. (holotype, NRC-AA-1204): **A** dorsal aspect of head; **B** ventral aspect of head; **C** lateral aspect of right side head; **D** aspect of cloacal region showing precloacal and femoral pores; **E** ventral aspect of left manus; **F** ventral aspect of left pes. Scale bars 5 mm; photos by Akshay Khandekar.

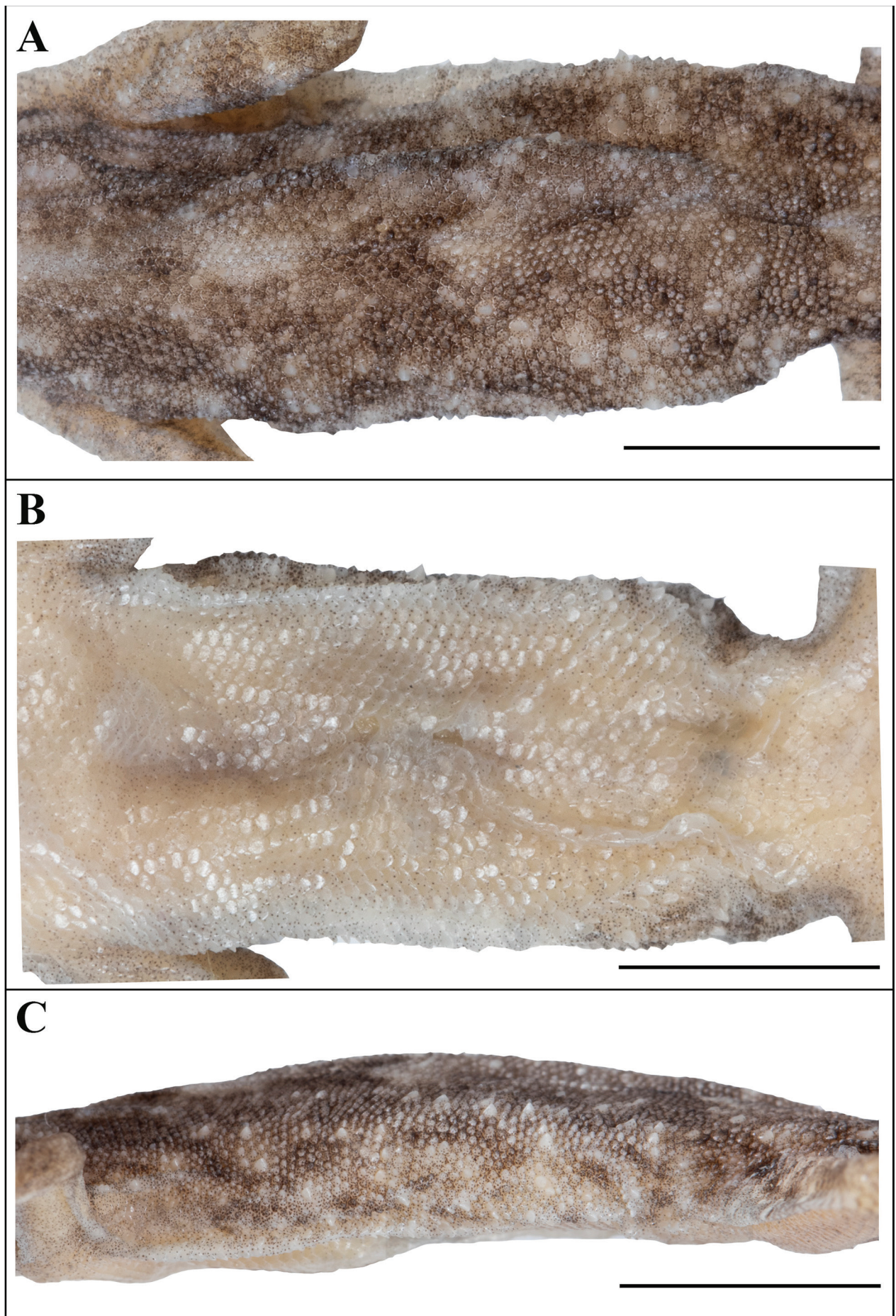


**Table 5.** Additional morphological character states evaluation for the type series of *Cnemaspis salimalii* sp. nov.. abs. = absent; / = data unavailable.

Types	Holotype	Paratypes							
Museum number	NRC-AA-1204	NRC-AA-1205	NRC-AA-1206	NRC-AA-1207	NRC-AA-1208	NRC-AA-1209	NRC-AA-1210	NRC-AA-1211	NRC-AA-1212
Sex	Male	Male	Male	Male	Male	Male	Female	Female	Male
Anterior extra-brillar fringe scales enlarged (1) or not enlarged (0)	1	1	1	1	1	1	1	1	1
Ventral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Gular scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Pectoral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Precloacal pores continuous (1) or separated (0)	0	0	0	0	0	0	abs.	abs.	0
Precloacal pores elongate (1) or round (0)	1	1	1	1	1	1	abs.	abs.	1
femoral pores elongate (1) or round (0)	1	1	1	1	0	1	abs.	abs.	1
Dorsal pholidosis homogeneous (1) or heterogeneous (0)	0	0	0	0	0	0	0	0	0
Dorsal tubercles keeled (1) or not keeled (0)	1	1	1	1	1	1	1	1	1
Tubercles linearly arranged (1) or more random (0)	0	0	0	0	0	0	0	0	0
Spine-like scales on flank present (1) or absent (0)	1	1	1	1	1	1	1	1	1
Lateral caudal furrows present (1) or absent (0)	1	/	/	1	1	1	1	1	1
Subcaudals keeled (1) or smooth (0)	0	/	/	0	0	0	0	0	0
Single median row of keeled subcaudals (1) or smooth (0)	0	/	/	0	0	0	0	0	0
Caudal tubercles encircle tail (1) or not (0)	1	/	/	1	1	1	1	1	1
Enlarged median subcaudal scale row (1) or not (0)	1	/	/	1	1	1	1	1	1
Enlarged femoral scales present (1) or absent (0)	0	1	0	1	1	1	1	0	1
Subtibial scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Occipital ocellus present (1) or absent (0)	0	0	0	0	1	1	1	0	1
Ocelli anterior of the shoulder present (1) or absent (0) & number	1 (1)	1 (1)	1 (1)	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Ocelli posterior of the shoulder present (1) or absent (0) & number	0	0	0	0	0	0	0	0	0
Original tail banded (1) or not (0)	1	/	/	1	1	1	1	1	1

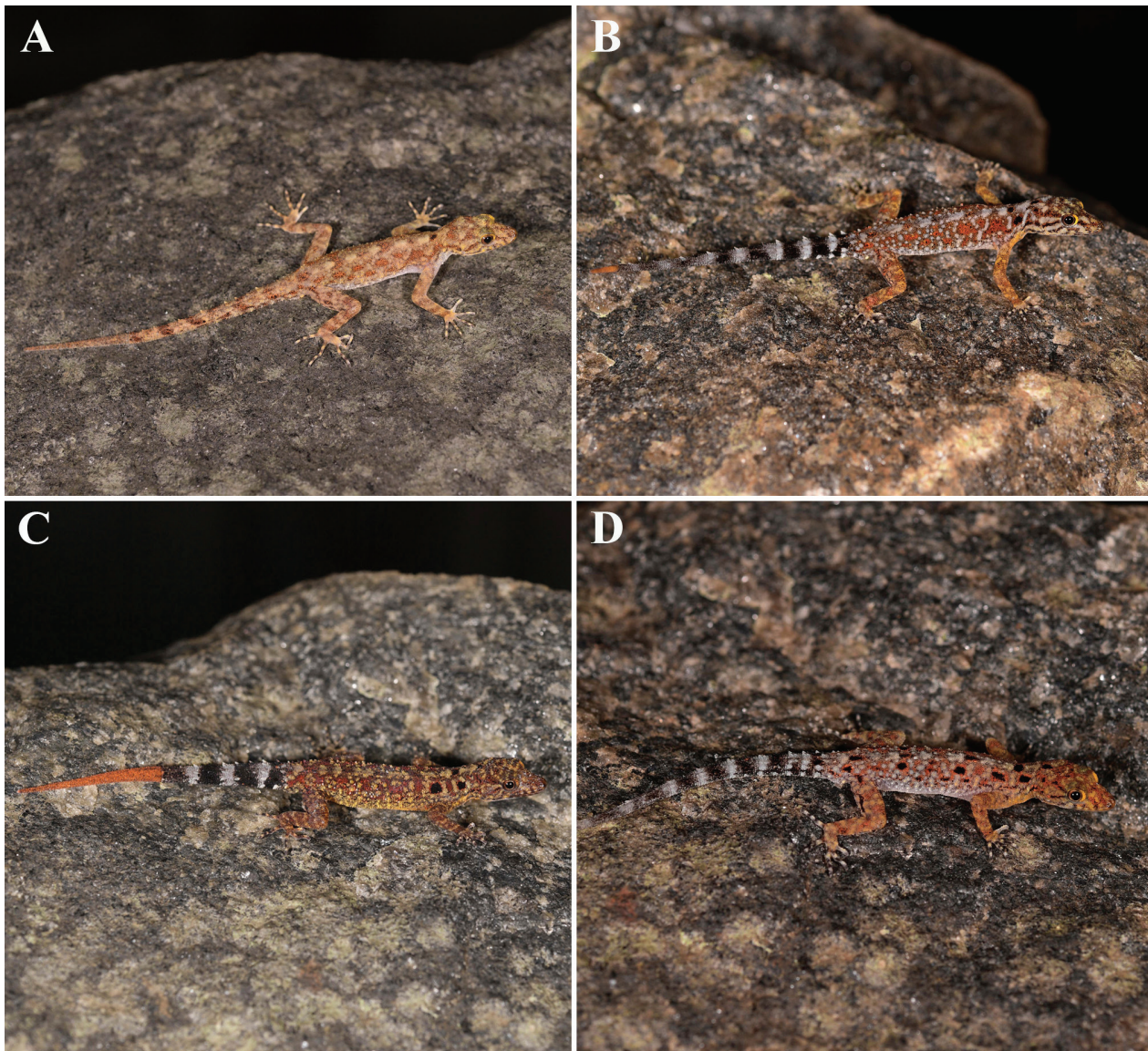
gradually becoming larger, flattened, imbricate posteriorly, intermixed with enlarged, strongly keeled, distinctly pointed, conical tubercles; enlarged tubercles on the tail forming whorls; six tubercles each on first eight whorls, four in whorls 9–11, only paravertebral tubercles in whorls 12–14, rest of tail tip regenerated (Fig. 3C, E).

Scales on ventral aspect of tail much larger than those on dorsal aspect, subimbricate, smooth; median series distinctly larger than rest, roughly pentagonal; scales on tail base slightly smaller than those on mid-body ventrals, smooth, imbricate; a single enlarged, smooth, and conical postcloacal spur on each side (Fig. 3D).



**Figure 5.** *Cnemaspis salimalii* sp. nov. (holotype, NRC-AA-1204): **A** dorsal aspect of mid-body; **B** ventral aspect of mid-body; **C** right side lateral aspect of mid-body. Scale bars 5 mm; photos by Akshay Khandekar.





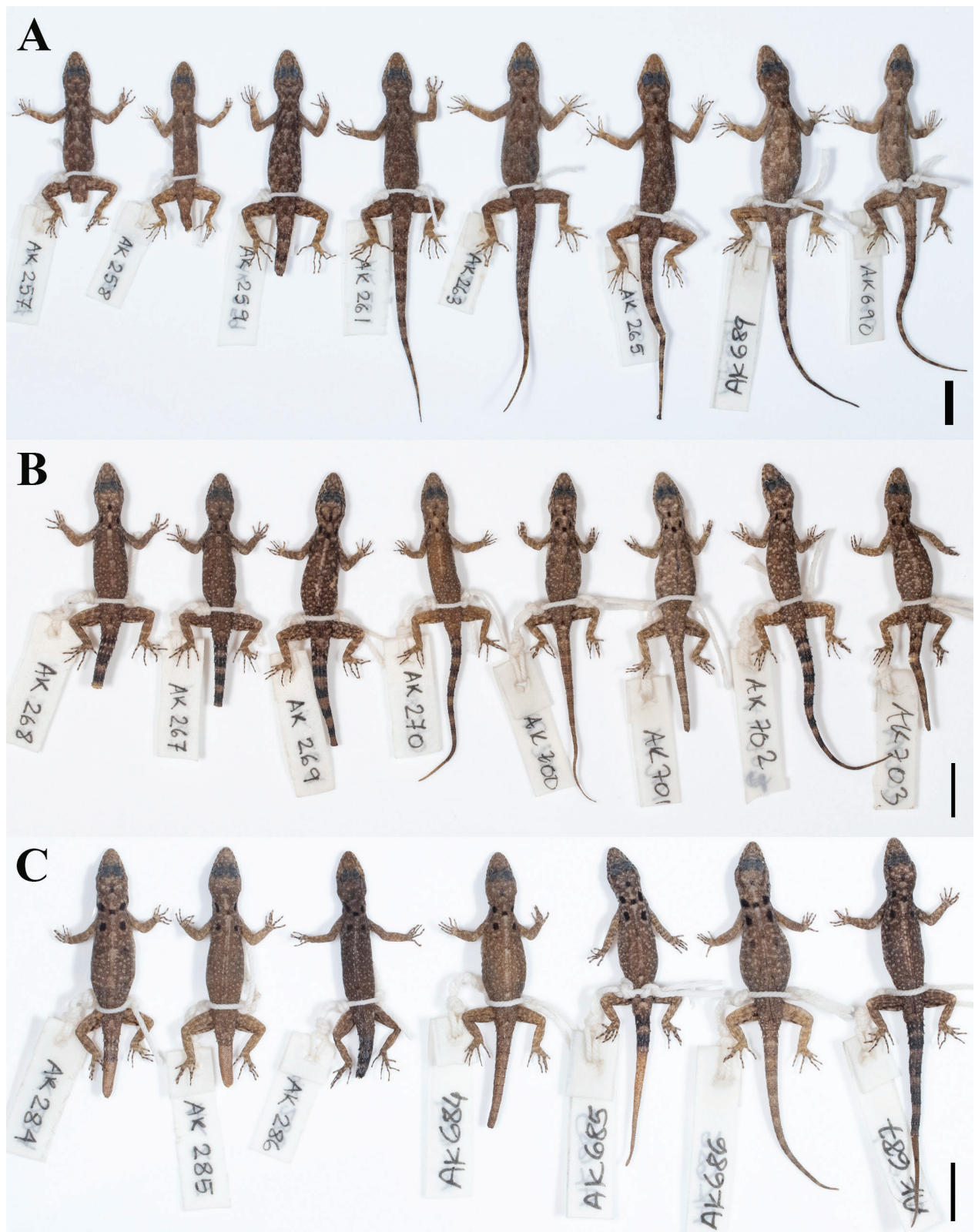
**Figure 6.** Colouration in life: **A** *Cnemaspis salimalii* **sp. nov.**, adult male (holotype, NRC-AA-1204); **B** *Cnemaspis agayagangai* **sp. nov.**, adult male (holotype, NRC-AA-1213); **C** *Cnemaspis fantastica* **sp. nov.**, adult male (holotype, NRC-AA-1222); **D** *Cnemaspis pachaimalaiensis* **sp. nov.**, adult male (holotype, NRC-AA-1230). Photos by Tejas Thackeray.

**Colouration in life (Fig. 6A).** Dorsum of head, body, limbs and tail base mottled light brown. Head with some orange blotches and alternating yellow and dark bands on labials. Two orangish-brown postorbital streaks terminating anterior to forelimb insertions and one suborbital streak extending onto throat. A single black ocellus with a margin of orangish scales on neck. Dorsum with five light tan vertebral blotches from neck to tail base, orangish-brown blotches interspersed with smaller yellowish-grey spots on rest of dorsum and flank. Dorsum of limbs more muted than back, digits with alternating dark and light bands. Tail with five indistinct dark brown bands with a brown regenerated tail tip. Venter off-white, with black speckles under limbs and throat.

**Variation and additional information from type series.** Mensural, meristic and additional character state data for the type series is given in Tables 1–3 respectively. There are four adult and two subadult males and two

adult females, ranging in size from 31.3–41.3 mm (Fig. 7A). All paratypes resemble the holotype except as follows: tubercles in paravertebral rows regular in all adult paratypes (condition not discernible in subadults), upper postmentals in contact with each other below mental in NRC-AA-1207, NRC-AA-1208, and NRC-AA-1212; upper postmentals bordered by mental, infralabial I, outer postmental, median chin shield and by a single large chin scale on either side in all paratypes except NRC-AA-1206 in which bordered by two chin scales on left and single on right side. Outer postmental bordered by inner postmental, infralabials I & II in all types except NRC-AA-1206, additionally, bordered by four chin scales on left and three on right side in NRC-AA-1209, four chin scales on left and five on right side in NRC-AA-1212, outer postmental bordered by inner postmental, infralabials II in NRC-AA-1206; outer postmental separated from each other medially by three enlarged chin scales in NRC-AA-1205, NRC-AA-1207, NRC-AA-1209, NRC-AA-1210, and



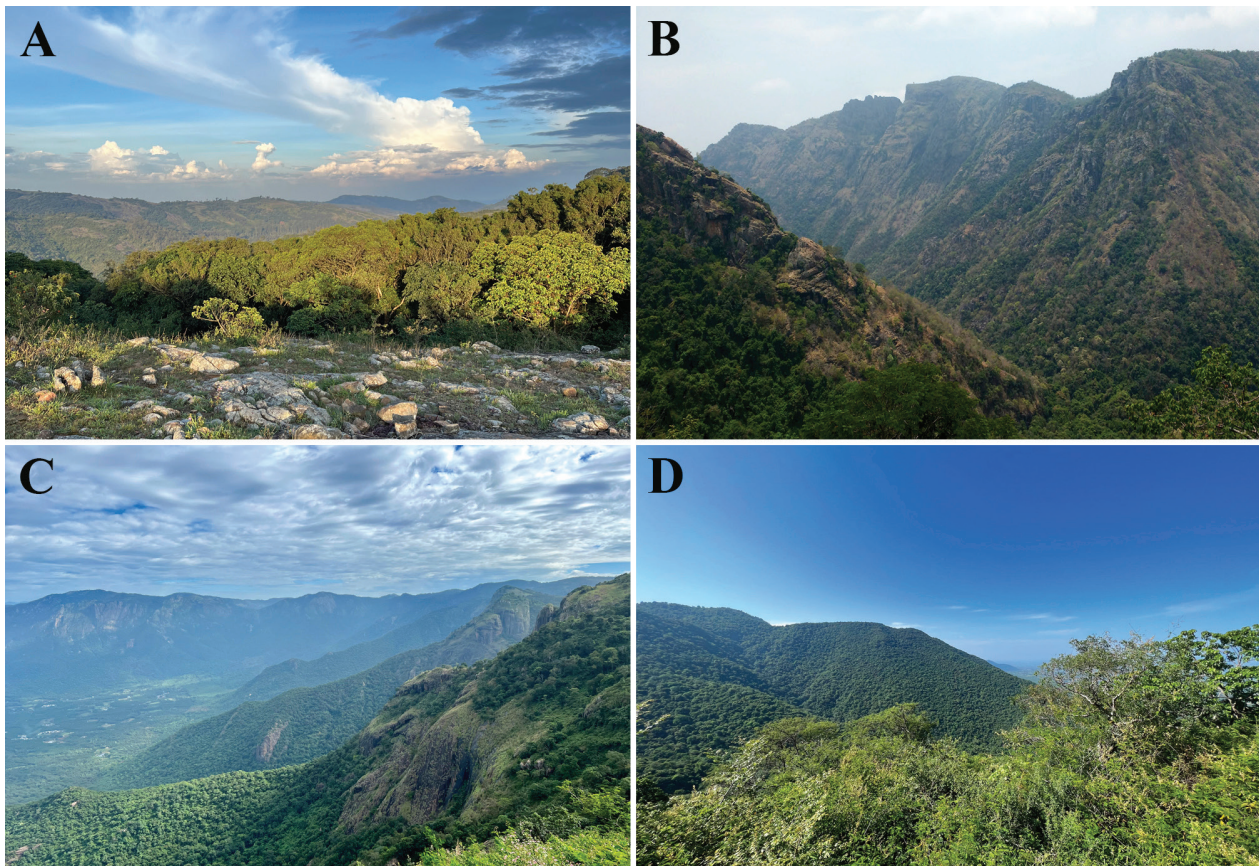


**Figure 7.** Paratype series: **A** *Cnemaspis salimalii* **sp. nov.**, from left to right, NRC-AA-1205–NRC-AA-1212; **B** *Cnemaspis agayagangai* **sp. nov.**, from left to right, NRC-AA-1214–NRC-AA-1221; **C** *Cnemaspis fantastica* **sp. nov.**, from left to right, NRC-AA-1223–NRC-AA-1229. Scale bar 10 mm; photos by Akshay Khandekar.

NRC-AA-1211. Five paratypes — NRC-AA-1208, NRC-AA-1209, NRC-AA-1210, NRC-AA-1211 and NRC-AA-1212 with original and complete tails, slightly longer than body except NRC-AA-1210 (TL/SVL 1.32, 1.29, 1.22 and 1.35 respectively), tail marginally longer than

body in NRC-AA-1210 (TL/SVL 1.09), tail mostly or completely missing in NRC-AA-1205, NRC-AA-1206, and NRC-AA-1207; original tail faintly banded in all paratypes (Fig. 7A).





**Figure 8.** Habitats of the new species in the vicinity of the type localities: **A** *Cnemaspis salimalii* **sp. nov.**; **B** *Cnemaspis agayagan-gai* **sp. nov.**; **C** *Cnemaspis fantastica* **sp. nov.**; **D** *Cnemaspis pachaimalaiensis* **sp. nov.** Photos by Akshay Khandekar.

**Distribution and Natural history.** *Cnemaspis salimalii* **sp. nov.** is currently known only from around its type locality (from vicinity of Nallathambi resort, Semmedu, Kolli Hills, ca. 1100–1300 m asl.) in Namakkal district, Tamil Nadu (Fig. 1). The new species seems to be diurnal, scansorial, and locally abundant. At collection sites, many individuals ( $n = >30$ ) were observed active during the daytime (0900–1230 hrs) on old mossy walls and tree trunks below 2 m height in moist evergreen forest patches (Fig. 8A). Individuals of the new species were observed in large numbers inactive during the night, resting on mossy walls and cement culverts along the road inside Semmedu village and Nallathambi Resort. Sympatric geckos encountered on trees and mossy walls at the locality include *Cnemaspis yercaudensis* Bauer & Das, *Hemidactylus parvimaclatus* Deraniyagala, *Hemidactylus* cf. *frenatus*, and *Hemiphyllodactylus kolliensis* Agarwal, Khandekar, Giri, Ramakrishnan & Karanth.

### *Cnemaspis agayagan-gai* **sp. nov.**

<https://zoobank.org/9823a5eb-1de2-402e-92ae-b9b0cbbbfaeb>

Figs 9–11, 6B, 7B, 8B; Tables 6–8

**Holotype.** NRC-AA-1213 (AK 699), adult male, near Agaya Gangai waterfalls (11.2640°N, 78.3925°E; ca. 860 m asl.), Kolli hills, Namakkal district, Tamil Nadu

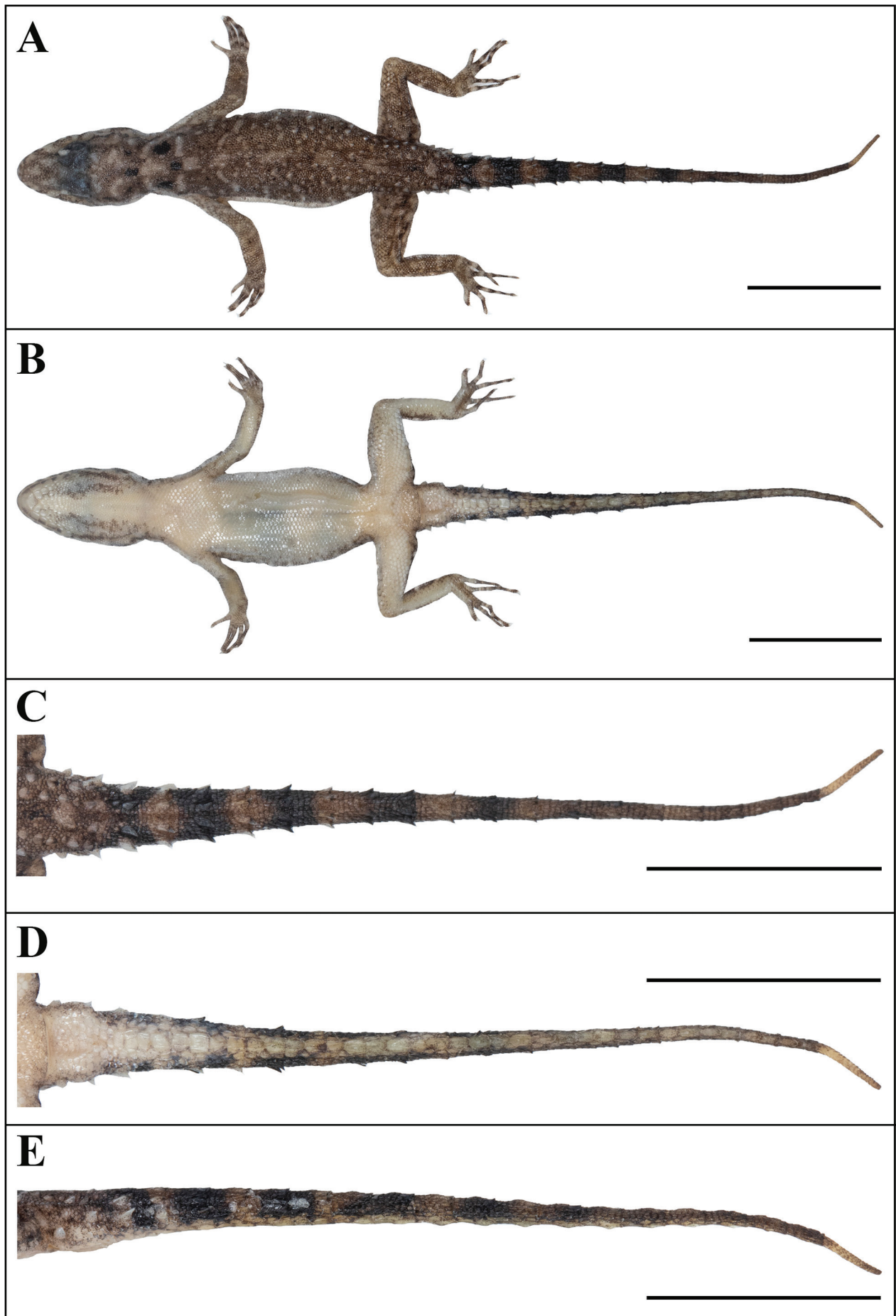
state, India; collected by Akshay Khandekar, Swapnil Pawar, and Tejas Thackeray on 29<sup>th</sup> May 2019.

**Paratypes.** NRC-AA-1215 (AK 267), NRC-AA-1214 (AK 268), adult males, same collection data as holotype; NRC-AA-1216 (AK 269), NRC-AA-1217 (AK 270) adult males, NRC-AA-1218 (AK 700), adult female, from near Arappaleeswarar temple (11.2645°N, 78.3906°E; ca. 940 m asl.); and NRC-AA-1220 (AK 702), adult male, NRC-AA-1219 (AK 701), NRC-AA-1221 (AK 703) adult females, from near Agaya Gangai waterfalls (11.2656°N, 78.3943°E; ca. 780 m asl.), collected by Akshay Khandekar, Ishan Agarwal, Nikhil Gaitonde on 20<sup>th</sup> December 2018.

**Etymology.** The specific epithet is for the type locality of the new species, the Agaya Gangai Waterfalls, and is used as a noun in apposition.

**Suggested Common Name.** Agaya Gangai dwarf gecko.

**Diagnosis.** A small-sized *Cnemaspis*, snout to vent length up to 31.8 mm ( $n = 9$ ). Dorsal pholidosis heterogeneous; weakly keeled granular scales intermixed with a fairly regularly arranged rows of enlarged, strongly keeled, conical tubercles; last one or two rows of enlarged tubercles on flank weakly keeled, spine-like; 10–12 rows of dorsal tubercles at mid-body, 14–18 tubercles in paravertebral rows; ventral scales smooth, subcircular, subimbricate,



**Figure 9.** *Cnemaspis agayagangai* sp. nov. (holotype, NRC-AA-1213): **A** dorsal aspect of body; **B** ventral aspect of body; **C** dorsal aspect of tail; **D** ventral aspect of tail; **E** lateral aspect of tail. Scale bars 10 mm; photos by Akshay Khandekar.

**Table 6.** Mensural (mm) data for the type series of *Cnemaspis agayagangai* **sp. nov.**. Abbreviations are listed in Materials and Methods. \* = incomplete tail.

Type	Holotype	Paratypes							
museum number	NRC-AA-1213	NRC-AA-1215	NRC-AA-1214	NRC-AA-1216	NRC-AA-1217	NRC-AA-1218	NRC-AA-1219	NRC-AA-1220	NRC-AA-1221
Sex	M	M	M	M	M	F	F	M	F
SVL	31.2	30.0	30.2	31.8	29.3	29.8	31.7	31.5	30.4
TL	37.0	14.9*	12.2*	20.6*	34.0	36.5	19.0*	41.1	21.3
TW	3.0	3.2	3.1	2.7	2.7	2.9	2.4	3.0	2.6
LAL	4.7	4.4	4.6	5.0	4.0	3.8	4.2	4.3	4.2
CL	5.6	5.5	5.6	5.7	5.1	4.9	4.9	5.4	4.8
AGL	12.6	12.4	12	12.7	11.8	12.4	12.8	12.2	12.3
BH	3.2	3.4	3.2	3.2	3.2	3.3	3.2	3.2	3.6
BW	6.5	5.5	6.0	5.8	5.1	5.6	7.1	5.3	6.2
HL	8.0	7.3	7.7	8.0	7.3	7.0	7.5	7.6	7.6
HW	5.4	4.9	5.1	5.0	4.8	4.8	4.9	5.0	4.8
HD	3.8	3.4	3.2	3.3	3.0	3.3	3.4	4.0	3.1
ED	1.7	1.6	1.6	1.8	1.6	1.5	1.7	1.8	1.6
EE	2.4	2.4	2.5	2.5	2.1	2.3	2.7	2.5	2.5
ES	4.0	3.8	3.9	3.9	3.6	3.6	3.6	4.0	3.9
EN	3.2	3.0	3.2	3.2	3.6	3.0	3.1	3.2	3.1
IN	1.0	1.0	0.9	1.0	0.9	0.9	1.0	0.9	1.0
IO	1.1	1.2	1.2	1.1	1.0	1.0	1.0	1.3	1.1
EL	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.4

**Table 7.** Meristic data for the type series of *Cnemaspis agayagangai* **sp. nov.**. Abbreviations are listed in Materials and Methods except for: L&R = Left & Right; abs. = absent; \* = paravertebral tubercles and lamellae incomplete; / = not available.

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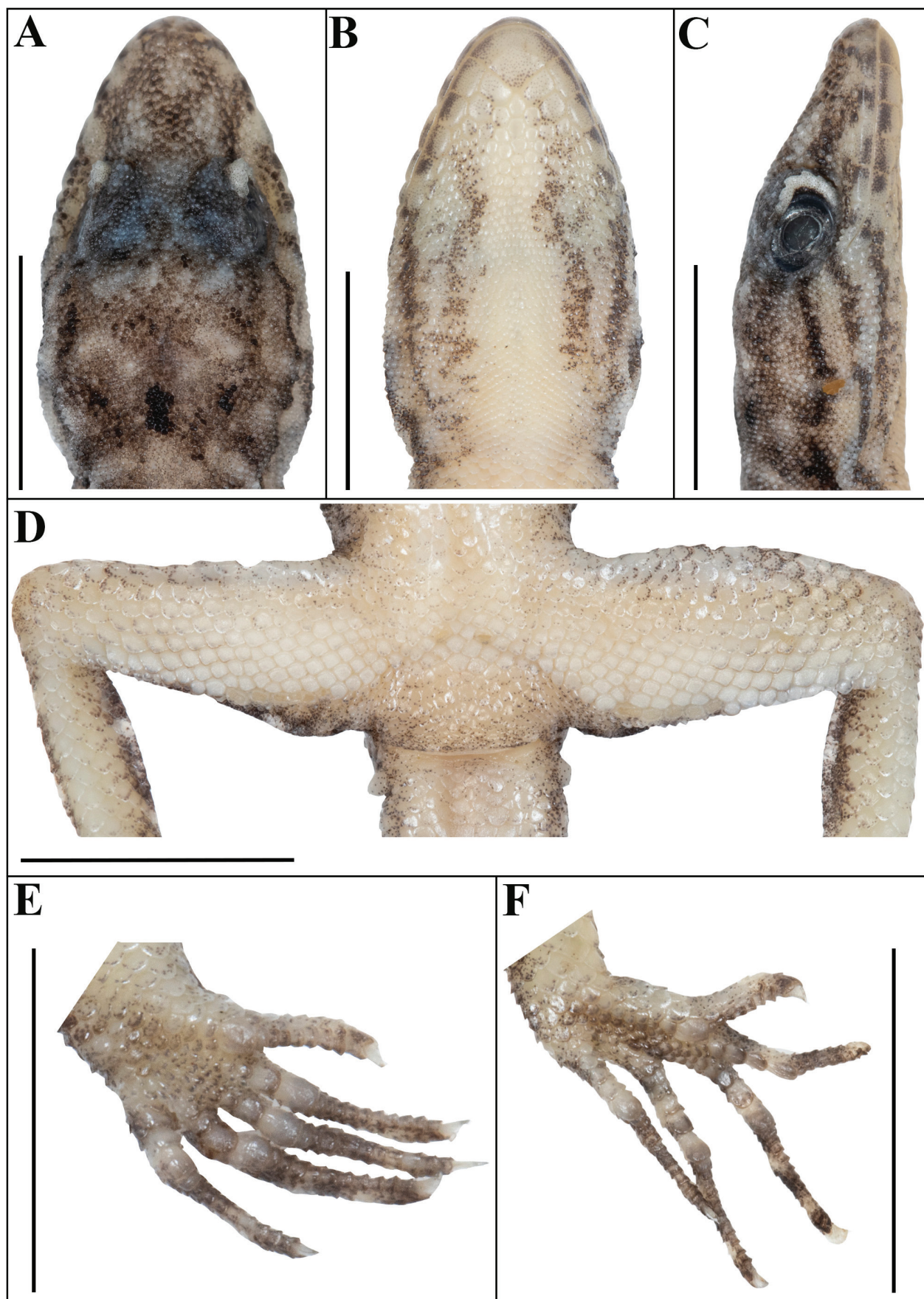
subequal from chest to vent, 28–34 scales across belly at mid-body, 106–120 longitudinal scales from mental to cloaca; subdigital scensors smooth, unpaired, unnotched; 9–11 lamellae under digit I of manus and 9–12 lamellae under digit I of pes; 14–16 lamellae under digit IV of manus and 17–20 lamellae under digit IV of pes; males ( $n = 6/9$ ) with four or five femoral pores on each thigh separated by 8–10 poreless scales from series of two precloacal pores, precloacal pores separated medially by single (rarely 2,  $n = 1/6$ ) poreless scales; tail with enlarged, strongly keeled, pointed, and spine-like tubercles forming whorls; median row of subcaudals smooth, roughly rectangular, and distinctly enlarged. Dorsum orange, mottled with numerous small light grey spots and fine black spots, light grey vertebral blotches sometimes distinct; a single central black dorsal ocellus each on neck and occiput separated by a light grey blotch, ocellus on neck flanked anteriorly on each side by a slightly larger ocellus, ocellus on occiput sometimes flanked on each side by smaller, indistinct ocellus; venter off-white with black speckles, two indistinct pairs of streaks on throat; original tail in males with about 8–10 alternating dark and light grey bands, regenerated tail orange-brown.

**Comparison with members of *C. gracilis* clade.** *Cnemaspis agayagangai* **sp. nov.** is a member of the *gracilis* clade and can be easily distinguished from all members of the clade by a combination of the following differing or non-overlapping characters: small-sized *Cnemaspis* with maximum SVL 32 mm (versus medium-sized *Cnemaspis*, SVL up to 41 mm in *C. thackerayi*, and *C. salimalii* **sp. nov.**); 14–18 tubercles in paravertebral rows (versus only a few irregularly arranged tubercles in paravertebral region in *C. mundanthuraiensis*, 10–14 in *C. gracilis*; 11 or 12 in *C. jackieii*);

10–12 rows of dorsal tubercles at mid-body (versus eight or nine rows of dorsal tubercles at mid-body in *C. jackieii*, 6–8 rows of dorsal tubercles at mid-body in *C. mundanthuraiensis*); spine-like tubercles present on flanks (versus spine-like tubercles absent on flanks in *C. agarwali*, *C. jackieii*, *C. shevaroyensis*, and *C. thackerayi*); 28–34 ventral scales across belly at mid-body (versus 24–26 ventral scales across belly at mid-body in *C. agarwali*, 21–24 in *C. shevaroyensis*, and 22–25 in *C. thackerayi*); a single central dorsal ocellus each on occiput and neck, ocellus on neck flanked anteriorly on each side by a slightly larger ocellus (versus a single central dorsal ocellus each on occiput and neck in *C. gracilis*, *C. mundanthuraiensis*, *C. thackerayi*; single dorsal ocellus on occiput absent, single dorsal ocellus on neck present in *C. salimalii* **sp. nov.**; a single dorsal ocellus each on occiput and neck, a smaller pair on either side just anterior to forelimb insertion in *C. jackieii*; a single dorsal ocellus each on occiput and neck, two pairs on either side just anterior and posterior to forelimb insertions in *C. shevaroyensis*). *Cnemaspis agayagangai* **sp. nov.** is diagnosed against *Cnemaspis fantastica* **sp. nov.**, *Cnemaspis pachaimalaiensis* **sp. nov.**, and *Cnemaspis rudhira* **sp. nov.** as part of their respective descriptions below.

**Description of the holotype.** Adult male in good state of preservation except regenerated portion of the tail tip slightly bent towards right, small skin injury left of sternum, and claw on 2<sup>nd</sup> digit of left foot missing (Fig. 9A–E). SVL 31.2 mm, head short (HL/SVL 0.25), wide (HW/HL 0.67), not strongly depressed (HD/HL 0.47), distinct from neck. Loreal region marginally inflated, canthus rostralis not distinct. Snout half of head length (ES/HL 0.50), almost 2.5 times eye diameter (ES/ED 2.35); scales on snout and canthus rostralis subcircular, subequal, smooth anteriorly, becoming weakly keeled, and conical posteriorly; and much larger than those on forehead and interorbital region; scales on forehead similar to those on snout and canthus rostralis except smaller, elongated, and weakly conical; scales on interorbital region even smaller, granular and weakly keeled; scales on occipital and temporal region heterogeneous, slightly enlarged, weakly keeled, conical tubercles intermixed with smaller, weakly keeled and weakly conical granular scales (Fig. 10A). Eye small (ED/HL 0.21) with round pupil; supraciliaries short, larger anteriorly; six interorbital scale rows across narrowest point of frontal bone; 27 or 28 scale rows between left and right supraciliaries at mid-orbit (Fig. 10A, C). Ear-opening deep, oval, small (EL/HL 0.05); eye to ear distance greater than diameter of eye (EE/ED 1.41) (Fig. 10C). Rostral 2× wider (1.60 mm) than high (0.80 mm), incompletely divided dorsally by a strongly developed rostral groove and internasal scale for more than half of its height; a single enlarged supranasal on each side, slightly larger than postnasals, separated from each other by a much smaller, elongated internasal scale and still smaller scale on snout; two postnasals, upper postnasal marginally larger than lower; rostral in contact with supralabial I, nostril, supranasal, and lower postnasal on either side; nostrils oval, surrounded by two postnasals, supranasal, and rostral on either side; two rows of scales separate orbit from supralabials (Fig. 10C). Mental enlarged, subtriangular, slightly wider (1.90 mm) than high (1.52 mm); two pairs of postmentals, inner pair roughly pentagonal, much shorter (0.80 mm) than mental, separated from each other below mental by a single enlarged median chin shield; inner pair bordered by mental, infralabial I, outer postmental, enlarged median chin shield and an enlarged chin shield on either side; outer postmentals roughly rectangular, even smaller (0.62 mm) than inner pair, bordered by inner postmentals, infralabial I and II, and three enlarged chin shields on either side; three enlarged gular scales between left and right outer postmentals; all chin scales bordering postmentals flat, subcircular, smooth, and smaller than outermost postmentals; scales on rest of throat, small, subequal, and smooth (Fig. 10B). Infralabials bordered below by a row or two of slightly enlarged, much elongated scales, decreasing in size posteriorly. Ten supralabials up to angle of jaw and six at midorbital position on either side; supralabial I largest, rest of the series gradually decreasing in size posteriorly; nine infralabials up to angle of jaw on left and 10 on right, five at midorbital position on either side; infralabial I largest, gradually decreasing in size posteriorly (Fig. 10C).





**Figure 10.** *Cnemaspis agayagangai* sp. nov. (holotype, NRC-AA-1213): **A** dorsal aspect of head; **B** ventral aspect of head; **C** lateral aspect of right side head; **D** aspect of cloacal region showing precloacal and femoral pores; **E** ventral aspect of left manus; **F** ventral aspect of left pes. Scale bars 5 mm; photos by Akshay Khandekar.

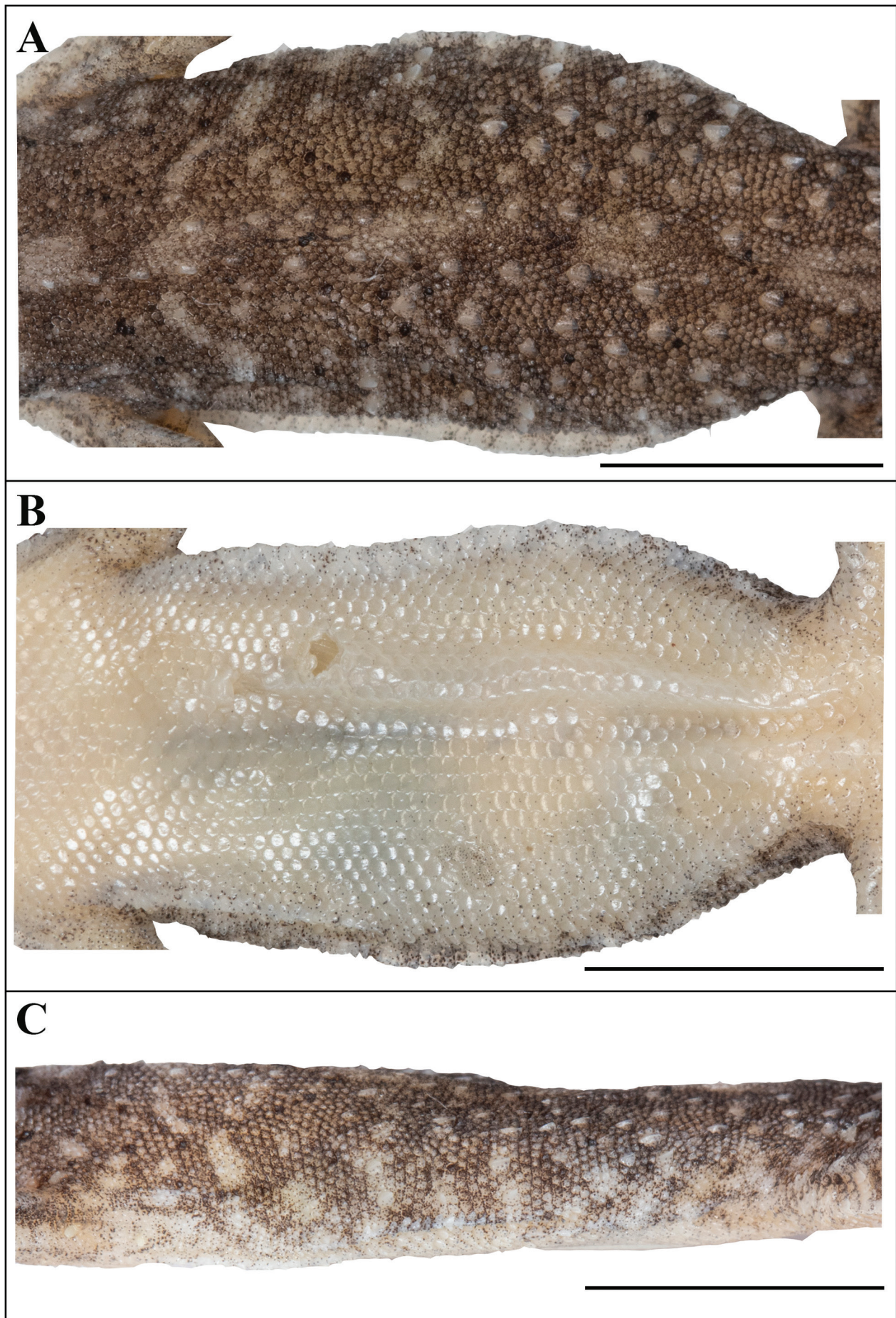
**Table 8.** Additional morphological character states evaluation for the type series of *Cnemaspis agayagangai* **sp. nov.**. abs. = absent; / = data unavailable.

Types	Holotype	Paratypes							
Museum number	NRC-AA-1213	NRC-AA-1215	NRC-AA-1214	NRC-AA-1216	NRC-AA-1217	NRC-AA-1218	NRC-AA-1219	NRC-AA-1220	NRC-AA-1221
Sex	M	M	M	M	M	F	F	M	F
Anterior extra-brillar fringe scales enlarged (1) or not enlarged (0)	1	1	1	1	1	1	1	1	1
Ventral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Gular scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Pectoral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Precloacal pores continuous (1) or separated (0)	0	0	0	0	1	abs.	abs.	0	abs.
Precloacal pores elongate (1) or round (0)	1	1	1	1	1	abs.	abs.	1	abs.
femoral pores elongate (1) or round (0)	1	1	1	1	1	abs.	abs.	1	abs.
Dorsal pholidosis homogeneous (1) or heterogeneous (0)	0	0	0	0	0	0	0	0	0
Dorsal tubercles keeled (1) or not keeled (0)	1	1	1	1	1	1	1	1	1
Tubercles linearly arranged (1) or more random (0)	1	1	1	1	1	1	1	1	1
Spine-like scales on flank present (1) or absent (0)	1	1	1	1	1	1	1	1	1
Lateral caudal furrows present (1) or absent (0)	1	1	1	1	1	1	1	1	1
Subcaudals keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Single median row of keeled subcaudals (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Caudal tubercles encircle tail (1) or not (0)	1	1	1	1	1	1	1	1	1
Enlarged median subcaudal scale row (1) or not (0)	1	1	1	1	1	1	1	1	1
Enlarged femoral scales present (1) or absent (0)	1	1	1	1	1	1	0	1	1
Subtibial scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0
Occipital ocellus present (1) or absent (0)	1	1	1	1	1	1	1	1	1
Ocelli anterior of the shoulder present (1) or absent (0) & number	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)
Ocelli posterior of the shoulder present (1) or absent (0) & number	0	0	0	0	0	0	0	0	0
Original tail banded (1) or not (0)	1	1	1	1	1	1	1	1	1

Body relatively slender (BW/AGL 0.51), trunk less than half of SVL (AGL/SVL 0.40) without ventrolateral folds; spine-like scales on flank present (Fig. 11A–C). Dorsal pholidosis heterogeneous; weakly keeled granular scales intermixed with a fairly regularly arranged row of enlarged, strongly keeled, conical tubercles; tubercles

in approximately 10 longitudinal rows at mid-body including spine-like scales at lower flank; 15 (left) and 14 (right) tubercles in paravertebral row from above forelimb insertion to the hind limb insertion (Fig. 11A, C). Ventral scales much larger than granular scales on dorsum smooth, subcircular, subimbricate, subequal from





**Figure 11.** *Cnemaspis agayagangai* sp. nov. (holotype, NRC-AA-1213): **A** dorsal aspect of mid-body; **B** ventral aspect of mid-body; **C** right side lateral aspect of mid-body. Scale bars 5 mm; photos by Akshay Khandekar.



chest to vent; mid-body scale rows across belly 32; 110 scales from mental to anterior border of cloaca (Fig. 11B). Scales on base of neck similar to those on belly, marginally smaller; gular region with still smaller, subequal, smooth, flattened scales, those bordering postmentals enlarged, smooth, subcircular, and flattened (Fig. 10B). Five femoral pores on either thigh, separated by eight poreless on either side from two precloacal pores, precloacal pores separated medially by two poreless scales (Fig. 10D).

Scales on palms and soles granular, smooth, rounded, and flattened; scales on dorsal aspects of limbs heterogeneous in shape and size; mixture of small granular, weakly keeled, imbricate scales which are twice the size of granules on the body dorsum, largest on anterolateral aspect of the hands and feet; posterolateral aspect of limbs with small weakly keeled to smooth granular scales; ventral aspect of forelimbs with small, smooth, subimbricate scales, larger on lower arm than upper arm; ventral aspect of hindlimb with enlarged, smooth, flattened, subimbricate scales, slightly larger than body ventrals (Fig. 9A, B). Forelimbs and hindlimbs moderately long, slender (LAL/SVL 0.15; CL/SVL 0.17); digits long, with strong, recurved claw, distinctly inflected, distal portions laterally compressed conspicuously. Digits with unpaired lamellae, separated into a basal and narrower distal series by single enlarged lamella at inflection; basal lamellae series: (1-3-3-4-3 right manus, 2-4-4-7-5 right pes), (1-3-3-4-3 left manus, Fig. 10E; 2-4-5-7-5 left pes, Fig. 10F); distal lamellae series: (8-9-10-11-9 right manus, 8-10-12-12-11 right pes), (8-10-11-10-9 left manus, Fig. 10E; 8-8\*-12-12-12 left pes, Fig. 10F). Relative length of digits (measurements in mm in parentheses): IV (2.8) = III (2.8) > II (2.6) > V (2.3) > I (1.8) (left manus); IV (3.6) > V (3.1) > III (3.0) > II (2.3\*) > I (1.9) (left pes).

Tail original except tip (3.1 mm) which is regenerated, entire, subcylindrical, slender, marginally longer than snout-vent length (TL/SVL 1.18; Fig. 9C–E). Dorsal scales on tail base weakly keeled, granular, similar in size and shape to granular scales on mid-body dorsum, gradually becoming larger, flattened, imbricate posteriorly, intermixed with enlarged, strongly keeled, distinctly pointed, conical tubercles; enlarged tubercles on the tail forming whorls; six tubercles each on first six whorls, four in 7–11<sup>th</sup> whorls, rest of the tail with only paravertebral tubercles (Fig. 9C, E). Scales on ventral aspect of tail much larger than those on dorsal aspect, subimbricate, smooth; median series distinctly larger than rest, roughly rectangular; scales on tail base slightly smaller than those on mid-body ventrals, smooth, imbricate; a single enlarged, weakly keeled and conical postcloacal spur on each side (Fig. 9D).

**Colouration in life (Fig. 6B).** Dorsum of head, body, and tail base orange, limbs brown. Head with numerous light grey blotches and some black spots, light grey and dark bands on labials. Two dark postorbital streaks flanked by slightly broader light grey streaks terminating anterior to forelimb insertion. A single central black dorsal

ocellus on neck and one on occiput separated by a larger light grey blotch, ocellus on neck flanked anteriorly on each side by a slightly larger ocellus, ocellus on occiput flanked one each side by a smaller ocellus; all ocelli with a fine orange margin. Dorsum with six light grey vertebral blotches from forelimb insertions to tail base, interspersed with smaller light-grey spots (sometimes forming streaks) and fine black spots on rest of dorsum and flank. Dorsum of limbs more muted than back, digits with alternating dark and light bands. Tail with seven or eight alternating light grey and black bands with an orange regenerated tip. Venter off-white with black speckles, two indistinct pairs of streaks on throat.

**Variation and additional information from type series.** Mensural, meristic and additional character state data for the type series is given in Tables 6–8 respectively. There are five adult male and three adult female specimens ranging in size from 29.3–31.8 mm (Fig. 7B). All paratypes resemble holotype except as follows: internasals absent, supranasals in strong contact with each other on snout in NRC-AA-1215, NRC-AA-1216, and NRC-AA-1220. Upper postmentals in contact with each other below mental in NRC-AA-1215, NRC-AA-1214, NRC-AA-1216, NRC-AA-1220, and NRC-AA-1221; upper postmentals bordered by mental, infralabial I, outer postmental, median chin shield, and by a single large chin scale on left side in NRC-AA-1219. Outer postmental bordered by inner postmental, infralabials I & II in all types, additionally, four chin scales on either side in NRC-AA-1216, four chin scales on left side in NRC-AA-1217, NRC-AA-1219, four chin scales on right side in NRC-AA-1218, NRC-AA-1220, and four chin scales on left and five on right side in NRC-AA-1221; outer postmental separated from each other medially by two enlarged chin scales in NRC-AA-1219. Three paratypes — NRC-AA-1217, NRC-AA-1218, and NRC-AA-1220 with original and complete tails, slightly longer than body (TL/SVL 1.16, 1.22, and 1.30 respectively); rest of the paratypes with original but incomplete tails. Original tail distinctly banded in all male paratypes and faintly banded in female paratypes, vertebral blotches not always distinct (Fig. 7B).

**Distribution and Natural history.** *Cnemaspis agaya-agangai* **sp. nov.** is currently known only from around its type locality (from Agaya Gangai waterfalls, Kolli hills, ca. 700–1000 m asl.) in Namakkal district, Tamil Nadu (Fig. 1). The new species was observed to be diurnal, rupicolous, and locally abundant. At collection sites, many individuals ( $n = >30$ ) were observed active during the daytime (0900–1430 hrs) on rocks and cement walls below 2 m height in moist deciduous to semi evergreen forest patches (Fig. 8B). Individuals of the new species were observed in great numbers across the elevation gradient, along the path to the Agaya Gangai waterfalls. Sympatric geckos encountered at the locality include *Cnemaspis yercaudensis*, *Hemidactylus* cf. *graniticolus*, *Hemidactylus leschenaultii* Duméril & Bibron, *Hemidactylus parvimaculatus*, and *Hemidactylus* cf. *frenatus*.

***Cnemaspis fantastica* sp. nov.**

<https://zoobank.org/c54dcb71-2502-4a8c-924a-072d64fd9fc3>

Figs 12–14, 6C, 7C, 8C; Tables 9–11

**Holotype.** NRC-AA-1222 (AK 688), adult male, near Tree view point, (11.3192°N, 78.3460°E; ca. 1060 m asl.), Kolli Hills, Solakkadu, Namakkal district, Tamil Nadu state, India; collected by Akshay Khandekar, Swapnil Pawar, and Tejas Thackeray on 28<sup>th</sup> May 2019.

**Paratypes.** NRC-AA-1224 (AK 285), NRC-AA-1225 (AK 286), adult males, same locality data as holotype; NRC-AA-1223 (AK 284), NRC-AA-1226 (AK 684), adult females (11.3240°N, 78.3419°E; ca. 800 m asl.), Kolli Hills; and NRC-AA-1227 (AK 685), NRC-AA-1229 (AK 687), adult males, NRC-AA-1228 (AK 686), adult female (11.3270°N, 78.3392°E; ca. 600 m asl.) Kolli Hills collected by Akshay Khandekar, Ishan Agarwal, Nikhil Gaitonde, on 20<sup>th</sup> December 2018.

**Etymology.** The specific epithet is derived from the Greek phantastikós, alluding to the spectacular colouration of the new species.

**Suggested Common Name.** Fantastic dwarf gecko.

**Diagnosis.** A small-sized *Cnemaspis*, snout to vent length up to 32.5 mm ( $n = 8$ ). Dorsal pholidosis heterogeneous; weakly keeled granular scales intermixed with a fairly regularly arranged rows of enlarged, strongly keeled, conical tubercles; last one or two rows of enlarged tubercles on flank weakly keeled, spine-like; 11–13 rows of dorsal tubercles at mid-body, 15–17 tubercles in paravertebral rows; ventral scales smooth, subcircular, subimbricate, subequal from chest to vent, 28–32 scales across belly at mid-body, 110–120 longitudinal scales from mental to cloaca; subdigital scensors smooth, unpaired, unnotched; 8–10 lamellae under digit I of manus and pes, 14–16 lamellae under digit IV of manus and 16–20 lamellae under digit IV of pes; males with four or five femoral pores on each thigh separated by 7–9 poreless scales from series of 2–4 precloacal pores, precloacal pores separated medially by one or two poreless scales; tail with enlarged, strongly keeled, pointed, and spine-like tubercles forming whorls; median row of subcaudals smooth, roughly pentagonal, and distinctly enlarged. Dorsum reddish, mottled with numerous small yellow spots some of which form an indistinct vertebral line; a single central ocellus on neck, flanked posteriorly by a pair of much larger squarish blotches and anteriorly by a pair of subequal squarish blotches, indistinct spot on occiput; venter off-white with black speckles, two distinct pairs of black streaks on throat; throat off-white with two pairs of black streaks; original tail in males with 8–9 alternating dark and light grey bands, regenerated tail orange.

**Comparison with members of *C. gracilis* clade.** *Cnemaspis fantastica* sp. nov. is a member of the *gracilis*

clade and can be easily distinguished from all members of the clade by a combination of the following differing or non-overlapping characters: small-sized *Cnemaspis* with maximum SVL 32 mm (versus medium-sized *Cnemaspis*, SVL up to 41 mm in *C. thackerayi* and *C. salimalii* sp. nov.); 15–17 tubercles in paravertebral rows (versus only a few irregularly arranged tubercles in paravertebral region in *C. mundanthuraiensis*, 10–14 in *C. gracilis*; 11 or 12 in *C. jackieii*);

11–13 rows of dorsal tubercles at mid-body (versus eight or nine rows of dorsal tubercles at mid-body in *C. jackieii*, 6–8 rows of dorsal tubercles at mid-body in *C. mundanthuraiensis*); spine-like tubercles present on flanks (versus spine-like tubercles absent on flanks in *C. agarwali*, *C. jackieii*, *C. shevaroyensis*, and *C. thackerayi*); 28–32 ventral scales across belly at mid-body (versus 24–26 ventral scales across belly at mid-body in *C. agarwali*, 21–24 in *C. shevaroyensis*, and 22–25 in *C. thackerayi*); a single central ocellus on neck, flanked posteriorly by a pair of much larger squarish blotches and anteriorly by a pair of subequal squarish blotches, indistinct spot on occiput (versus a single central dorsal ocellus each on occiput and neck, ocellus on neck flanked anteriorly on each side by a slightly larger ocellus in *C. agayagangai* sp. nov., a single central dorsal ocellus each on occiput and neck in *C. gracilis*, *C. mundanthuraiensis*, *C. thackerayi*; single dorsal ocellus on occiput absent, single dorsal ocellus on neck present in *C. salimalii* sp. nov.; a single dorsal ocellus each on occiput and neck, a smaller pair on either side just anterior to forelimb insertion in *C. jackieii*). *Cnemaspis fantastica* sp. nov. overlaps in all morphological and meristic characters to *C. agayagangai* sp. nov. apart from the condition of the ventral scales in the original tail, which are roughly pentagonal and in a relatively regular series, size more than half tail width (versus irregular in shape and arrangement, size less than half tail width in *C. agayagangai* sp. nov.); and colour pattern, with the dorsal ocelli on the new species relatively larger and squarish with the central ocellus smallest and forming an X with five ocelli (versus four smaller, rounded subequal ocelli forming a diamond in *C. agayagangai* sp. nov.). *Cnemaspis fantastica* sp. nov. is diagnosed against *Cnemaspis pachaimalaiensis* sp. nov. and *Cnemaspis rudhira* sp. nov. as part of their respective descriptions below.

**Description of the holotype.** Adult male in good state of preservation except tail tip marginally bent towards right (Fig. 12A–E). SVL 31.0 mm, head short (HL/SVL 0.24), wide (HW/HL 0.66), not strongly depressed (HD/HL 0.44), distinct from neck. Loreal region marginally inflated, canthus rostralis not distinct. Snout half of head length (ES/HL 0.50), almost 2.5 times eye diameter (ES/ED 2.43); scales on snout and canthus rostralis subcircular to oval, subequal, smooth anteriorly, becoming weakly keeled, and conical posteriorly; and much larger than those on forehead and interorbital region; scales on forehead similar to those on snout and canthus rostralis except smaller, somewhat elongated, and weakly conical; scales on interorbital region even smaller, granular and weakly keeled; scales on occipital and temporal region



heterogeneous, slightly enlarged, weakly keeled, conical tubercles intermixed with smaller, weakly keeled and weakly conical granular scales (Fig. 13A). Eye small (ED/HL 0.20) with round pupil; supraciliaries short, larger anteriorly; five interorbital scale rows across narrowest point of frontal bone; 24 or 25 scale rows between left and right supraciliaries at mid-orbit (Fig. 13A, C). Ear-opening deep, oval, small (EL/HL 0.06); eye to ear distance greater than diameter of eye (EE/ED 1.5) (Fig. 13C). Rostral  $2\times$  wider (1.50 mm) than high (0.53 mm), incompletely divided dorsally by a strongly developed rostral groove and internasal scale for more than half of its height; a single enlarged supranasal on each side, slightly larger than upper postnasal, separated from each other by a much smaller, elongated internasal scale and still smaller scale on snout; two postnasals, upper postnasal slightly larger than lower; rostral in contact with supralabial I, nostril, supranasal, and lower postnasal on either side; nostrils oval, surrounded by two postnasals, supranasal, and rostral on either side; two rows of scales separate orbit from supralabials (Fig. 13C). Mental enlarged, subtriangular, slightly wider (1.71 mm) than high (1.34 mm); two pairs of postmentals, inner pair roughly rectangular, much shorter (0.71 mm) than mental, in strong contact with each other below mental; inner pair bordered by mental, infralabial I, outer postmental, enlarged median chin shield and an enlarged chin shield on either side; outer postmentals roughly rectangular, even smaller (0.40 mm) than inner pair, bordered by inner postmentals, infralabial I and II, and four enlarged chin scales on left and three on right side; three enlarged gular scales between left and right outer postmentals; all chin scales bordering postmentals somewhat tubular, subcircular, smooth, and slightly smaller than outermost postmentals; scales on rest of throat, small, subequal, flattened and smooth (Fig. 13B). Infralabials bordered below by a row or two slightly enlarged, much elongated scales, decreasing in size posteriorly. Eight supralabials up to angle of jaw on left and nine on right side, and six at midorbital position on either side; supralabial I largest, rest of the series gradually decreasing in size posteriorly; eight infralabials up to angle of jaw on either side, and six at midorbital position on left and five on right side; infralabial I largest, rest of the series gradually decreasing in size posteriorly (Fig. 13C).

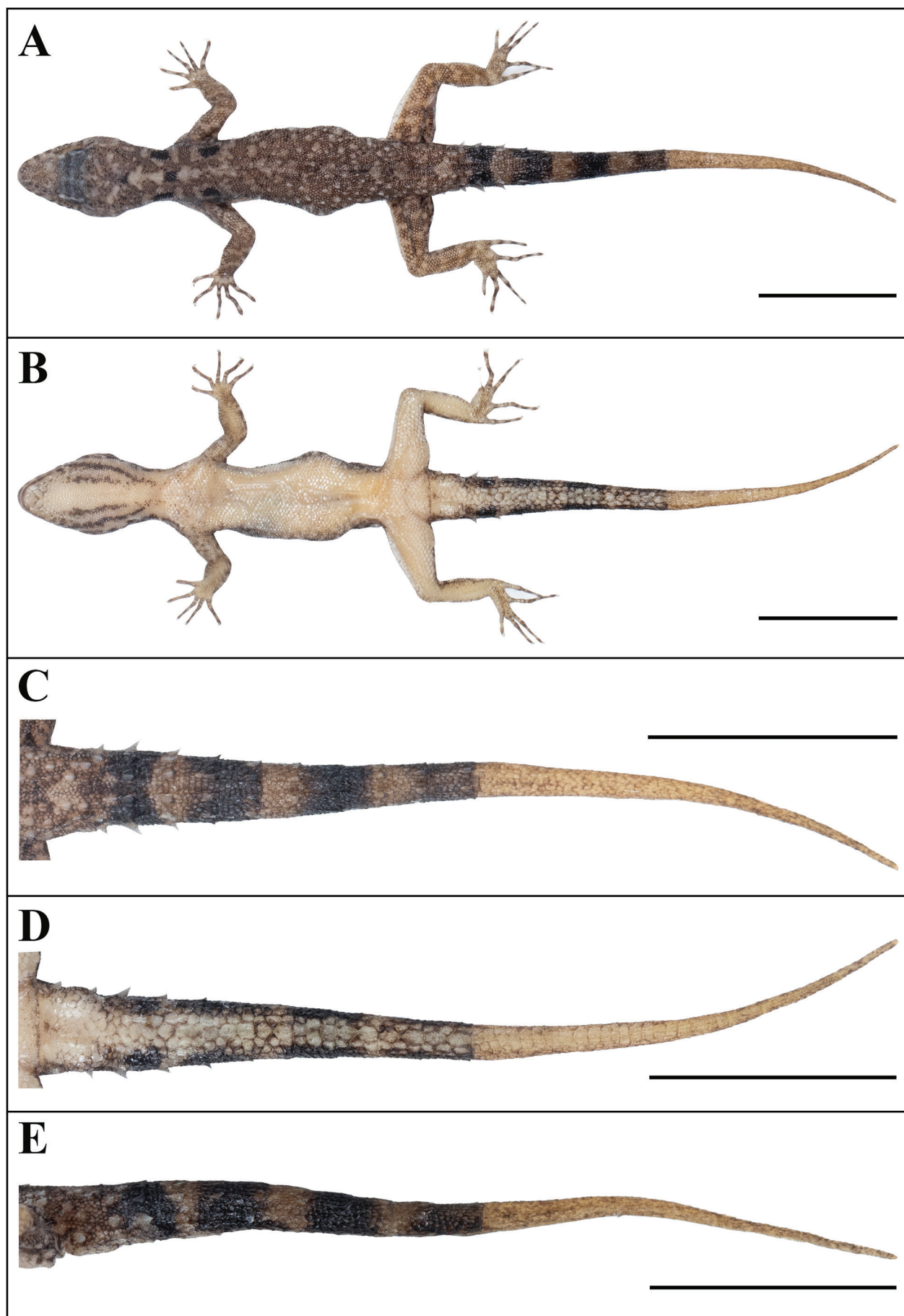
Body relatively slender (BW/AGL 0.45), trunk less than half of SVL (AGL/SVL 0.39) without ventrolateral folds; short spine-like scales on flank present (Fig. 14A–C). Dorsal pholidosis heterogeneous; weakly keeled granular scales intermixed with a fairly regularly arranged row of enlarged, strongly keeled, conical tubercles; tubercles in approximately 12 longitudinal rows at mid-body including spine-like scales at lower flank; 17 tubercles in paravertebral rows from above forelimb insertion to the hind limb insertion (Fig. 14A, C). Ventral scales more than twice the size than granular scales on dorsum, smooth, subcircular, subimbricate, subequal from chest to vent; mid-body scale rows across belly 30; 113 scales from mental to anterior border of cloaca (Fig. 14B). Scales on base of neck similar to those on belly,

except smaller; gular region with still smaller, subequal, smooth, flattened scales, those bordering postmentals enlarged, smooth, subcircular, and somewhat tubular (Fig. 13B). Five femoral pores on left thigh and four on right, separated by eight poreless on either side from two precloacal pores, precloacal pores separated medially by a single poreless scale (Fig. 13D).

Scales on palms and soles granular, smooth, subcircular, and flattened; scales on dorsal aspects of limbs heterogeneous in shape and size; mixture of small granular, weakly keeled, imbricate scales which are twice the size of granules on the body dorsum, largest on antero-lateral aspect of the hands and feet; posterolateral aspect of limbs with small weakly keeled to smooth granular scales; scales on upper hand and thigh larger than lower hand and shank respectively; ventral aspect of forelimbs with small, smooth, subimbricate scales, larger on lower arm than upper arm; ventral aspect of hindlimb with enlarged, smooth, flattened, subimbricate scales, slightly larger than body ventrals (Fig. 12A, B). Forelimbs and hindlimbs moderately long, slender (LAL/SVL 0.14; CL/SVL 0.17); digits long, with strong, recurved claw, distinctly inflected, distal portions laterally compressed conspicuously. Digits with unpaired lamellae, separated into a basal and narrower distal series by single enlarged lamella at inflection; basal lamellae series: (1-3-3-4-4 right manus, 1-4-4-6-5 right pes), (1-4-4-4-4 left manus, Fig. 13E; 1-4-4-7-4 left pes, Fig. 13F); distal lamellae series: (7-9-11-11-10 right manus, 8-10-13-12-12 right pes), (8-9-11-11-10 left manus, Fig. 13E; 8-10-12-12-12 left pes, Fig. 13F). Relative length of digits (measurements in mm in parentheses): IV (2.6) = III (2.6) > II (2.4) > V (2.3) > I (1.7) (left manus); IV (3.5) > V (3.3) = III (3.3) > II (2.9) > I (1.8) (left pes).

Tail half original half regenerated, entire, subcylindrical, slender, marginally longer than snout-vent length (TL/SVL 1.16; Fig. 12C–E). Dorsal scales on tail base weakly keeled, granular, similar in size and shape to granular scales on mid-body dorsum, gradually becoming larger, flattened, imbricate posteriorly, intermixed with enlarged, strongly keeled, distinctly pointed, conical tubercles; enlarged tubercles on the tail forming whorls; six tubercles each on first four whorls, four in 5–8<sup>th</sup> whorls, only paravertebral tubercles in 9<sup>th</sup> and 10<sup>th</sup> whorls, rest of the tail regenerated (Fig. 12C, E). Scales on ventral aspect of original tail much larger than those on dorsal aspect, subimbricate, smooth; median series distinctly larger than rest, roughly pentagonal; scales on tail base slightly smaller than those on mid-body ventrals, smooth, imbricate; a single enlarged, smooth to weakly keeled and conical postcloacal spur on each side (Fig. 12D).

**Colouration in life (Fig. 6C).** Dorsum of head, body, limbs and tail base reddish. Head with numerous yellow spots, yellow and dark bands on labials, postorbital streaks indistinct. A single central ocellus on neck, flanked posteriorly by a pair of much larger squarish blotches and anteriorly by a pair of subequal squarish blotches, indistinct spot on occiput; all ocelli black with a fine orange and diffuse yellow margin. Dorsum mottled with numer-



**Figure 12.** *Cnemaspis fantastica* sp. nov. (holotype, NRC-AA-1222): **A** dorsal aspect of body; **B** ventral aspect of body; **C** dorsal aspect of tail; **D** ventral aspect of tail; **E** lateral aspect of tail. Scale bars 10 mm; photos by Akshay Khandekar.



**Table 9.** Mensural (mm) data for the type series of *Cnemaspis fantastica* **sp. nov.**. Abbreviations are listed in Materials and Methods. \* = incomplete tail.

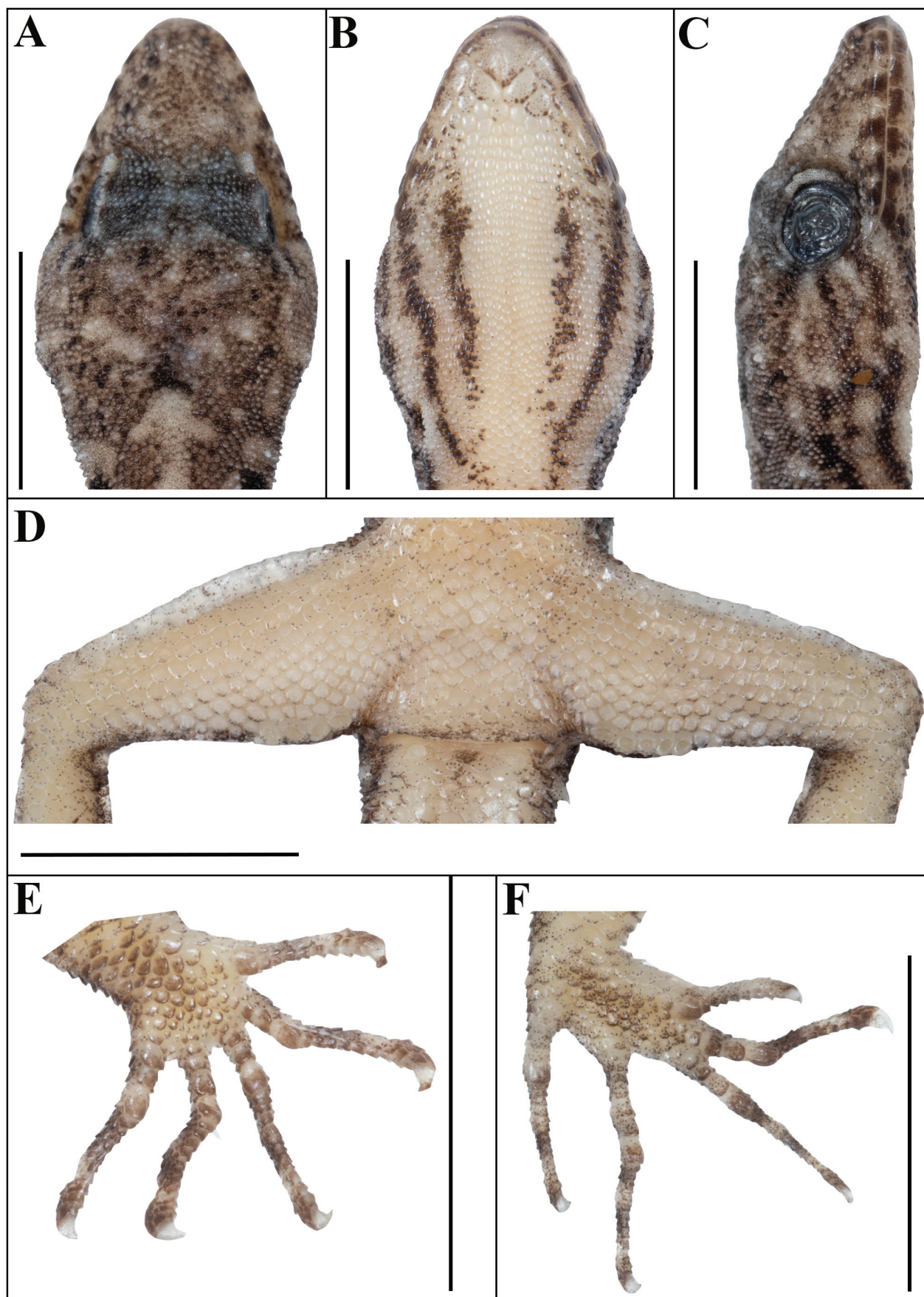
Type	Holotype	Paratypes						
museum number	NRC-AA-1222	NRC-AA-1223	NRC-AA-1224	NRC-AA-1225	NRC-AA-1226	NRC-AA-1227	NRC-AA-1228	NRC-AA-1229
Sex	M	F	M	M	F	M	F	M
SVL	31.0	31.9	32.5	30.5	32.1	28.4	31.9	31.4
TL	36.0	12.9*	10.3*	9.5*	19.5*	28.5	36.1	38.4
TW	3.1	2.5	2.8	2.5	2.9	2.8	2.8	3.3
LAL	4.4	4.4	4.5	4.4	4.2	4.0	4.4	4.6
CL	5.4	4.9	5.5	5.2	5.0	5.0	5.2	5.2
AGL	12.3	13.6	12.9	12.9	13.6	12.1	13.8	12.8
BH	3.1	4.0	3.3	3.0	3.7	3.0	3.8	3.5
BW	5.6	6.8	5.8	5.1	6.7	6.1	6.7	6.5
HL	7.7	7.8	7.9	7.6	7.4	7.0	7.8	7.6
HW	5.1	5.0	5.0	4.9	5.0	5.0	5.4	5.1
HD	3.4	3.4	3.4	3.0	3.2	3.3	3.2	3.5
ED	1.6	1.5	1.6	1.5	1.6	1.4	1.7	1.7
EE	2.4	2.5	2.4	2.0	2.6	2.2	2.5	2.5
ES	3.9	3.8	3.8	3.7	3.9	3.5	3.7	3.9
EN	3.1	3.3	3.1	3.1	3.1	2.8	3.1	3.0
IN	1.0	1.1	1.0	0.8	1.0	1.0	1.1	1.0
IO	1.4	1.2	0.9	1.2	1.2	1.2	1.0	1.2
EL	0.5	0.5	0.4	0.5	0.5	0.4	0.4	0.6

**Table 10.** Meristic data for the type series of *Cnemaspis fantastica* **sp. nov.**. Abbreviations are listed in Materials and Methods except for: L&R = Left & Right; abs. = absent; / = not available.

Type	Holotype	Paratypes						
Museum number	NRC-AA-1222	NRC-AA-1223	NRC-AA-1224	NRC-AA-1225	NRC-AA-1226	NRC-AA-1227	NRC-AA-1228	NRC-AA-1229
Sex	M	F	M	M	F	M	F	M
SL (L&R)	8&9	9&8	8&8	8&8	9&8	9&10	8&9	9&9
IL (L&R)	8&8	9&8	7&7	8&8	8&7	8&9	7&8	7&7
SL M (L&R)	6&6	6&6	6&6	6&6	5&5	6&6	6&6	6&6
IL M (L&R)	6&5	5&5	5&5	6&6	5&5	5&5	5&5	5&6
PVT (L&R)	17&17	16&16	16&16	16&17	16&16	/	15&15	17&17
DTR	12	13	12	12	11	12	11	11
MVSR	30	31	32	30	32	31	29	28
VS	113	110	116	113	117	120	114	112
LamF1 (L&R)	9&8	8&8	9&9	8&8	9&10	9&9	9&9	9&9
LamF4 (L&R)	15&15	15&14	14&15	14&14	16&16	16&16	14&15	15&15
LamT1 (L&R)	9&9	8&9	9&9	9&9	9&9	10&10	10&10	9&10
LamT4 (L&R)	19&18	17&16	19&19	19&19	18&18	20&19	18&18	19&17
LamT5 (L&R)	16&17	15&15	16&16	16&16	16&16	18&18	17&17	16&17
PP L&R	1&1	abs.	2&2	1&1	abs.	1&1	abs.	1&1
SBPP	1	abs.	1	2	abs.	2	abs.	2
SB PP&FP (L&R)	8&8	abs.	7&8	8&8	abs.	9&9	abs.	8&9
FP (L&R)	5&4	abs.	5&5	5&5	abs.	5&5	abs.	4&4
SBFP	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.
PCT (L&R)	1&1	0&1	1&1	1&1	1&1	1&1	1&1	1&1

ous small yellow spots some of which form an indistinct vertebral line and fine black spots. Dorsum of limbs more muted than back with indistinct yellow bands, digits with alternating dark and light bands. Tail with four black and

three light grey bands with an orange regenerated tip. Venter off-white with black speckles, two distinct pairs of black streaks on throat.



**Figure 13.** *Cnemaspis fantastica* sp. nov. (holotype, NRC-AA-1222): **A** dorsal aspect of head; **B** ventral aspect of head; **C** lateral aspect of right side head; **D** aspect of cloacal region showing precloacal and femoral pores; **E** ventral aspect of left manus; **F** ventral aspect of left pes. Scale bars 5 mm; photos by Akshay Khandekar.



**Table 11.** Additional morphological character states evaluation for the type series of *Cnemaspis fantastica* **sp. nov.**. abs. = absent; / = data unavailable.

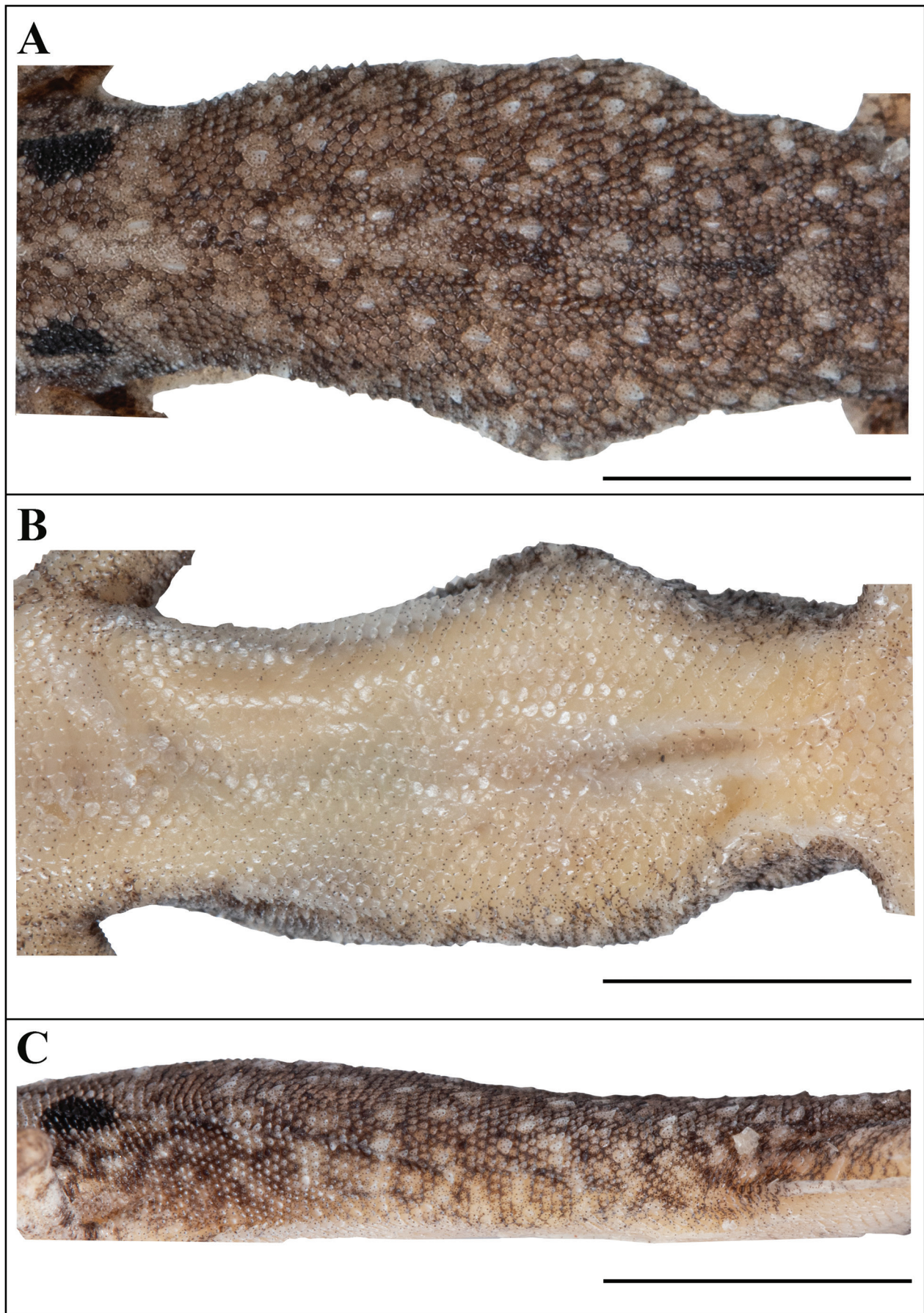
Types	Holotype	Paratypes						
museum number	NRC-AA-1222	NRC-AA-1223	NRC-AA-1224	NRC-AA-1225	NRC-AA-1226	NRC-AA-1227	NRC-AA-1228	NRC-AA-1229
Sex	M	F	M	M	F	M	F	M
Anterior extra-brilliar fringe scales enlarged (1) or not enlarged (0)	1	1	1	1	1	1	1	1
Ventral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0
Gular scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0
Pectoral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0
Precloacal pores continuous (1) or separated (0)	0	abs.	0	0	abs.	0	abs.	0
Precloacal pores elongate (1) or round (0)	1	abs.	1	0	abs.	0	abs.	1
femoral pores elongate (1) or round (0)	1	abs.	1	1	abs.	1	abs.	1
Dorsal pholidosis homogeneous (1) or heterogeneous (0)	0	0	0	0	0	0	0	0
Dorsal tubercles keeled (1) or not keeled (0)	1	1	1	1	1	1	1	1
Tubercles linearly arranged (1) or more random (0)	1	1	1	1	1	1	1	1
Spine-like scales on flank present (1) or absent (0)	1	1	1	1	1	1	1	1
Lateral caudal furrows present (1) or absent (0)	1	/	/	/	1	/	0	1
Subcaudals keeled (1) or smooth (0)	0	/	/	/	0	/	0	0
Single median row of keeled subcaudals (1) or smooth (0)	0	/	/	/	0	/	0	0
Caudal tubercles encircle tail (1) or not (0)	1	/	/	/	1	/	1	1
Enlarged median subcaudal scale row (1) or not (0)	1	/	/	/	1	/	1	1
Enlarged femoral scales present (1) or absent (0)	1	0	0	0	0	1	1	1
Subtibial scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0
Occipital ocellus (present or absent)	P	P	A	A	P	P	A	P
Ocelli anterior of the shoulder present (1) or absent (0) & number	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)
Ocelli posterior of the shoulder present (1) or absent (0) & number	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)
Original tail banded (1) or not (0)	1	/	/	1	1	1	1	1

**Variation and additional information from type series.**

Mensural, meristic and additional character state data for the type series is given in Tables 9–11 respectively. There are four adult male and three adult female specimens ranging in size from 28.4–32.5 mm (Fig. 7C). All paratypes resemble holotype except as follows: internasal

absent, supranasals in strong contact with each other on snout in NRC-AA-1223.

Upper postmentals marginally in contact with each other below mental in NRC-AA-1224; upper postmentals separated from each other below mental by a single median enlarged chin shields in NRC-AA-1227 and NRC-



**Figure 14.** *Cnemaspis fantastica* sp. nov. (holotype, NRC-AA-1222): **A** dorsal aspect of mid-body; **B** ventral aspect of mid-body; **C** right side lateral aspect of mid-body. Scale bars 5 mm; photos by Akshay Khandekar.



AA-1228; upper postmentals bordered by mental, infralabial I, outer postmental, and by a single large chin scale on either side in NRC-AA-1223, NRC-AA-1225, NRC-AA-1226, and NRC-AA-1229. Outer postmental bordered by inner postmental, infralabials I & II in all types, additionally, four chin scales on either side in NRC-AA-1223, NRC-AA-1226, NRC-AA-1228, five chin scales on right in NRC-AA-1227, and five chin scales on left and four on right side in NRC-AA-1229; outer postmental separated from each other medially by two enlarged chin scales in NRC-AA-1223, NRC-AA-1225, NRC-AA-1226, and NRC-AA-1229. Two paratypes — NRC-AA-1228 and NRC-AA-1229 with original and complete tails, slightly longer than body (TL/SVL 1.13 and 1.22 respectively); tail entire but mostly regenerated in NRC-AA-1227, equal to body length (TL/SVL 1.00); tail entire but incomplete in NRC-AA-1225 and NRC-AA-1226 (TL = 9.5 and 19.5 mm respectively); tail almost entirely regenerated and largely lost in NRC-AA-1223 and NRC-AA-1224; original tail distinctly banded in males and faintly in female paratypes; regenerated tail orangish in life and yellowish-grey in preservative. (Fig. 7C).

**Distribution and Natural history.** *Cnemaspis fantastica* **sp. nov.** is currently known only from around its type locality (Karavallicombai reserve forest, Kolli hills, between an elevational gradient of ca. 600–1100 m asl.) in Namakkal district, Tamil Nadu (Fig. 1). Like most of the other members of its clade, the new species seems to be diurnal, rupicolous, and locally abundant. At collection sites, many individuals ( $n = >40$ ) were observed active during the daytime (1100–1430 hrs) on rocks, road side rocky cuttings, and building walls below 2 m height, and under cement culverts in moist deciduous to semi-evergreen forest patches (Fig. 8C). Sympatric geckos encountered at the locality include *Cyrtodactylus* (*Geckoella*) sp., *Hemidactylus* cf. *graniticulus*, *Hemidactylus parvimaculatus*, *Hemidactylus* cf. *frenatus*, and *Hemiphyllodactylus kolliensis*.

### *Cnemaspis pachaimalaiensis* **sp. nov.**

<https://zoobank.org/0e7c9cad-5434-4d36-a764-a5ac0a5de030>

Figs 15–17; 6D, 8D, 18A; Tables 12–14

**Holotype.** NRC-AA-1230 (AK 711), adult male, from near Mangalam waterfalls, (11.3422°N, 78.6047°E; ca. 650 m asl.), Pachaimalai hills, Trichy district, Tamil Nadu state, India; collected by Akshay Khandekar, Ishan Agarwal, Swapnil Pawar and Tejas Thackeray on 30<sup>th</sup> May 2019.

**Paratypes.** NRC-AA-1231 (AK 708), NRC-AA-1232 (AK 709), adult males, same data as holotype; NRC-AA-1233 (AK 712), adult male, NRC-AA-1234 (AK 713), adult female, from near Shri Kaliyamma temple (11.3642°N, 78.5910°E; ca. 960 m asl.); NRC-AA-1235 (AK 730), NRC-AA-1236 (AK 731), NRC-AA-1237

(AK 753), adult males, from Pachaimalai RF (11.3167°N, 78.6018°E; ca. 840 m asl.), same data as holotype.

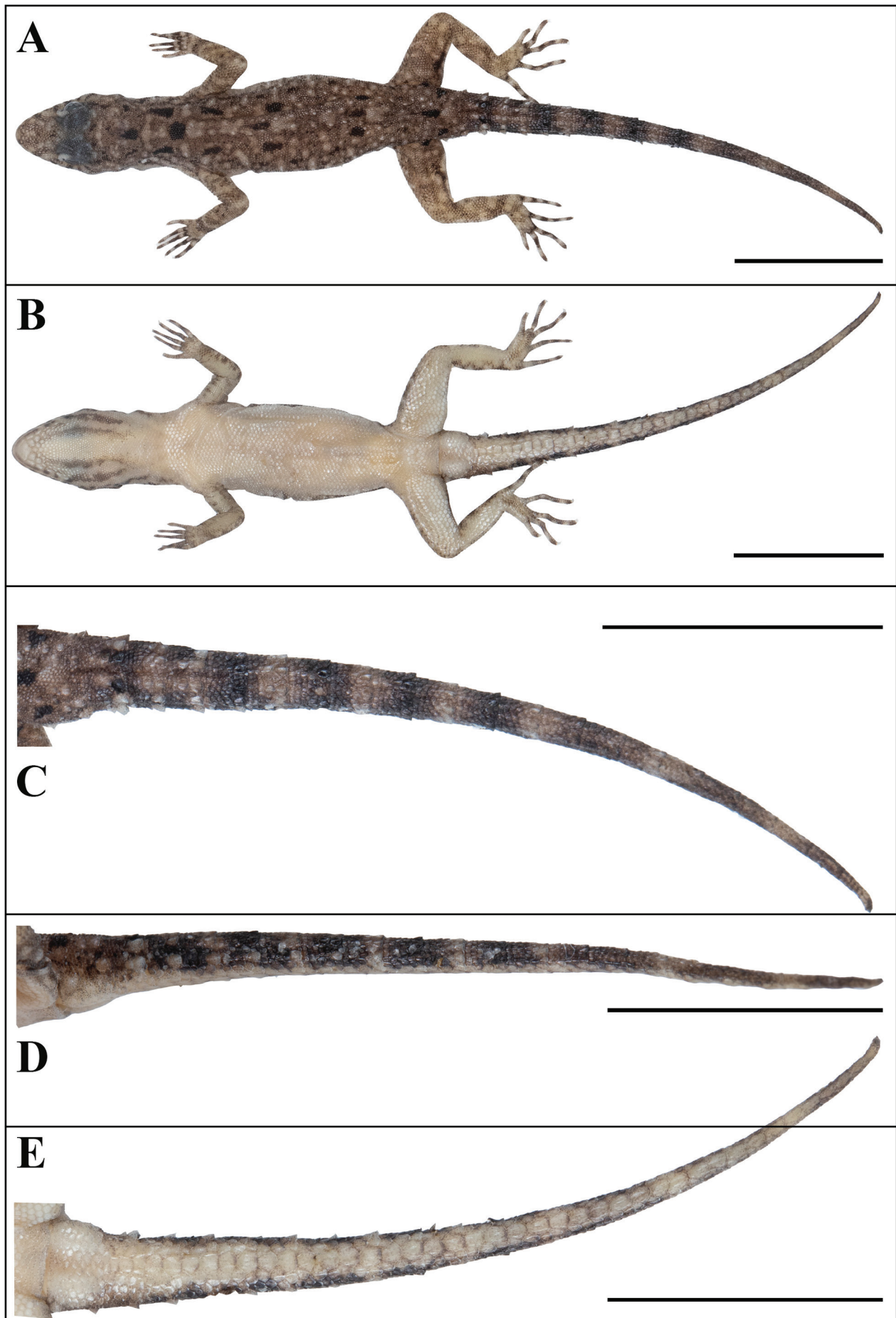
**Etymology.** The specific epithet is a toponym for the Pachaimalai hills in Trichy district of Tamil Nadu, the type and currently only known locality for this species.

**Suggested Common Name.** Pachaimalai dwarf gecko.

**Diagnosis.** A small-sized *Cnemaspis*, snout to vent length up to 33.6 mm ( $n = 8$ ). Dorsal pholidosis heterogeneous; weakly keeled, weakly conical, granular scales intermixed with a fairly regularly arranged rows of enlarged, strongly keeled, conical tubercles; last one or two rows of enlarged tubercles on flank short spine-like; 10–12 rows of dorsal tubercles at mid-body, 13–17 tubercles in paravertebral rows; ventral scales subcircular, smooth, subequal from chest to vent, 30–33 scales across belly at mid-body, 112–125 longitudinal scales from mental to cloaca; subdigital scensors smooth, unpaired, unnotched; 9–11 lamellae under digit I of manus and 9–12 lamellae under digit I of pes, 15–18 lamellae under digit IV of manus and 18–22 lamellae under digit IV of pes; males with 4–7 femoral pores on each thigh separated by 7–11 poreless scales from continuous series of 2–5 precloacal pores ( $n = 7/8$ ); tail with enlarged, strongly keeled, pointed, and spine-like tubercles forming whorls; median row of subcaudals smooth, roughly pentagonal, and distinctly enlarged. Dorsum orange, mottled with numerous light grey spots and fine black spots; a large central black dorsal ocellus on neck flanked anteriorly and posteriorly on each side by elongate dark ocelli, smaller ocellus on occiput flanked on each side by a smaller ocellus; indistinct rows of smaller dark ocelli may be present; venter off-white with black speckles, two distinct pairs of black streaks on throat; original tail in males with 9–11 alternating dark and light grey bands, regenerated tail orange.

**Comparison with members of *C. gracilis* clade.** *Cnemaspis pachaimalaiensis* **sp. nov.** is a member of the *gracilis* clade and can be easily distinguished from all members of the clade by a combination of the following differing or non-overlapping characters: males with continuous series of precloacal pores (versus precloacal pore series medially separated by at least one poreless scale in males of *C. agarwali*, *C. agayagangai* **sp. nov.**, *C. gracilis*, *C. jackiei*, *C. fantastica* **sp. nov.**, *C. salimalii* **sp. nov.**, *C. thackerayi*, *C. shevaroyensis*; precloacal pores either absent or medially separated by 2–4 poreless scales in *C. mundanthuraiensis*); small-sized *Cnemaspis* with maximum SVL 32 mm (versus medium-sized *Cnemaspis*, SVL up to 41 mm in *C. thackerayi*, and *C. salimalii* **sp. nov.**); 13–17 tubercles in paravertebral rows (versus only a few irregularly arranged tubercles in paravertebral region in *C. mundanthuraiensis*, 11 or 12 in *C. jackiei*); 10–12 rows of dorsal tubercles at mid-body (versus eight or nine rows of dorsal tubercles at mid-body in *C. jackiei*, 6–8 rows of dorsal tubercles at mid-body in *C. mundanthuraiensis*); short spine-like tubercles present on flanks (versus spine-like tubercles absent on flanks in *C. agar-*





**Figure 15.** *Cnemaspis pachaimalaiensis* sp. nov. (holotype, NRC-AA-1230): **A** dorsal aspect of body; **B** ventral aspect of body; **C** dorsal aspect of tail; **D** ventral aspect of tail; **E** lateral aspect of tail. Scale bars 10 mm; photos by Akshay Khandekar.

**Table 12.** Mensural (mm) data for the type series of *Cnemaspis pachaimalaiensis* **sp. nov.**. Abbreviations are listed in Materials and Methods. \* = incomplete tail.

Type	Holotype	Paratypes						
museum number	NRC-AA-1230	NRC-AA-1231	NRC-AA-1232	NRC-AA-1233	NRC-AA-1234	NRC-AA-1235	NRC-AA-1236	NRC-AA-1237
Sex	Male	Male	Male	Male	Female	Male	Male	Male
SVL	28.8	30.7	28.6	31.5	33.6	30.6	30.3	31.9
TL	32.2	8.5*	32.0	40.7	36.3	40.0	34.0	42.6
TW	2.7	3.0	2.4	3.1	2.8	2.9	2.9	3.3
LAL	4.3	4.5	3.7	4.5	4.8	4.6	4.5	4.6
CL	5.1	5.5	4.8	5.6	5.3	5.3	5.6	5.4
AGL	11.5	11.7	10.8	12.7	14.4	13	12	13.3
BH	3.0	3.3	2.7	3.4	3.8	3.1	3.3	3.5
BW	5.4	5.5	4.7	6.4	6.4	5.6	6.3	6.4
HL	7.0	7.5	7.2	8.0	7.8	7.6	7.7	8.0
HW	4.8	4.9	4.6	5.5	5.2	5.3	5.1	5.2
HD	3.2	3.5	3.0	3.7	3.4	3.4	3.2	3.3
ED	1.5	1.6	1.6	1.8	1.9	1.5	1.6	1.8
EE	2.4	2.3	2.2	2.5	2.5	2.4	2.3	2.6
ES	3.5	3.8	3.5	3.7	4.1	3.9	3.9	4.0
EN	2.7	3.0	2.8	3.0	3.4	3.0	3.1	3.2
IN	0.8	1.0	0.8	1.1	1.1	1.0	1.0	0.9
IO	1.1	1.0	1.0	1.1	1.1	1.3	1.3	1.5
EL	0.4	0.4	0.4	0.4	0.6	0.4	0.6	0.6

**Table 13.** Meristic data for the type series of *Cnemaspis pachaimalaiensis* **sp. nov.**. Abbreviations are listed in Materials and Methods except for: L&R = Left & Right; abs. = absent; \* = paravertebral tubercles and lamellae incomplete.

Type	Holotype	Paratypes						
Museum number	NRC-AA-1230	NRC-AA-1231	NRC-AA-1232	NRC-AA-1233	NRC-AA-1234	NRC-AA-1235	NRC-AA-1236	NRC-AA-1237
Sex	Male	Male	Male	Male	Female	Male	Male	Male
SL (L&R)	8&8	9&8	8&8	8&8	9&8	8&8	8&8	8&8
IL (L&R)	7&7	7&6	7&8	8&7	8&7	7&7	7&8	7&7
SL M (L&R)	6&6	6&6	6&7	6&6	6&6	6&5	6&6	6&6
IL M (L&R)	5&5	5&5	5&6	5&5	5&5	5&5	5&5	5&5
PVT (L&R)	14&16	15&17	13*&15	15&14	13&13	16&14	16&16	15&14
DTR	11	12	11	10	10	11	12	10
MVSR	31	30	30	32	32	32	31	33
VS	115	112	118	113	125	117	124	118
LamF1 (L&R)	9&10	10&10	10&10	10&10	9&10	10&10	10&10	11&10
LamF4 (L&R)	15&15	17&18	16&15	16&16	15&16	17&17	17&18	17&16
LamT1 (L&R)	9&9	10&10	9&10	10&10	10&9	10&10	10&8*	12&11
LamT4 (L&R)	19&18	22&22	19&19	18&18	20&*	21&21	22&21	21&22
LamT5 (L&R)	18&17	18&19	18&19	18&17	18&18	20&19	18&17	18&19
PP L&R	3	4	5	3	0	4	3	4
SBPP	0	0	0	0	0	0	0	0
SB PP&FP (L&R)	10&10	9&9	7&7	8&7	0	8&8	10&10	9&11
FP (L&R)	5&4	5&4	7&7	6&6	0	7&7	5&6	7&6
SBFP	A	A	A	A	0	A	A	A
PCT (L&R)	1&1	1&1	1&1	1&1	1&1	1&1	1&1	1&1

wali, *C. jackieii*, *C. shevaroyensis*, and *C. thackerayi*); 30–33 ventral scales across belly at mid-body (versus 24–26 ventral scales across belly at mid-body in *C. agarwali*, 21–24 in *C. shevaroyensis*, and 22–25 in *C. thackerayi*); a large central black dorsal ocellus on neck flanked

anteriorly and posteriorly on each side by elongate dark ocelli, smaller ocellus on occiput flanked on each side by a smaller ocellus; indistinct rows of smaller dark ocelli may be present (versus a single central dorsal ocellus each on occiput and neck in *C. gracilis*, *C. mundanthu-*



**Table 14.** Additional morphological character states evaluation for the type series of *Cnemaspis pachaimalaiensis* **sp. nov.** abs. = absent; / = data unavailable.

Types	Holotype	Paratypes						
Museum number	NRC-AA-1230	NRC-AA-1231	NRC-AA-1232	NRC-AA-1233	NRC-AA-1234	NRC-AA-1235	NRC-AA-1236	NRC-AA-1237
Sex	Male	Male	Male	Male	Female	Male	Male	Male
Anterior extra-brilliar fringe scales enlarged (1) or not enlarged (0)	1	1	1	1	1	1	1	1
Ventral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0
Gular scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0
Pectoral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0
Precloacal pores continuous (1) or separated (0)	1	1	1	1	abs.	1	1	1
Precloacal pores elongate (1) or round (0)	1	1	0	1	abs.	1	1	1
femoral pores elongate (1) or round (0)	1	1	1	1	abs.	1	1	1
Dorsal pholidosis homogeneous (1) or heterogeneous (0)	0	0	0	0	0	0	0	0
Dorsal tubercles keeled (1) or not keeled (0)	1	1	1	1	1	1	1	1
Tubercles linearly arranged (1) or more random (0)	1	1	1	1	1	1	1	1
Spine-like scales on flank present (1) or absent (0)	1	1	1	1	1	1	1	1
Lateral caudal furrows present (1) or absent (0)	1	/	1	1	1	1	1	1
Subcaudals keeled (1) or smooth (0)	0	/	0	0	0	0	0	0
Single median row of keeled subcaudals (1) or smooth (0)	0	/	0	0	0	0	0	0
Caudal tubercles encircle tail (1) or not (0)	1	/	1	1	1	1	1	1
Enlarged median subcaudal scale row (1) or not (0)	1	/	1	1	1	1	1	1
Enlarged femoral scales present (1) or absent (0)	1	1	0	1	0	1	0	1
Subtibial scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0
Occipital ocellus present (1) or absent (0)	1	1	1	1	1	1	1	1
Ocelli anterior of the shoulder present (1) or absent (0) & number	1 (3)	1 (2*)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)
Ocelli posterior of the shoulder present (1) or absent (0) & number	1 (+3)	1 (2)	1 (2)	0	1 (2)	0	1 (2)	1 (2)
Original tail banded (1) or not (0)	1	/	1	1	1	1	1	1

*raiensis*, *C. thackerayi*; single dorsal ocellus on occiput absent, single dorsal ocellus on neck present in *C. salimalii* **sp. nov.**; a single dorsal ocellus each on occiput and neck, a smaller pair on either side just anterior to forelimb insertion in *C. jackieii*). *Cnemaspis pachaimalaiensis* **sp. nov.** is diagnosed against *Cnemaspis rudhira* **sp. nov.** as part of its descriptions below.

**Description of the holotype.** Adult male in good state of preservation except tail slightly bent towards left (Fig. 15A–E). SVL 28.8 mm, head short (HL/SVL 0.24), wide (HW/HL 0.68), not strongly depressed (HD/HL 0.45), distinct from neck. Loreal region marginally inflated, canthus rostralis not distinct. Snout half of head length (ES/HL 0.50), almost 2.5 times eye diameter (ES/ED 2.33); scales on snout and canthus rostralis subcircular, subequal, weakly keeled, somewhat conical, and much larger than those on forehead and interorbital region; scales on

forehead similar to those on snout and canthus rostralis except smaller and elongated, and weakly conical; scales on interorbital region even smaller, granular; scales on occipital and temporal region heterogeneous, enlarged, keeled, conical tubercles intermixed with much smaller, weakly keeled and weakly conical granular scales (Fig. 16A). Eye small (ED/HL 0.21) with round pupil; supraciliaries short, larger anteriorly; five interorbital scale rows across narrowest point of frontal bone; 28–30 scale rows between left and right supraciliaries at mid-orbit (Fig. 16A, C). Ear-opening deep, oval, small (EL/HL 0.05); eye to ear distance greater than diameter of eye (EE/ED 1.60) (Fig. 16C). Rostral more than twice as wide (1.40 mm) as high (0.55 mm), incompletely divided dorsally by a strongly developed rostral groove for more than half of its height; a single enlarged supranasal on each side, slightly larger than upper postnasal, separated from each other by a much smaller, elongated internasal scale and

still smaller scale on snout; two postnasals, upper postnasal slightly larger than lower; rostral in contact with supralabial I, nostril, supranasal, and weakly in contact with lower postnasal on either side; nostrils oval, surrounded by two postnasals, supranasal, and rostral on either side; one or two rows of scales separate orbit from supralabials (Fig. 16C). Mental enlarged, subtriangular, marginally wider (1.64 mm) than high (1.30 mm); two pairs of postmentals, inner pair roughly rectangular, much shorter (0.63 mm) than mental, separated from each other below mental by a single enlarged median chin shield; inner pair bordered by mental, infralabial I, outer postmental, enlarged median chin shield and an enlarged chin shield on either side; outer postmentals roughly rectangular, even smaller (0.52 mm) than inner pair, bordered by inner postmentals, infralabial I and II, and four enlarged chin shields on either side; three enlarged gular scales between left and right outer postmentals; all chin scales bordering postmentals flat, subcircular, smooth, and slightly smaller than outermost postmentals; scales on rest of throat granular, small, smooth (Fig. 16B). Infralabials bordered below by a row or two of slightly enlarged, much elongated scales, decreasing in size posteriorly. Eight supralabials up to angle of jaw and six at midorbital position on either side; supralabial I largest, rest of the series gradually decreasing in size posteriorly; seven infralabials up to angle of jaw, five at midorbital position on either side; infralabial I largest, rest of the series gradually decreasing in size posteriorly (Fig. 16C).

Body relatively slender (BW/AGL 0.46), trunk less than half of SVL (AGL/SVL 0.39) without ventrolateral folds; short spine-like scales on flank present (Fig. 17A–C). Dorsal pholidosis heterogeneous; weakly keeled granular scales intermixed with a fairly regularly arranged row of enlarged, strongly keeled, conical tubercles; tubercles in approximately 11 longitudinal rows at mid-body including short spine-like scales at lower flank; 14 (left) and 16 (right) tubercles in paravertebral row from above forelimb insertion to the hind limb insertion (Fig. 17A, C). Ventral scales much larger than granular scales on dorsum smooth, subcircular, subimbricate, subequal from chest to vent; mid-body scale rows across belly 31; 115 scales from mental to anterior border of cloaca (Fig. 17B). Scales on base of neck similar to those on belly, marginally smaller; gular region with much smaller, smooth, granular scales, those bordering postmentals enlarged, smooth, subcircular, and flattened (Fig. 16B). Five femoral pores on left thigh and four on right, separated by 10 poreless on either side from continuous series of three precloacal pores (Fig. 16D).

Scales on palms and soles granular, smooth, rounded, and flattened; scales on dorsal aspects of limbs heterogeneous in shape and size; mixture of small granular, weakly keeled, imbricate scales which are twice the size of granules on the body dorsum, largest on anterolateral aspect of the hands and feet; posterolateral aspect of limbs with small weakly keeled to smooth granular scales; ventral aspect of forelimbs with small, smooth, subimbricate scales, larger on lower arm than upper arm; ventral aspect of hindlimb with enlarged, smooth, flattened,

subimbricate scales, slightly larger than body ventrals (Fig. 15A, B). Forelimbs and hindlimbs moderately long, slender (LAL/SVL 0.14; CL/SVL 0.17); digits long, with strong, recurved claw, distinctly inflected, distal portions laterally compressed conspicuously. Digits with unpaired lamellae except for a few basal lamellae which are paired, separated into a basal and narrower distal series by single enlarged lamella at inflection; basal lamellae series: (1-3-3-4-3 right manus, 1-4-5-6-5 right pes), (1-3-3-4-3 left manus, Fig. 16E; 1-4-6-7-5 left pes, Fig. 16F); distal lamellae series: (9-11-12-11-10 right manus, 8-10-13-12-12 right pes), (8-9-11-11-11 left manus, Fig. 16E; 8-11-13-12-13 left pes, Fig. 16F). Relative length of digits (measurements in mm in parentheses): IV (2.5) > III (2.3) > V (2.0) = II (2.0) > I (1.5) (left manus); IV (3.1) > V (3.0) > III (2.9) > II (2.6) > I (1.9) (left pes).

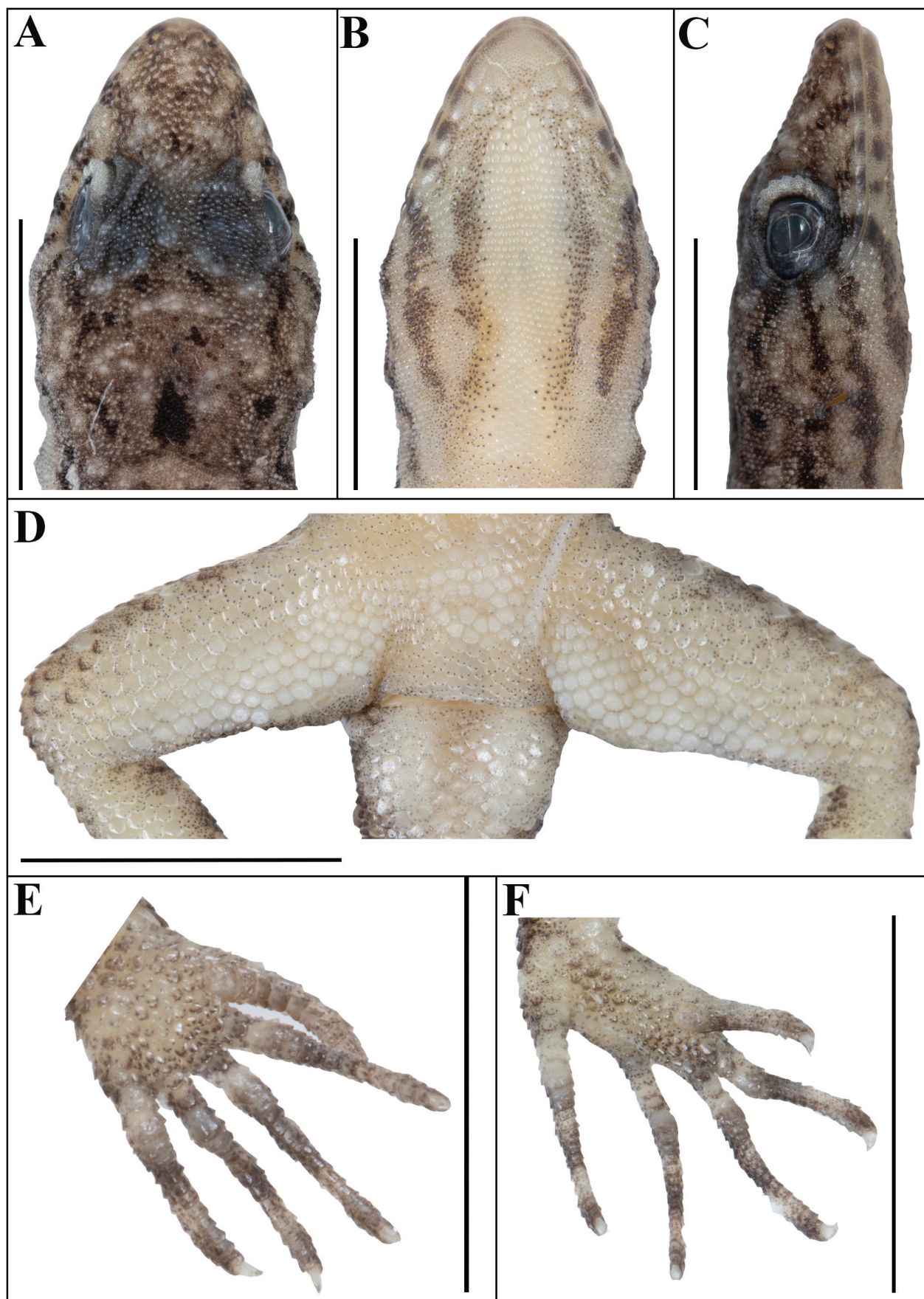
Tail original, entire, subcylindrical, slender, marginally longer than snout-vent length (TL/SVL 1.11; Fig. 15C–E). Dorsal scales on tail base weakly keeled, granular, similar in size and shape to granular scales on mid-body dorsum, gradually becoming larger, flattened, imbricate posteriorly, intermixed with enlarged, strongly keeled, distinctly pointed, conical tubercles; enlarged tubercles on the tail forming whorls; six tubercles each on first nine whorls, four in 10–13<sup>th</sup> whorls, rest of the tail with only paravertebral tubercles (Fig. 15A, C). Scales on ventral aspect of tail much larger than those on dorsal aspect, subimbricate, smooth; median series distinctly larger than rest, roughly pentagonal; scales on tail base slightly smaller than those on mid-body ventrals, smooth, imbricate; a single enlarged, conical, and smooth postcloacal spur on each side (Fig. 15B).

**Colouration in life (Fig. 6D).** Dorsum of head, body, limbs and tail base orange-brown. Head with numerous yellow blotches and some black spots, yellow and dark bands on labials. Three dark postorbital streaks, all terminating anterior to forelimb insertions, suborbital streak continues onto throat. A large central black dorsal ocellus on neck flanked anteriorly and posteriorly on each side by elongate dark ocelli, smaller ocellus on occiput flanked on each side by a smaller ocellus; approximately three rows of three smaller dark ocelli; all ocelli with a diffuse orange margin. Dorsum mottled with smaller light-grey spots and fine black spots. Dorsum of limbs more muted than back, digits with alternating dark and light bands. Tail with seven or eight alternating light grey and black bands with an orange regenerated tip. Venter off-white with black speckles, two distinct pairs of black streaks on throat.

#### Variation and additional information from type series.

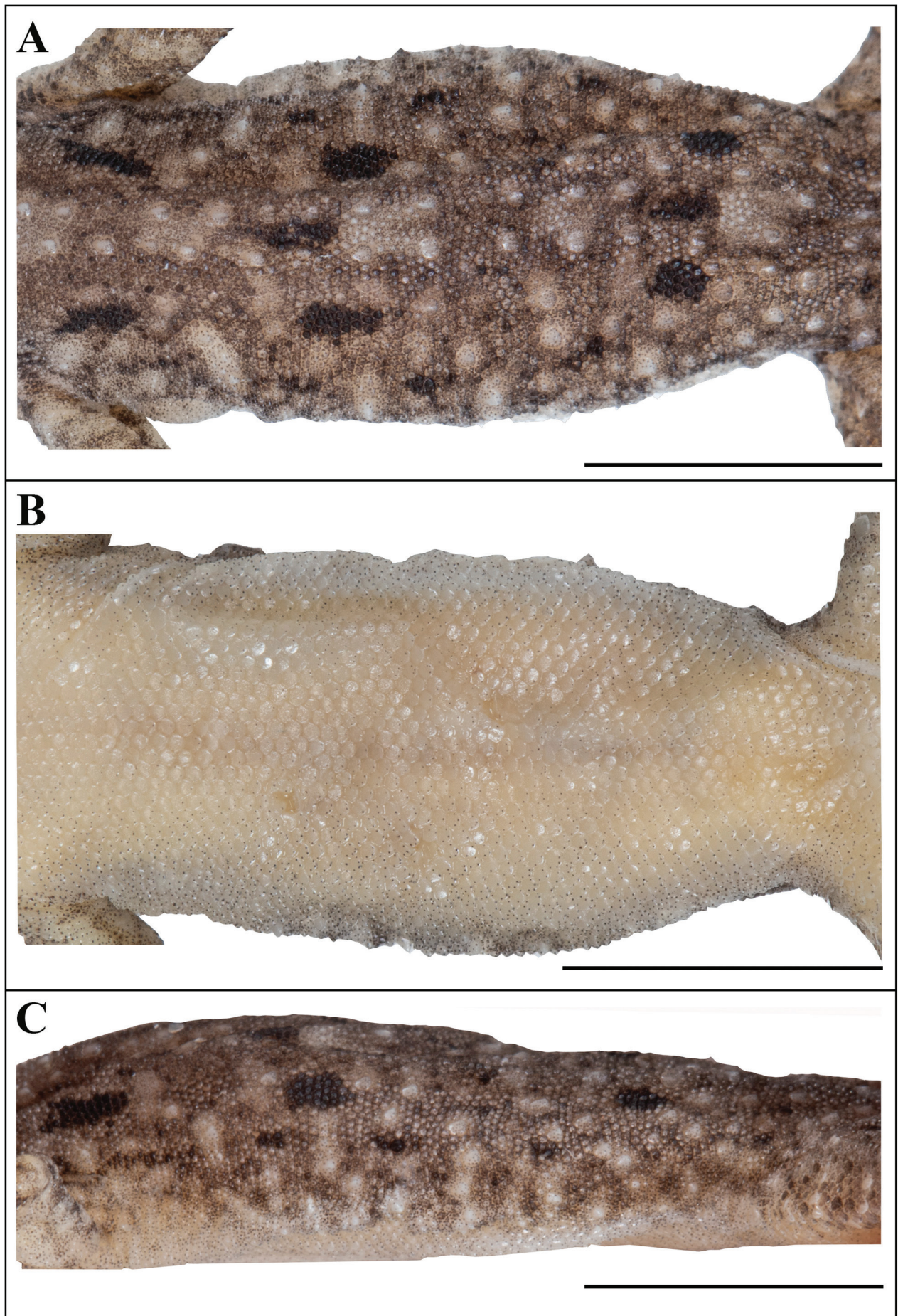
Mensural, meristic and additional character state data for the type series is given in Tables 12–14 respectively. There are six adult male and a single adult female specimens ranging in size from 28.6–33.6 mm (Fig. 18A). All paratypes resemble holotype except as follows: supranasals in contact with each other behind internasal in NRC-AA-1233 and NRC-AA-1237; upper postmentals in contact with each other below mental in NRC-AA-1231,





**Figure 16.** *Cnemaspis pachaimalaiensis* sp. nov. (holotype, NRC-AA-1230): **A** dorsal aspect of head; **B** ventral aspect of head; **C** lateral aspect of right side head; **D** aspect of cloacal region showing precloacal and femoral pores; **E** ventral aspect of left manus; **F** ventral aspect of left pes. Scale bars 5 mm; photos by Akshay Khandekar.





**Figure 17.** *Cnemaspis pachaimalaiensis* **sp. nov.** (holotype, NRC-AA-1230): **A** dorsal aspect of mid-body; **B** ventral aspect of mid-body; **C** right side lateral aspect of mid-body. Scale bars 5 mm; photos by Akshay Khandekar.



NRC-AA-1233, NRC-AA-1234, and NRC-AA-1237; upper postmentals separated from each other below mental by two median enlarged chin shields in NRC-AA-1236; upper postmentals bordered by mental, infralabial I, outer postmental, and by a single large chin scale on either side in NRC-AA-1231, NRC-AA-1233, NRC-AA-1236; upper postmentals bordered by mental, infralabial I, outer postmental, median chin shield, and by a single large chin scale on either side in NRC-AA-1234, NRC-AA-1237. Outer postmental bordered by inner postmental, infralabials I & II in all types, additionally, five chin scales on either side in NRC-AA-1231, five chin scales on right in NRC-AA-1233 and NRC-AA-1236, three scales on right in NRC-AA-1232 and NRC-AA-1237; outer postmental separated from each other medially by two enlarged chin scales in NRC-AA-1231, NRC-AA-1233. Three paratypes — NRC-AA-1232, NRC-AA-1233, and NRC-AA-1235 with original and complete tails, slightly longer than body (TL/SVL 1.11, 1.27, and 1.30 respectively); tail entire but partially regenerated in NRC-AA-1234, NRC-AA-1236, and NRC-AA-1237, marginally to slightly longer than body (TL/SVL 1.08, 1.12, and 1.33 respectively); original tail entirely lost, small regenerated portion present in NRC-AA-1231. Ocelli on body between limb insertions are highly variable in all paratypes; original tail banded in all paratypes; regenerated tail orangish in life and yellowish-grey in preservative. (Fig. 18A).

**Distribution and Natural history.** *Cnemaspis pachaimalaiensis* **sp. nov.** is currently known only from around its type locality (near Mangalam waterfalls, Pachaimalai Hills, between an elevational gradient of ca. 600–1000 m asl.) in Trichy district, Tamil Nadu (Fig. 1). Like most other members of its clade, the new species is diurnal, rupicolous, and fairly abundant locally. At each collection site, many individuals ( $n = >20$ ) were observed active during the daytime (0900–1630 hrs) on rocks, road side rocky cuttings, and building walls below 2 m height, and under cement culverts in dry deciduous to semi-evergreen forest patches (Fig. 8D). Sympatric geckos encountered at the locality include *Cyrtodactylus* (*Geckoella*) sp., *Hemidactylus kolliensis* Agarwal, Bauer, Giri & Khandekar, *Hemidactylus leschenaultii*, *Hemidactylus whitakeri* Mirza, Gowande, Patil, Ambekar & Patel, *Hemidactylus parvimaculatus*, *Hemidactylus* cf. *frenatus*, and *Hemiphyllodactylus* sp.

### *Cnemaspis rudhira* **sp. nov.**

<https://zoobank.org/06b3772f-2903-49e1-b345-48b1e8f915d2>

Figs 18B–22; Tables 15–17

*Cnemaspis* cf. *gracilis* Khandekar et al. 2019

**Holotype.** NRC-AA-1238 (AK 566), adult male, from near Sri Salaiparai Muniappan Temple, Yercaud, in the Shevaroy hill range (11.7761°N, 78.1900°E; 1060 m asl.), Salem district, Tamil Nadu state, India, collected by Ak-

shay Khandekar, Swapnil Pawar, and Tejas Thackeray on 2<sup>nd</sup> January 2019.

**Paratypes.** NRC-AA-1246 (AK 567), adult male, NRC-AA-1247 (AK 568), adult female, same data as holotype; NRC-AA-1239 (AK 208), NRC-AA-1240 (AK 209), NRC-AA-1241 (AK 212) adult males, from Yercaud Ghat, in the Shevaroy hill range (11.7796°N, 78.1911°E; 1200 m asl.), and NRC-AA-1242 (AK 213) adult female (11.7655°N, 78.1884°E; 800 m asl.), collected by Akshay Khandekar, Ishan Agarwal, Nikhil Gaitonde, on 18<sup>th</sup> December 2018; NRC-AA-1243 (AK 539), NRC-AA-1244 (AK 541), NRC-AA-1245 (AK 543), adult males, from near Botanical garden, Yercaud, in the Shevaroy hill range (11.7810°N, 78.2035°E; 1400 m asl.), same collection data as holotype.

**Etymology.** The specific epithet is from the Sanskrit *rudhira* which means blood, alluding to the blood-red colouration of this beautiful species, and is used as a noun in apposition.

**Suggested Common Name.** Scarlet dwarf gecko.

**Diagnosis.** A small-sized *Cnemaspis*, snout to vent length up to 33.8 mm ( $n = 10$ ). Dorsal pholidosis heterogeneous; weakly keeled granular scales intermixed with a fairly regularly arranged rows of enlarged, strongly keeled, conical tubercles; last one or two rows of enlarged tubercles on flank weakly keeled, spine-like; 10–12 rows of dorsal tubercles at mid-body, 13–17 tubercles in paravertebral rows; ventral scales smooth, subcircular, subimbricate, subequal from chest to vent, 30–32 scales across belly at mid-body, 101–121 longitudinal scales from mental to cloaca; subdigital scansors smooth, mostly unpaired, unnotched; 8–11 lamellae under digit I of manus and pes; 14–17 lamellae under digit IV of manus and 17–21 lamellae under digit IV of pes; males with four or five femoral pores on each thigh separated by 6–9 poreless scales from series of 4–6 precloacal pores, precloacal pores separated medially by single (rarely 2,  $n = 1/8$ ) poreless scales; tail with enlarged, strongly keeled, pointed, and spine-like tubercles forming whorls; median row of subcaudals smooth, roughly rectangular, and distinctly enlarged. Dorsum orange, mottled with numerous small light grey spots and fine black spots with an indistinct series of light grey vertebral blotches extending from neck to tail base; single central black dorsal ocellus on neck and smaller ocellus on occiput, separated by a light grey blotch; venter off-white with black speckles, margin of throat strongly marked; original tail in males grey or with 9–11 alternating dark and light grey bands, regenerated tail orange.

**Comparison with members of *C. gracilis* clade.** *Cnemaspis rudhira* **sp. nov.** is a member of the *gracilis* clade and can be easily distinguished from all members of the clade by a combination of the following differing or non-overlapping characters: small-sized *Cnemaspis* with maximum SVL 34 mm (versus medium-sized *Cnemaspis*

**Table 15.** Mensural (mm) data for the type series of *Cnemaspis rudhira* **sp. nov.**. Abbreviations are listed in Materials and Methods. \* = incomplete tail.

Type	Holotype	Paratypes								
Museum number	NRC-AA-1238	NRC-AA-1239	NRC-AA-1240	NRC-AA-1241	NRC-AA-1242	NRC-AA-1243	NRC-AA-1244	NRC-AA-1245	NRC-AA-1246	NRC-AA-1247
Sex	Male	Male	Male	Male	Female	Male	Male	Male	Male	Female
SVL	32.3	32.9	32.1	30.5	27.9	33.8	31.5	33.5	33.7	29.8
TL	42.3	2.2*	12.1*	19.7*	16.7*	35.1	41.8	43.5	43.8	35.6
TW	3.3	3.3	3.3	3.0	2.3	3.2	3.0	3.1	3.0	2.7
LAL	4.9	4.9	4.7	4.5	3.7	4.9	4.4	4.9	5.0	4.1
CL	5.9	6.1	5.7	5.7	4.6	6.0	5.5	5.9	6.0	5.1
AGL	12.5	12.6	12.9	12.6	12.6	14.3	12.5	14.3	15.0	12.4
BH	3.5	3.4	3.4	2.6	2.2	3.1	2.4	3.7	3.1	3.0
BW	6.4	5.8	5.9	5.4	5.0	5.4	5.1	5.4	5.6	5.7
HL	8.0	8.6	8.1	7.6	7.0	8.3	8.0	8.1	7.4	7.3
HW	5.3	5.6	5.5	5.0	4.6	5.2	5.1	5.2	5.0	4.9
HD	3.8	3.7	3.6	3.2	2.5	3.4	3.1	3.5	3.7	3.5
ED	1.6	1.8	1.8	1.6	1.5	1.8	1.7	1.6	1.7	1.5
EE	2.5	2.6	2.5	2.4	2.1	2.5	2.5	2.4	2.3	2.4
ES	4.2	4.3	4.2	3.5	3.2	4.1	4.1	4.1	3.8	3.5
EN	3.3	3.2	3.4	3.0	2.7	3.4	3.3	3.3	3	2.9
IN	1.0	1.1	1.0	1.0	0.8	1.1	0.9	1	0.9	0.9
IO	1.3	1.1	1.1	1.0	0.7	1.1	1.4	1.5	1.3	1.1
EL	0.4	0.5	0.5	0.5	0.4	0.4	0.6	0.5	0.4	0.4

**Table 16.** Meristic data for the type series of *Cnemaspis rudhira* **sp. nov.**. Abbreviations are listed in Materials and Methods except for: L&R = Left & Right; abs. = absent; \* = lamellae incomplete.

Type	Holotype	Paratypes								
Museum number	NRC-AA-1238	NRC-AA-1239	NRC-AA-1240	NRC-AA-1241	NRC-AA-1242	NRC-AA-1243	NRC-AA-1244	NRC-AA-1245	NRC-AA-1246	NRC-AA-1247
Sex	Male	Male	Male	Male	Female	Male	Male	Male	Male	Female
SL (L&R)	10&11	7&9	9&9	9&10	7&7	10&10	9&8	10&10	10&9	8&8
IL (L&R)	8&9	7&7	9&8	8&8	6&7	8&10	7&7	10&7	8&9	7&6
SL M (L&R)	6&6	6&6	6&6	6&6	6&6	6&6	6&6	6&6	7&7	6&6
IL M (L&R)	5&5	5&5	5&5	5&6	6&5	5&6	5&6	6&6	5&5	5&5
PVT (L&R)	14&15	13&14	14&14	13&14	15&14	14&14	13&14	14&14	17&15	14&15
DTR	12	10	11	11	12	11	11	10	11	12
MVSR	31	32	31	32	31	32	30	31	31	30
VS	115	112	101	118	110	121	116	116	118	115
LamF1 (L&R)	11&10	9&9	9&9	10&10	9&9	11&11	9&9	10&10	8&8	10&10
LamF4 (L&R)	16&16	15&15	15&4*	17&16	15&15	17&16	14&15	15&16	16&15	16&16
LamT1 (L&R)	10&10	2*&11	10&10	10&9	9&9	11&10	9&10	10&11	8&8	10&10
LamT4 (L&R)	21&21	19&20	10*&19	19&19	19&20	19&20	17&17	19&20	17&18	20&20
LamT5 (L&R)	19&17	18&19	18&18	19&0*	17&18	20&19	18&17	19&19	16&17	18&17
PP L&R	2&2	2&2	2&2	3&3	abs.	2&2	2&2	2&2	2&2	abs.
SBPP	1	1	1	1	abs.	1	1	1	2	abs.
SB PP&FP (L&R)	9&9	8&8	6&6	7&7	abs.	8&8	7&7	8&7	7&7	abs.
FP (L&R)	4&4	4&4	5&4	5&5	abs.	5&4	5&4	5&5	5&5	abs.
SBFP	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.
PCT (L&R)	1&1	1&1	1&1	1&1	1&1	1&1	1&1	1&1	1&1	1&1

*pis*, SVL up to 41 mm in *C. thackerayi*, and *C. salimalii* **sp. nov.**; 13–17 tubercles in paravertebral rows (versus only a few irregularly arranged tubercles in paravertebral region in *C. mundanthuraiensis*, 11 or 12 in *C. jackieii*); 10–12 rows of dorsal tubercles at mid-body (versus eight

or nine rows of dorsal tubercles at mid-body in *C. jackieii*, 6–8 rows of dorsal tubercles at mid-body in *C. mundanthuraiensis*); spine-like tubercles present on flanks (versus spine-like tubercles absent on flanks in *C. agarwali*, *C. jackieii*, *C. shevaroyensis*, and *C. thackerayi*); 30–32



**Figure 18.** Paratype series: **A** *Cnemaspis pachaimalaiensis* sp. nov., from left to right, NRC-AA-1231–NRC-AA-1237; **B** *Cnemaspis rudhira* sp. nov., from left to right, NRC-AA-1239–NRC-AA-1247. Scale bar 10 mm; photos by Akshay Khandekar.

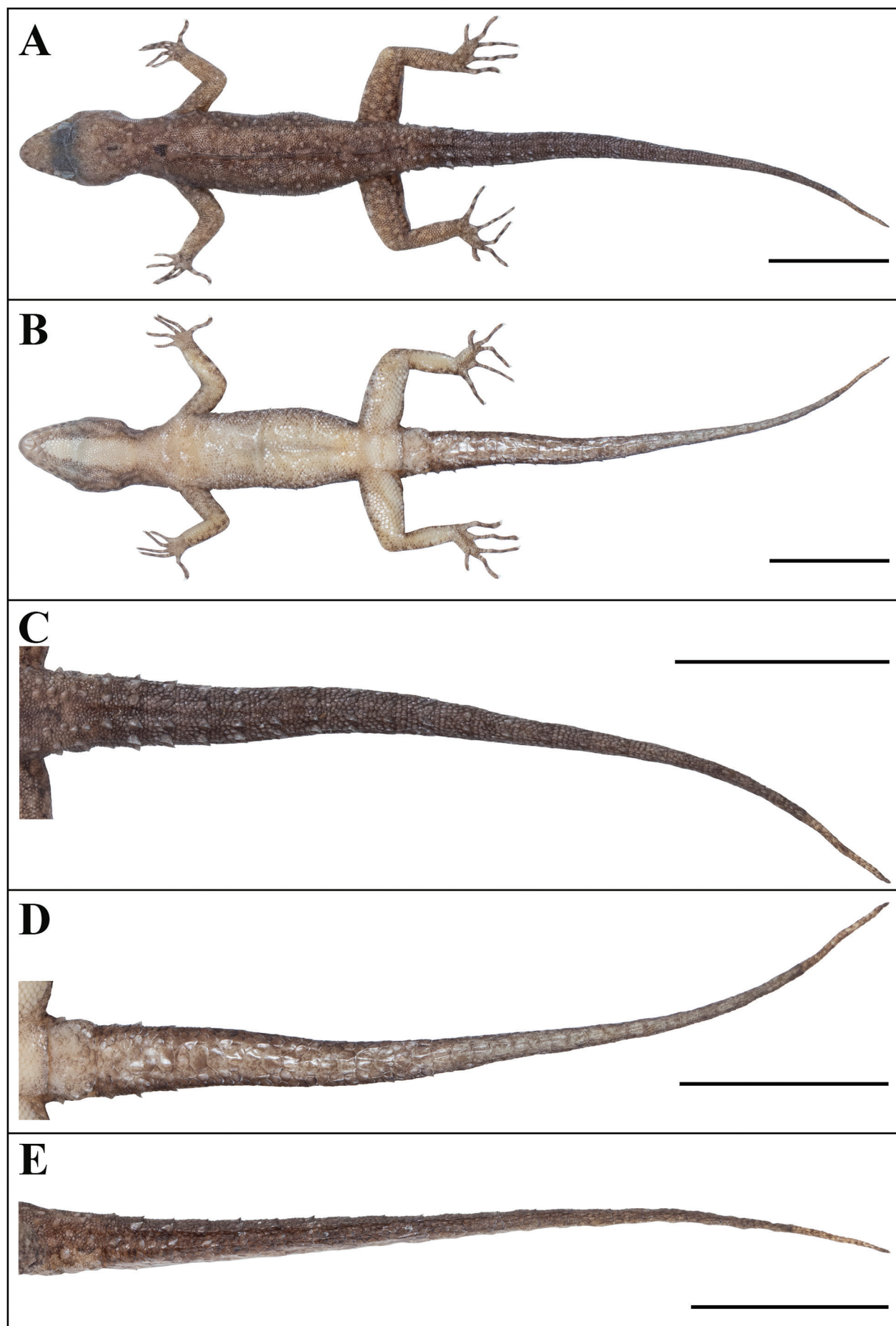


**Table 17.** Additional morphological character states evaluation for the type series of *Cnemaspis rudhira* **sp. nov.** abs. = absent; / = data unavailable.

Types	Holotype	Paratypes								
Museum number	NRC-AA-1238	NRC-AA-1239	NRC-AA-1240	NRC-AA-1241	NRC-AA-1242	NRC-AA-1243	NRC-AA-1244	NRC-AA-1245	NRC-AA-1246	NRC-AA-1247
Sex	Male	Male	Male	Male	Female	Male	Male	Male	Male	Female
Anterior extra-brilliar fringe scales enlarged (1) or not enlarged (0)	1	1	1	1	1	1	1	1	1	1
Ventral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0	0
Gular scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0	0
Pectoral scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0	0
Precloacal pores continuous (1) or separated (0)	0	0	0	0	abs.	0	0	0	0	abs.
Precloacal pores elongate (1) or round (0)	1	1	1	1	abs.	1	1	1	1	abs.
femoral pores elongate (1) or round (0)	1	1	1	1	abs.	1	1	1	1	abs.
Dorsal pholidosis homogeneous (1) or heterogeneous (0)	0	0	0	0	0	0	0	0	0	0
Dorsal tubercles keeled (1) or not keeled (0)	1	1	1	1	1	1	1	1	1	1
Tubercles linearly arranged (1) or more random (0)	1	1	1	1	1	1	1	1	1	1
Spine-like scales on flank present (1) or absent (0)	1	1	1	1	1	1	1	1	1	1
Lateral caudal furrows present (1) or absent (0)	1	/	/	1	/	/	1	1	1	1
Subcaudals keeled (1) or smooth (0)	0	/	/	0	/	/	0	0	0	0
Single median row of keeled subcaudals (1) or smooth (0)	0	/	/	0	/	/	0	0	0	0
Caudal tubercles encircle tail (1) or not (0)	1	/	/	1	/	/	1	1	1	1
Enlarged median subcaudal scale row (1) or not (0)	1	/	/	1	/	/	1	1	1	1
Enlarged femoral scales present (1) or absent (0)	0	1	1	1	0	1	1	0	1	1
Subtibial scales keeled (1) or smooth (0)	0	0	0	0	0	0	0	0	0	0
Occipital ocellus present (1) or absent (0)	1	0	0	1	1	0	0	P	P	P
Ocelli anterior of the shoulder present (1) or absent (0) & number	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Ocelli posterior of the shoulder present (1) or absent (0) & number	0	0	0	0	0	0	0	0	0	0
Original tail banded (1) or not (0)	0	/	1	0	/	0	0	0	1	0

ventral scales across belly at mid-body (versus 24–26 ventral scales across belly at mid-body in *C. agarwali*, 26–29 (rarely 30) in *C. gracilis*, 21–24 in *C. shevaroyensis*, and 22–25 in *C. thackerayi*); males with two (rarely 3) precloacal pore on each side which are separated medially by single (rarely 2) poreless scales (versus males with single (rarely 2) precloacal pore on each side which are separated medially by 2–4 poreless scales in *C. gracilis*; preclo-

acal pores either absent or single precloacal pores on each side which are separated medially by 2–4 poreless scales in *C. mundanthuraiensis*; males with continuous series of precloacal pores in *C. pachaimalaiensis* **sp. nov.**; single central dorsal ocellus each on occiput and neck (versus a single dorsal ocellus present on occiput and neck, two pairs on either side just anterior and sometimes posterior to forelimb insertions in *C. agarwali*; a single central



**Figure 19.** *Cnemaspis rudhira* sp. nov. (holotype, NRC-AA-1238): **A** dorsal aspect of body; **B** ventral aspect of body; **C** dorsal aspect of tail; **D** ventral aspect of tail; **E** lateral aspect of tail. Scale bars 10 mm; photos by Akshay Khandekar.

dorsal ocellus each on occiput and neck, ocellus on neck flanked anteriorly on each side by a slightly larger ocellus in *C. agayagangai* **sp. nov.**; a single central ocellus on neck, flanked posteriorly by a pair of much larger squarish blotches and anteriorly by a pair of subequal squarish blotches, indistinct spot on occiput in *C. fantastica* **sp. nov.**; a large central black dorsal ocellus on neck flanked anteriorly and posteriorly on each side by elongate dark ocelli, smaller ocellus on occiput flanked on each side by a smaller ocellus; indistinct rows of smaller dark ocelli may be present in *C. pachaimalaiensis* **sp. nov.**; a single dorsal ocellus present on occiput and neck, two pairs on either side just anterior and posterior to forelimb insertions in *C. shevaroyensis*.

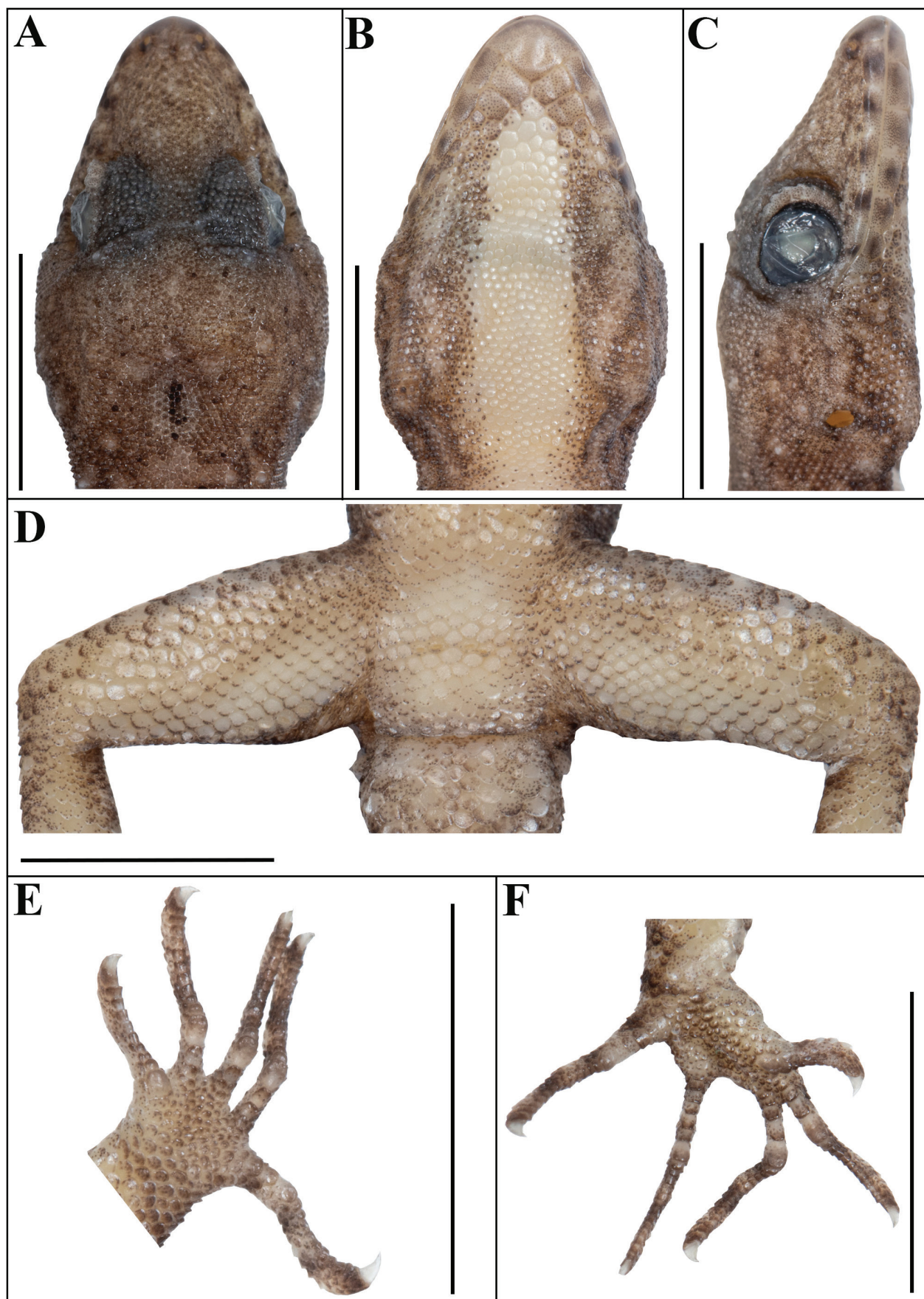
**Description of the holotype.** Adult male in good state of preservation except tail tip slightly bend towards left, longitudinal skin fold on vertebral region between limb insertions (Fig. 19A–E). SVL 32.3 mm, head short (HL/SVL 0.24), wide (HW/HL 0.66), not strongly depressed (HD/HL 0.47), distinct from neck. Loreal region marginally inflated, canthus rostralis not distinct. Snout half of head length (ES/HL 0.52), marginally more than 2.5 times eye diameter (ES/ED 2.6); scales on snout and canthus rostralis subcircular, subequal, and weakly keeled; much larger than those on forehead and interorbital region; scales on forehead similar to those on snout and canthus rostralis except smaller, elongated, and weakly conical; scales on interorbital region even smaller, granular and weakly keeled; scales on occipital and temporal region heterogeneous, slightly enlarged, weakly keeled, conical tubercles intermixed with smaller, weakly keeled and weakly conical granular scales (Fig. 20A). Eye small (ED/HL 0.20) with round pupil; supraciliaries short, larger anteriorly; six interorbital scale rows across narrowest point of frontal bone; 25 or 26 scale rows between left and right supraciliaries at mid-orbit (Fig. 20A, C). Ear-opening deep, oval, small (EL/HL 0.05); eye to ear distance greater than diameter of eye (EE/ED 1.50) (Fig. 20C). Rostral more than two times wider (1.56 mm) than high (0.72 mm), incompletely divided dorsally by a strongly developed rostral groove and internasal scale for more than half of its height; a single enlarged supranasal on each side, much larger than postnasals, separated from each other by a much smaller, elongated internasal scale and still smaller scale on snout; two postnasals, upper postnasal marginally larger than lower; rostral in contact with supralabial I, nostril, internasal, supranasal, and lower postnasal on either side; nostrils oval, surrounded by two postnasals, supranasal, and rostral on either side; two rows of scales separate orbit from supralabials (Fig. 20C). Mental enlarged, subtriangular, slightly wider (1.97 mm) than high (1.50 mm); two pairs of postmentals, inner pair roughly rectangular, much shorter (0.84 mm) than mental, in strong contact with each other below mental; inner pair bordered by mental, infralabial I, outer postmental, enlarged median chin shield on either side and an enlarged chin shield on left side; outer postmentals roughly rectangular, even smaller (0.63 mm) than inner pair, bordered by inner postmentals, infralabial I and II,

and three enlarged chin shields on either side and median chin shield on left side; three enlarged gular scales between left and right outer postmentals; all chin scales bordering postmentals flat, subcircular, smooth, and smaller than outermost postmentals; scales on rest of throat, even smaller, flattened, subequal, and smooth (Fig. 20B). Infralabials bordered below by a row or two of slightly enlarged, much elongated scales, decreasing in size posteriorly. Ten supralabials up to angle of jaw on left, 11 on right side, and six at midorbital position on each side; supralabial I largest, gradually decreasing in size posteriorly; eight infralabials up to angle of jaw on left and nine on right, five at midorbital position on either side; infralabial I largest, gradually decreasing in size posteriorly (Fig. 20C).

Body relatively slender (BW/AGL 0.51), trunk less than half of SVL (AGL/SVL 0.38) without ventrolateral folds; spine-like scales on flank present (Fig. 21A–C). Dorsal pholidosis heterogeneous; weakly keeled granular scales intermixed with a fairly regularly arranged row of enlarged, strongly keeled, conical tubercles; tubercles in approximately 12 longitudinal rows at mid-body including spine-like scales at lower flank; 14 (left) and 15 (right) tubercles in paravertebral row from above forelimb insertion to the hind limb insertion (Fig. 21A, C). Ventral scales much larger than granular scales on dorsum smooth, subcircular, subimbricate, subequal from chest to vent; mid-body scale rows across belly 31; 115 scales from mental to anterior border of cloaca (Fig. 21B). Scales on base of neck similar to those on belly, marginally smaller; gular region with still smaller, subequal, smooth, flattened scales, those bordering postmentals enlarged, smooth, subcircular, and flattened (Fig. 20B). Four femoral pores on either thigh, separated by nine poreless on either side from four precloacal pores, precloacal pores separated medially by a single poreless scale (Fig. 20D).

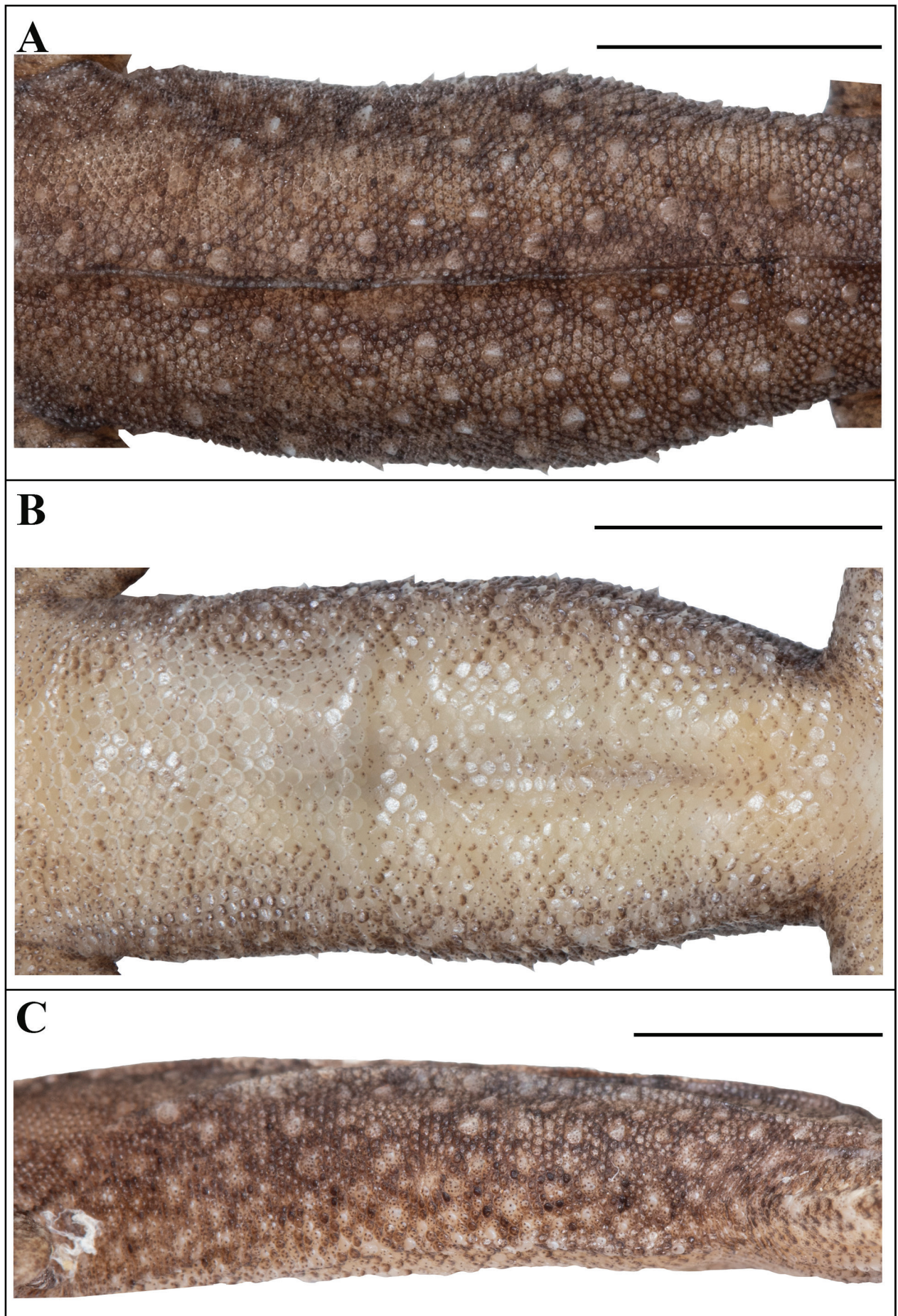
Scales on palm and soles granular, smooth, subcircular, subimbricate and flattened; scales on dorsal aspects of limbs heterogeneous in shape and size; mixture of small granular, weakly keeled, imbricate scales which are twice the size of granules on the body dorsum, largest on anterolateral aspect of the hands and feet; posterolateral aspect of limbs with small weakly keeled to smooth granular scales; scales on lower arm and shank small, subimbricate, and keeled; ventral aspect of forelimbs with small, smooth, subimbricate scales, larger on lower arm than upper arm; ventral aspect of hindlimb with enlarged, smooth, flattened, subimbricate scales, slightly larger than body ventrals (Fig. 19A, B). Forelimbs and hindlimbs moderately long, slender (LAL/SVL 0.15; CL/SVL 0.18); digits long, with strong, recurved claw, distinctly inflected, distal portions laterally compressed conspicuously. Digits with unpaired lamellae except basal one or two paired on some digits, separated into a basal and narrower distal series by single enlarged lamella at inflection; basal lamellae series: (1-4-4-4-4 right manus, 1-5-5-8-6 right pes), (2-3-4-4-3 left manus, Fig. 20E; 1-4-5-8-6 left pes, Fig. 20F); distal lamellae series: (9-10-13-12-10 right manus, 9-11-13-13-11 right pes), (9-10-12-12-10





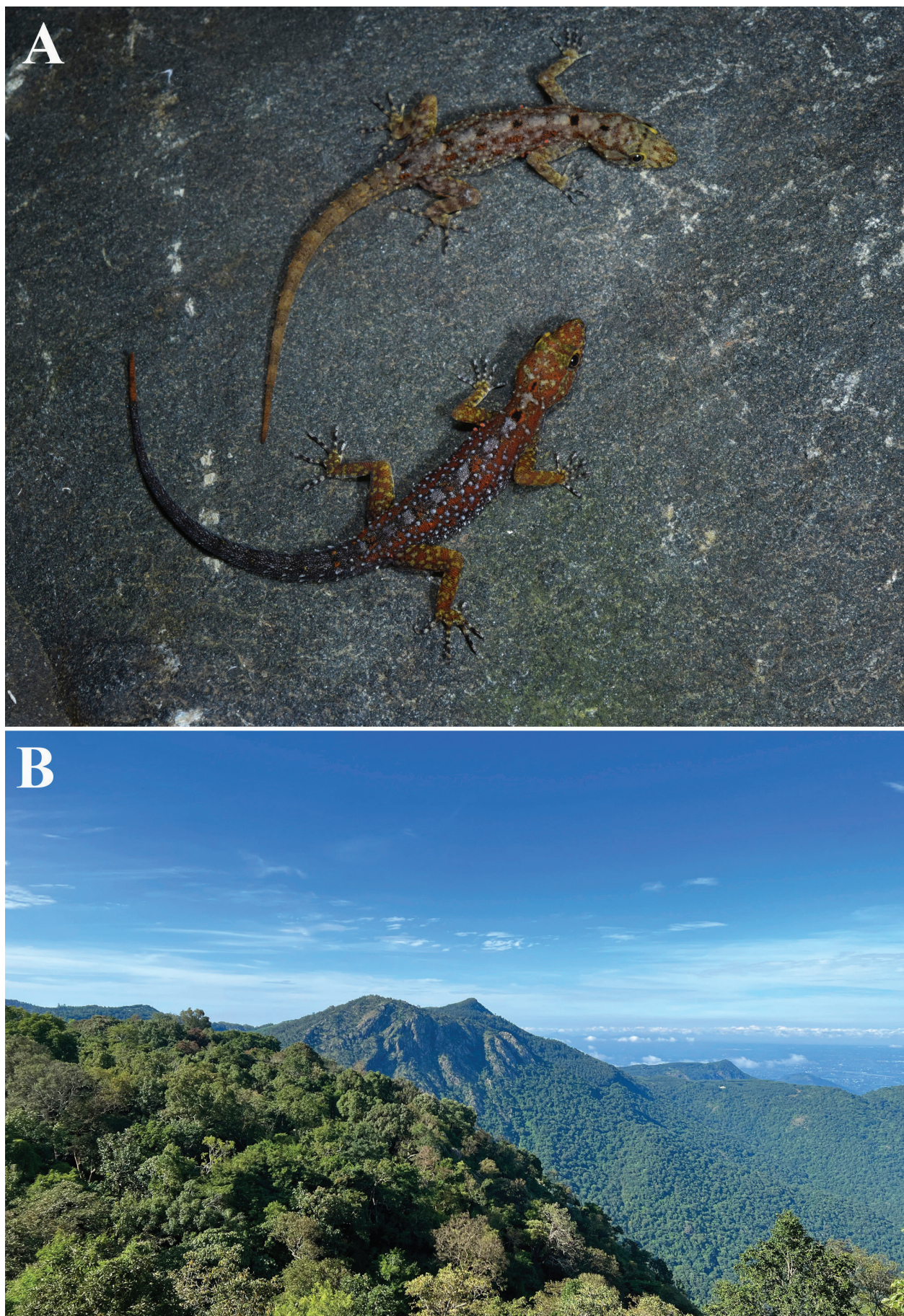
**Figure 20.** *Cnemaspis rudhira* sp. nov. (holotype, NRC-AA-1238): **A** dorsal aspect of head; **B** ventral aspect of head; **C** lateral aspect of right side head; **D** aspect of cloacal region showing precloacal and femoral pores; **E** ventral aspect of left manus; **F** ventral aspect of left pes. Scale bars 5 mm; photos by Akshay Khandekar.





**Figure 21.** *Cnemaspis rudhira* sp. nov. (holotype, NRC-AA-1238): **A** dorsal aspect of mid-body; **B** ventral aspect of mid-body; **C** right side lateral aspect of mid-body. Scale bars 5 mm; photos by Akshay Khandekar.





**Figure 22.** A Colouration in life of *Cnemaspis rudhira* sp. nov. showing sexual dichromatism: **top** adult female (paratype, NRC-AA-1247), **bottom** adult male (holotype, NRC-AA-1238), photo by Tejas Thackeray; **B** Habitat at the type locality of *Cnemaspis rudhira* sp. nov. showing general habitat, rocky outcrop in evergreen forest. Photo by Akshay Khandekar.



left manus, Fig. 20E; 9-11-14-13-13 left pes, Fig. 20F). Relative length of digits (measurements in mm in parentheses): IV (2.6) > III (2.4) > II (2.3) = V (2.3) > I (1.9) (left manus); IV (3.9) > V (3.3) > III (3.2) > II (2.9) > I (1.8) (left pes).

Tail original except tip (5.1 mm) which is regenerated, entire, subcylindrical, slender, slightly longer than snout-vent length (TL/SVL 1.30; Fig. 19C–E). Dorsal scales on tail base weakly keeled, granular, similar in size and shape to granular scales on mid-body dorsum, gradually becoming larger, flattened, imbricate posteriorly, intermixed with enlarged, strongly keeled, distinctly pointed, conical tubercles; enlarged tubercles on the tail forming whorls; six tubercles each on first eight whorls, four in 9–12th whorls, rest of the tail with only paravertebral tubercles except original and regenerated portion of the tail lacking enlarged tubercles (Fig. 19C, E). Scales on ventral aspect of tail much larger than those on dorsal aspect, subimbricate, smooth; median series distinctly larger than rest, roughly rectangular; scales on tail base slightly larger than those on mid-body ventrals, smooth, imbricate; a single enlarged, weakly keeled and conical postcloacal spur on each side (Fig. 19D).

**Colouration in life (Fig. 22).** Dorsum of head, body, limbs and tail base orange. Head with numerous light grey and yellow blotches and fine black spots, light grey and dark bands on labials; indistinct grey postorbital streaks. A single central black dorsal ocellus on neck and a smaller one on occiput separated by a larger light grey blotch, both ocelli with an orange margin. Dorsum with numerous light-grey spots and fine black spots and six light grey vertebral blotches from forelimb insertions to tail base. Dorsum of limbs with yellow reticulation, digits with alternating dark and light bands. Tail grey with an orange regenerated tip. Venter off-white with black speckles, margin of throat strongly marked.

**Variation and additional information from type series.** Mensural, meristic and additional character state data for the type series is given in Tables 15–17 respectively. There are seven adult male and two adult female specimens ranging in size from 27.9–33.8 mm (Fig. 18B). All paratypes resemble holotype except as follows: supranasals in strong contact with each other behind internasals on snout in NRC-AA-1243. Upper postmentals separated from each other below mental by enlarged median chin shield in NRC-AA-1246; upper postmentals bordered by mental, infralabial I, outer postmental, median chin shield, and additionally by a single large chin scale on either side in NRC-AA-1239, NRC-AA-1241, NRC-AA-1245; upper postmental bordered by both infralabial I & II on left and a single large chin scale on either side in NRC-AA-1240, and NRC-AA-1246. Outer postmental bordered by inner postmental, infralabials I & II and additionally, four chin scales on left and three on right side in NRC-AA-1239, NRC-AA-1241, NRC-AA-1244, NRC-AA-1247, four chin scales on either side in NRC-AA-1243; outer postmental bordered by inner postmental, infralabials I (on left), and

four chin scales on either side in NRC-AA-1240, NRC-AA-1246; outer postmental separated from each other medially by two enlarged chin scales in NRC-AA-1242, NRC-AA-1243, and NRC-AA-1247. Four paratypes — NRC-AA-1244, NRC-AA-1245, NRC-AA-1246, and NRC-AA-1247 with original and complete tails, slightly longer than body (TL/SVL 1.32, 1.29, 1.29, and 1.19 respectively); NRC-AA-1243 with complete but fully regenerated tail, almost equal to the body (TL/SVL 1.03); NRC-AA-1240 and NRC-AA-1241 with partial but original tail; tail almost entirely lost in NRC-AA-1239 and NRC-AA-1242. Original tail distinctly banded only in two male paratypes — NRC-AA-1240 and NRC-AA-1246 (Fig. 18B).

**Distribution and Natural history.** *Cnemaspis rudhira* sp. nov. is known from a broad elevation gradient of ca. 800–1400 m asl. around its type locality, Yercaud, in the Shevaroy hills, Salem district, Tamil Nadu (Fig. 1). The new species was observed to be diurnal, scansorial, and locally highly abundant. At each collection site, many individuals ( $n = >30$ ) were observed active during the daytime (0900–1430 hrs) on rocks, cement walls, trees, inside cement culverts etc. all below 2–3 m height in moist deciduous to evergreen forest patches (Fig. 22). Individuals of the new species were observed both daytime and at night in large numbers across the elevation gradient, along the ghat road leading to Yercaud town. Sympatric geckos encountered at the locality include *Cnemaspis yercaudensis*, *Cnemaspis thackerayi*, *Cyrtodactylus* (*Geckoella*) sp. *Hemidactylus* cf. *graniticus*, *Hemidactylus leschenaultii*, *Hemidactylus parvimaculatus*, *Hemidactylus* cf. *frenatus*, *Hemidactylus whitakeri*, and *Hemiphyllodactylus aurantiacus* (Beddome).

## Discussion

The description of these five new species from the Shevaroy Group of hills in southern India brings the number of *Cnemaspis* species known from peninsular India outside the Western Ghats to 23 and from the *gracilis* clade to 11. Seven divergent lineages of the *gracilis* clade are now known from three hill blocks that are < 70 km from one another, with three lineages each in Yercaud and Kollimalai, the two largest massifs. The massif of Yercaud rises from < 350–1623 m asl, Kollimalai from < 200–1400 m asl, and Pachaimalai from < 200–1000 m, each < 500 km<sup>2</sup> in area. Though at a relatively small spatial scale, the incredibly high microendemism within a single clade in a continental setting is perhaps comparable in sheer numbers of species per unit area to only a few squamate radiations on large continental islands such as *Bavayia* Roux, *Dierogecko* Bauer, Jackman, Sadlier & Whitaker and *Nannoscincus* Günther on Grand Terre in New Caledonia (Bernstein et al. 2021), numerous radiations in Madagascar (Vences et al. 2009; Uetz et al. 2022), *Cnemaspis* sensu stricto in Southeast Asia (Gris-

mer et al. 2014) and South Asian *Cnemaspis* in Sri Lanka (Karunaratna et al. 2023). Additionally, 12 microendemic karst species of *Cyrtodactylus* Gray are distributed within 90 km of one another in the Salween Basin of Myanmar (Grismer et al. 2018). There is a need for fine scale surveys in unexplored and previously surveyed areas to fully understand patterns of diversity and distribution in this incredibly diverse clade of geckos.

Potential explanations for the high level of diversity and microendemism seen in the *gracilis* clade in the Shevaroy landscape include the role of elevation and intrinsic habitat heterogeneity, dispersal, and sexual selection. These mountains are known to form part of a sky-island complex for geckos of the genus *Hemiphylodactylus* with very different forests and climate from the surrounding lowland habitats (Agarwal et al. 2019b). The timing of initial diversification within the *gracilis* clade as estimated by Agarwal et al. (2020b) was in the middle Miocene, the start of strong seasonality and aridification in peninsular India which is likely to have caused the fragmentation of once relatively contiguous tropical forest (Morley 2007; Pound et al. 2012), likely disproportionately impacting the most cool-adapted, forest-dwelling taxa (as for example high elevation species). These massifs appear to have acted as long term refugia for members of this clade, with complex patterns of dispersal between them and other parts of the range of the *gracilis* clade.

*Cnemaspis fantastica* **sp. nov.** and its sister taxon *C. shevaroyensis* have the lowest genetic divergence within known species of Indian *Cnemaspis* at 4.6%. Though a 5 % p-distance cut-off has been proposed as indicative of species divergence in gekkonids (e.g., Grismer et al. 2013), a finer 3.7 % cut-off was suggested for the Sri Lankan clades of South Asian *Cnemaspis* based on the lowest divergence between named, morphologically diagnosable species (Agarwal et al. 2017). Additional morphologically distinct *Cnemaspis* species have been described since show < 5% genetic divergence from their respective sister species (e.g., Batuwita et al. 2019; Karunaratna et al. 2019). Lending support to the specific status of *Cnemaspis fantastica* **sp. nov.** is the fact that strong morphological characters separate it from its sister taxon *C. shevaroyensis* — the presence vs absence of spinelike tubercles and 28–32 scales across the belly versus 21–24 (integration by congruence, sensu Padi-al et al. 2010). In addition, none of the members of the *gracilis* complex are known from multiple massifs in this landscape, and the low hills separating massifs have additional undescribed species (Khandekar, Thackeray and Agarwal, unpubl. data).

All the species of the *gracilis* clade are sexually dichromatic, males in general with much brighter dorsal colouration, dark ocelli on the forebody, strong markings on the throat and a strongly banded tail, apart from the two medium-bodied species that are restricted to high elevations, *C. salimalii* **sp. nov.** and *C. thackerayi* which are less striking in the differences between sexes. As these species are conspicuously diurnal, there is a potential role for sexual selection based on visual traits to drive diver-

sification within the group (Darwin 1859). Chemical signalling is known in South Asian *Cnemaspis*, and visual traits have been established in intraspecific communication for at least a few species, though those studies only evaluated gular or gular and brille colouration (Kabir et al. 2019, 2020). Preliminary observations suggest members of the *gracilis* clade are often found in pairs consisting of a single male and female, but quantitative data is needed to ascertain if this is true and what the role of sexual selection, if any, is in the formation of pairs and how this may drive diversification. It is striking that there are two pairs of cryptic, non-sister taxa, *C. fantastica* **sp. nov.** + *C. agayagangai* **sp. nov.** and *C. rudhira* **sp. nov.** + *C. gracilis*, each pair of which overlaps in practically all aspects of their morphology, differing mainly in male colouration.

The ancestral state for colour pattern of the forebody (in males) appears to be a single, central ocellus on the neck (seen in *C. salimalii* **sp. nov.** and *C. thackerayi*), and the most common colour pattern is a single, central ocellus each on the neck and occiput (seen in *C. gracilis*, *C. mundanthuraiensis* and *C. rudhira* **sp. nov.**; *C. jackieii* has two additional small lateral ocelli). The remaining species have multiple ocelli on the neck (*C. agarwali* and *C. agayagangai* **sp. nov.**) or multiple ocelli on the neck and between forelimbs (*C. fantastica* **sp. nov.**, *C. pachaimalaiensis* **sp. nov.** and *C. shevaroyensis*). Though our phylogeny does not receive high support at more basal nodes and is based on a partial fragment of one mitochondrial gene, both multi-ocellate and two single central ocelli-bearing morphs occur in multiple, well-supported clades within the phylogeny. Understanding the evolution of colour pattern in this diverse clade needs more sampling of genes and taxa.

Other geckos within this landscape show contrasting patterns of distribution — *Cnemaspis yercaudensis* from the *mysoriensis* clade of South Asian *Cnemaspis* is a truly widely distributed mid to high elevation species, with little genetic structure or morphological differentiation between populations in the Shevaroy landscape (Ganesh and Arumugam 2016; Khandekar et al. 2019); *Hemidactylus kolliensis* is found in both Kollimalai and Pachaimalai while divergent lineages of the *Hemidactylus graniticolus* complex are found in Yercaud and Kollimalai (Agarwal et al. 2019a); the genus *Hemiphylodactylus* has a different endemic species each in Yercaud, Kollimalai and Pachaimalai (Agarwal et al. 2019b; Agarwal, Thackeray and Khandekar unpubl. data). These are all our recent records from the region, as previous records apart from original descriptions of taxa are scanty and many did not include specimens. For example, records of an undescribed *Cnemaspis* with three precloacal pores and three or four femoral pores from <1350 m the Shevaroy and Kolli Hills, in addition to *C. yercaudensis* Bauer & Das, the only non *gracilis* clade *Cnemaspis* known from these hills, may represent *C. salimalii* **sp. nov.** from the Kolli Hills and *C. fantastica* **sp. nov.** from the Shevaroy, but this cannot be ascertained as no photographs were provided nor specimens collected (Ganesh and Arumugam 2016).



## Conservation status

These new species join a large proportion of gekkonid species known only from their type localities (23 %, Meiri et al. 2018; though that analysis considered the type locality to have a maximum latitudinal and longitudinal extent of < 10 km). We surveyed the vicinity of the type localities of all seven species found in the Shevaroy landscape and found that *C. rudhira* **sp. nov.** is widely distributed across the elevational gradient in Yercaud, *C. thackerayi* and *C. salimalii* **sp. nov.** are widely distributed on the high elevation plateaus at their respective type localities, while the other three species are extremely local in distribution, each of which is found in only one or a few closely spaced localities on their respective massifs. This implies that each of these species would qualify as critically endangered under IUCN's criterion B1 of extent of occurrence < 100 km<sup>2</sup>, meeting subcriterion a. (known from a single location) and b. (iii) (potential for a decline in habitat quality) (IUCN 2012). *Cnemaspis shevaroyensis* and *C. thackerayi* are currently listed as critically endangered while *C. yercaudensis* is endangered (IUCN 2022).

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## Appendix 1

### Material examined.

Institutional abbreviations are as follows: National Centre for Biological Sciences, Bengaluru (NCBS-AU/ NCBS-BH/NRC-AA/ Akshay Khandekar field series [AK/ AK R]); Bombay Natural History Society, Mumbai (BNHS); Centre for Ecological Sciences, Bangalore (CES G).

*Cnemaspis agarwali*: holotype, NCBS-AU486 (adult male); paratypes, NCBS-AU487, BNHS 2337, NCBS-AU488, NCBSAU490, and BNHS 2338, (adult males), NCBS-AU485, BNHS 2336, and BNHS 2339, (adult females), from Sankari, Salem District, Tamil Nadu, India.

*Cnemaspis gracilis*: CESG385 from Chittur River, Palakkad District, Kerala, India. AK 133, AK 134, AK 135, AK 136, AK 137, AK 138, AK 139, AK 140, AK 141, AK 142, AK 143, AK 144, from Valparai, Coimbatore District, Tamil Nadu, India.

*Cnemaspis shevaroyensis*: holotype, NCBS-BH674 (adult male); paratypes, BNHS 2530, BNHS 2531, (adult males), NCBS-BH675, NCBS-BH676, BNHS 2529, (adult females) from the Shevaroy hills, Salem District, Tamil Nadu, India.

*Cnemaspis thackerayi*: holotype, NCBS-BH670 (adult male); paratypes, NCBS-BH671, BNHS 2527, (adult males), NCBS-BH672, NCBS-BH673, BNHS 2526, BNHS 2528, (adult females) from Yercaud, in Shevaroy hills, Salem District, Tamil Nadu, India.

*Cnemaspis mundanthuraiensis*: holotype, NRC-AA-1175 (adult male); paratypes, NRC-AA-1176, NRC-AA-1177, NRC-AA-1178, BNHS 2822, BNHS 2824, and BNHS 2825, (adult males), BNHS 2823, (adult female), NRC-AA-1179, (subadult female) from Papanasam reserve forest, Mundanthurai forest range, Kalakad Mundanthurai Tiger Reserve, Tirunelveli district, Tamil Nadu state, India.