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A preliminary 16S rRNA phylogeny of the Indian *Cnemaspis* Strauch, 1887 (Squamata: Gekkonidae) with the description of two new cryptic species from the *C. wynadensis* clade

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Abstract

Two new species of geckos of the genus *Cnemaspis* Strauch, 1887 are described from the Western Ghats of Kerala using an integrated taxonomic approach employing phylogenetic and multivariate morphometric methods. We provide a preliminary 16S rRNA tree of the Indian *Cnemaspis* and ascertain the phylogenetic placement of the two new species within the *wynadensis* clade. Our morphometric analysis indicates that, although there was overlap in the morphospace across species, the morphospace occupied by the two new species were considerably different from most other species within the *wynadensis* clade. Both the species Viz. *C. zacharyi* **sp. nov.** and *C. chengodumalaensis* **sp. nov.** are medium to large-sized *Cnemaspis* and are genetically and morphologically distinct from other Indian congeners. Both species are predominantly found in rocky outcrops within forested patches outside protected areas in north Kerala, which are currently under threat from illegal quarrying and other unplanned developmental activities. The discovery of these novel species outside protected areas highlights the conservation value of rocky outcrops outside Wildlife Sanctuaries and National Parks and calls for urgent need to document species across protected and non-protected areas of the Western Ghats as well as the midland hillocks of Kerala.

Key words

Conservation, day geckos, integrative taxonomy, new species, non-protected areas, Western Ghats.

Introduction

The genus *Cnemaspis* Strauch, 1887 is a highly speciose old-world gekkotan genera within Gekkonidae, with more than 150 known species (Uetz *et al.*, 2019). Currently, the genus *Cnemaspis* is polyphyletic with large-scale molecular phylogenies recovering three distantly related clades – an African clade, a southeast Asian clade and a south Asian clade (Gamble *et al.*, 2012; Pyron *et al.*, 2013; Zheng & Wiens, 2016). With a recent taxonomic revision in the South Asian clade (Manamendra-Arachchi *et al.*, 2007), there has been an upsurge in documenting species of *Cnemaspis* within India and Sri Lanka (Agarwal *et al.*, 2017; Iskandar *et al.*, 2017; Cyriac *et al.*, 2018; Sayyed *et al.*, 2018), with around 15 species described from India in the last five years. Together, these studies indicate that the diversity within *Cnemaspis* remains largely underestimated (Cyriac & Umesh, 2014; Srinivasulu *et al.*, 2015; Cyriac *et al.*, 2018; Sayyed *et al.*, 2018; Khandekar, 2019; Khandekar *et al.*, 2019).

Although the genus *Cnemaspis* has a wide distribution in mainland India, most of the species are restricted to the forests and adjacent low-lying areas of the Western Ghats. Studies also indicate that most species of *Cnem-*

aspis within the Western Ghats occupy narrow distributional ranges and likely harbour cryptic diversity (Cyriac & Umesh, 2014; Sayyed *et al.*, 2018; Khandekar *et al.*, 2019). Recent phylogenetic analyses based on single mitochondrial genes have shed some light on the relationships between the Indian *Cnemaspis* and have allowed classifying species into broader taxonomic clades based on phylogenetic position (Sayyed *et al.*, 2016, 2018; Khandekar *et al.*, 2019). However, these studies have predominantly sampled species from the northern and central Western Ghats with low representation of members from the southern Western Ghats and adjacent midland hillocks.

Here, based on fresh specimens collected from midland hillocks and forests of the Western Ghats in the Kerala region, we reconstruct a preliminary 16S rRNA phylogeny of the Indian *Cnemaspis*. Our sampling also revealed two medium to large-sized cryptic species of *Cnemaspis* resembling *C. sisparensis* (Theobald, 1876) and allied to *C. wynadensis* (Beddome, 1870). Thus, using DNA sequence data obtained from the 16S rRNA gene and morphological data, we evaluate the taxonomic status of members of the *wynadensis* clade. The *wynadensis* clade currently includes *C. heteropholis* Bauer, 2002, *C. kolhapurensis* Giri, Bauer & Gaikwad, 2009, *C. kottiyoorensis* Cyriac & Umesh, 2014, *C. sisparensis* and *C. wynadensis*, and is defined by their medium to large adult size (30–65 mm SVL), absence of spine-like tubercles on the flanks, presence of only 4–8 femoral pores or a series of 24–28 femoral-precloacal pores and the absence of whorls of tubercles on the tail. We hereby show that the two medium to large-sized cryptic species are genetically and morphologically distinct from other closely related members of the *wynadensis* clade and describe the two species as *C. zacharyi* **sp. nov.** and *C. chengodumalaensis* **sp. nov.**

Methodology

We carried out field surveys in the Western Ghats of Kerala and Karnataka states between 2013 to 2019. Specimens from various locations were photographed, euthanized, and fixed in 10% formalin solution and then transferred to 70% ethanol. Tail clips or liver tissue were collected from representative specimens and preserved in absolute ethanol for further DNA extraction. Additional morphological data for *Cnemaspis* species were sourced from descriptions of Inger *et al.* (1984), Das & Bauer (2000), Bauer (2002), Giri *et al.* (2009), Cyriac & Umesh (2014), Mirza *et al.* (2014), Srinivasulu *et al.* (2015), Cyriac *et al.* (2018), Cyriac *et al.* (2019), Khandekar (2019), Khandekar *et al.* (2019), Murthy *et al.* (2019), Sayyed *et al.* (2016) and Sayyed *et al.* (2018) and from a taxonomic review of the south Asian *Cnemaspis* by Manamendra-Arachchi *et al.* (2007). Opportunistic natural history observations were made during our field visits. The Phylogenetic and morphometric data can be accessed with the Figshare DOI: 10.6084/m9.figshare.11987877.

DNA extraction and phylogenetic reconstruction

Total genomic DNA was extracted using the Quigen DNeasy Blood and Tissue kit following their protocol. We amplified the mitochondrial 16S rRNA gene with standard 3-step PCR protocol (Palumbi, 1996) using primers designed by Palumbi *et al.* (1991). Both forward (F) and reverse (R) primers were attached with universal primer tails – T7 (F) and T3 (R) promoters for PCR amplification. PCR products were checked on an agarose gel, purified with ExoFastAP (Thermo Scientific™) and Sanger sequenced using the forward primer tails.

Phylogenetic analyses

We generated a total of 11 additional sequences of the 16S rRNA gene for *Cnemaspis* species collected from the central and southern Western Ghats. Sequences of the 16S rRNA gene of other *Cnemaspis* species from India generated by Sayyed *et al.* (2018) and their outgroups were obtained from Genbank (Appendix 1). All sequences were aligned using the muscle algorithm (Edgar, 2004) implemented in mega7 (Kumar *et al.*, 2016). Columns that contain 75% or more gaps in the alignment were removed using gap strip/squeeze v 2.1.0 (http://www.hiv.lanl.gov) by setting the gap tolerance at 75%. The final gene dataset contained 64 sequences of 524 bp. A Maximum Likelihood analysis was carried out in raxml gui v 1.3 (Silvestro & Michalak, 2012) with 1000 bootstrap replicates using default parameters on the unpartitioned 16S rRNA dataset.

We also compared the uncorrected pairwise sequence divergence between the 16S rRNA sequences of the *wynadensis* clade using mega7 (Kumar *et al.*, 2016). Sequence divergences were calculated after removing columns with 75% or more gaps.

Morphological data

To examine the morphological distinctiveness between species in the *wynadensis* clade, we collected a set of 22 morphometric variables from samples collected by us during fieldwork. We also collected morphological data from type specimens of *C. sisparensis*, *C. kottiyoorensis* and *C. kolhapurensis* deposited at the Zoological Survey of India (ZSI), Kolkata, Natural History Museum, Trivandrum (TMNH) and the Bombay Natural History Society (BNHS), Mumbai. The types examined for *C. sisparensis* included the types of *C. anaikattiensis* Mukherjee, Bhupathy & Nixon, 2005, and the holotype of *Gonatodes bireticulatus* (Annandale, 1915), both of which are junior synonyms of *C. sisparensis* (Manamendra-Arachchi *et al.*, 2007; also see discussion section).We also examined other species belonging to the *wynadensis* clade deposited at ZSI and BNHS (see Appendix 2). Morphometric measurements were taken ei-

ther using a Mitutoyo 500 or a Yuri Silver, Japan digital vernier calliper (to the nearest 0.1mm) from preserved specimens. Measurements included: SVL, snout to vent length; AG, axilla to groin distance; TW, trunk width; ED, eye diameter; EN, eye to nostril distance; ES, snout length; ET, eye to ear distance; IN, internarial distance; TD, diameter of ear opening; HL, head length; HW, head width; HD, head depth; IO, interorbital distance; UAL, upper arm length; LAL, lower arm length; PAL, palm length; FL, finger length; FEL, femur length; TBL, tibia length; TOL, toe length; TL, tail length; TBW, tail base width. Measurements follow the definitions provided in Cyriac & Umesh (2013). Meristic data recorded included the number of supralabials (SL) and infralabials (IL) on the left (L) and right (R) side; subdigital lamellae on digit I and IV of manus (LamM) and pes (LamP), arrangement of dorsal scales (DS), number of mid-ventral scale rows (MVS) across the belly, and the number of femoral pores (FP) on the left and right femur and the number of poreless scales between femoral pores (PLFP). Overall, we obtained data for four specimens of *C. heteropholis*, nine specimens of *C. kolhapurensis*, six specimens of *C. kottiyoorensis*, three specimens of *C. sisparensis*, seven specimens of *C. wynadensis* and nine specimens each of the two new species described here. Specimens were deposited at ZSI-WRC, Pune, Maharashtra and BNHS, Mumbai.

Morphometric analyses

All analyses were carried out in r v. 3.5.2 (R Core Team, 2016). We carried out multivariate analyses on the 22 morphometric variables (see Appendix 3). Since it is recommended that morphometric and meristic data should not be analysed together due the statistical differences associated with the type of data (Seal, 1964), we performed the multivariate analyses using only morphometric data and not the meristic data. To test if there was overlap in morphospace between different species of the *wynadensis* clade, we performed a Principal Component Analysis (PCA) to reduce the dimensionality of the data and to identify the variables that contribute to the variation in the data. We plotted the first two Principal Components (PCs) using the r package factoextra v. 1.0.5 (Kassambara & Mundt, 2017) to visually examine the morphospace between species.

Results

Phylogenetic relationship

The Maximum Likelihood analysis recovered a topology with most deeper nodes being well supported, while shallower nodes were less supported. The analysis indicated that all Indian *Cnemaspis* formed a clade (Fig. 1). Interestingly, *C. nilagirica* was recovered as sister to all other Indian *Cnemaspis*, although, with low support. The *wynadensis* clade consisting of *C. heteropholis*, *C. kolhapurensis*, *C. kottiyoorensis*, *C. wynadensis* and the two new species identified by our molecular and morphometric analyses (*C. zacharyi* **sp. nov.** and *C. chengodumalaensis* **sp. nov.**) were recovered as sister to the rest of the Indian *Cnemaspis* (excluding *C. nilagirica*) with moderate support (Fig. 1). The southern Western Ghats clade consisting of *C. anamudiensis* and two other species of *Cnemaspis*, all of which are medium to large-sized species with males possessing only pre-cloacal pores, are recovered sister to the *C. littoralis* + (*giri* clade + (*indica* clade + ((*gracilis* clade + *goaensis* clade) + *C. amboliensis*)) clade with high support. Within the *wynadensis* clade, there is strong support for a basal split between *C. kolhapurensis* and other members of the *wynadensis* clade. There is moderate support for a sister relationship between *C. zacharyi* **sp. nov.** and a clade containing *C. kottiyoorensis*, *C. heteropholis*, *C. wynadensis* and *C. chengodumalaensis* **sp. nov.** (Fig. 1). Although there was strong support for a split between *C. kottiyoorensis* and (*C. heteropholis* + *C. wynadensis* + *C. chengodumalaensis* **sp. nov.**) clade, the relationships between species in the latter clade are not well resolved and have very low support values.

Genetic distance within *wynadensis* clade

Uncorrected pairwise genetic distance of the 16S rRNA gene estimated for the *wynadensis* clade indicated that *Cnemaspis kolhapurensis* and *C. zacharyi* **sp. nov.** are deeply divergent from each other (8.9–9.1% sequence divergence) and the rest of the *wynadensis* clade (*C. kolhapurensis:* 9.5–11.1% sequence divergence; *C. zacharyi* **sp. nov.**: 7.1–9.3% sequence divergence) (Table 1). Sequence divergence between *C. chengodumalaensis* **sp. nov.** and the rest of the *wynadensis* clade (excluding *C. kolhapurensis* and *C. zacharyi* **sp. nov.**) ranged from 3.7–5.5%. Between species sequence divergence estimated for *C. wynadensis*, *C. kottiyoorensis* and *C. heteropholis* ranged from ca. 3.8–5.6%. Intraspecific sequence divergence was around 0.2 % for *C. kolhapurensis*, 0.8–1.2% for *C. kottiyoorensis* and 0.2 % for *C. zacharyi* **sp. nov.** However, intraspecific sequence divergence between *C. heteropholis* was around 5% (Table 1).

Morphometric analyses

Principal Component Analysis indicated that most of the variability in morphology was explained by the first two principal components (PCs) (91.4 % of the variation). PC1 explained ca. 88.1 % of the variance and was highly correlated to all the morphological variables. PC2 explained only ca. 3.3 % of the variance and described a short head with smaller ear opening (see Appendix 3). Plotting the first two PCs indicated differences in the

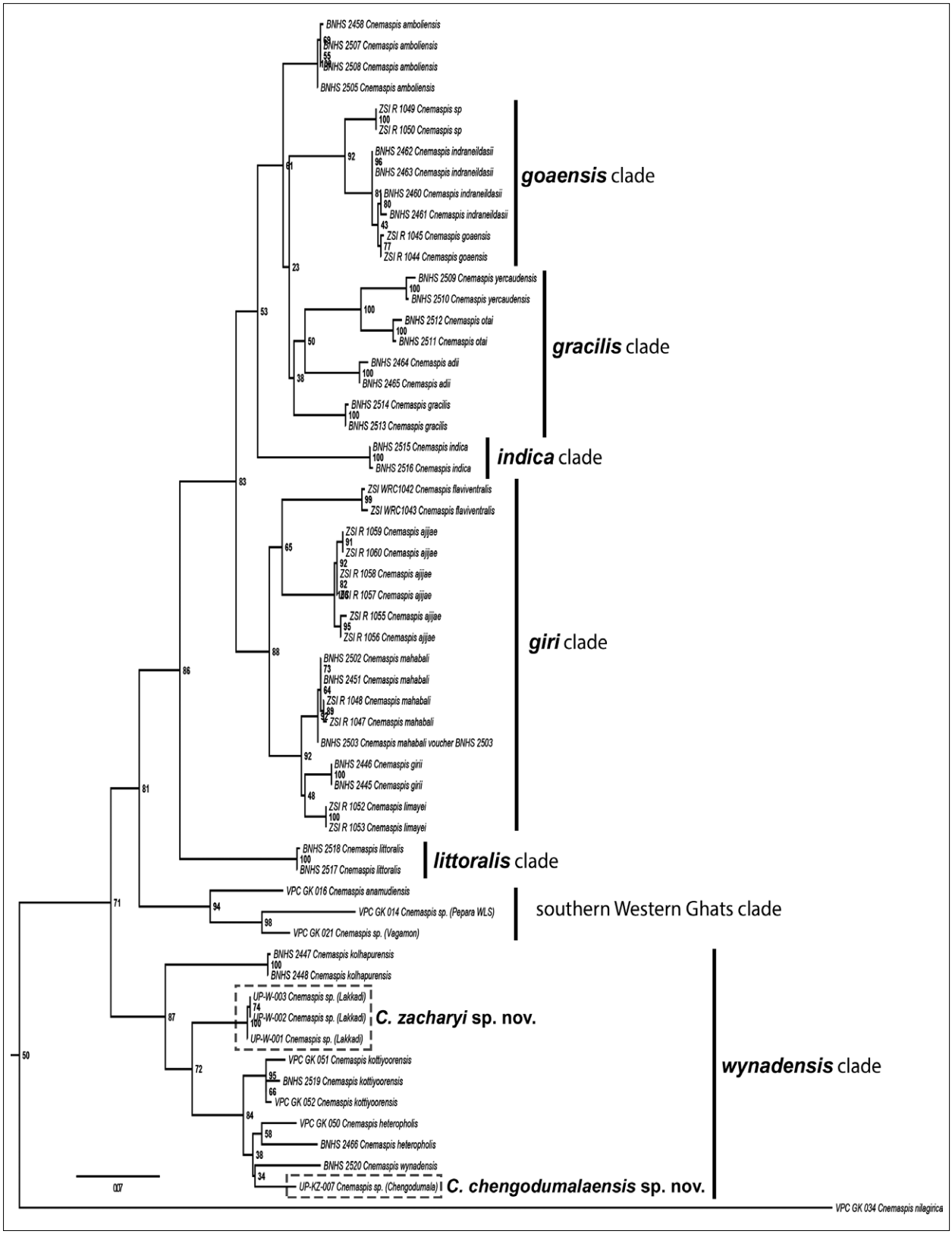

Fig. 1. Maximum Likelihood tree of the Indian *Cnemaspis* based on 16S rRNA gene excluding members of the outgroup. Values at the node indicate bootstrap support values with values < 70 indicating low support, between 70-90 indicating moderate support and > 90 indicating strong support. The dashed box indicates the phylogenetic position of the two new species.

morphospace between species. The morphospace of the two new species differed from each other along PC1 and from *C. sisparensis* along PC2. However, visually there was considerable overlap among species, especially between *C. wynadensis*, *C. kottiyoorensis* and *C. kolhapurensis* (Fig. 2).

Table 1. Pairwise uncorrected sequence divergence (in %) for the 16S rRNA gene of members of the *wynadensis* clade. Values in bold indicate intraspecific divergences.

	Species	1	2	3	4	5	6	7	8	9	10	11
1	*C. kolhapurensis* (BNHS 2448)	—										
2	*C. kolhapurensis* (BNHS 2447)	**0.2**	—									
3	*C.* cf. *heteropholis* (BNHS 2466)	11.1	11.3	—								
4	*C.* cf. *heteropholis* (BNHS 2745)	10.1	10.3	**5.0**	—							
5	*C. chengodumalaensis* **sp. nov.** (BNHS 2741)	9.5	9.7	5.4	4.2	—						
6	*C. wynadensis* (BNHS 2520)	10.1	10.3	5.6	5.2	5.0	—					
7	*C. kottiyoorensis* (VPC GK 052)	10.5	10.7	5.6	4.4	3.8	5.6	—				
8	*C. kottiyoorensis* (BNHS 2519)	10.7	10.9	5.6	4.8	4.4	5.6	**1.2**	—			
9	*C. kottiyoorensis* (BNHS 2747)	10.5	10.7	5.2	4.4	4.0	5.2	**0.8**	**1.2**	—		
10	*C. zacharyi* **sp. nov.** (BNHS 2737)	9.1	9.3	8.3	8.0	8.5	8.3	7.8	7.4	7.8	—	
11	*C. zacharyi* **sp. nov.** (BNHS 2736)	9.1	9.3	8.3	8.0	8.5	8.3	7.8	7.4	7.8	**0.0**	—
12	*C. zacharyi* **sp. nov.** (BNHS 2735)	8.9	9.1	8.2	7.8	8.3	8.3	7.6	7.2	7.6	**0.2**	**0.2**

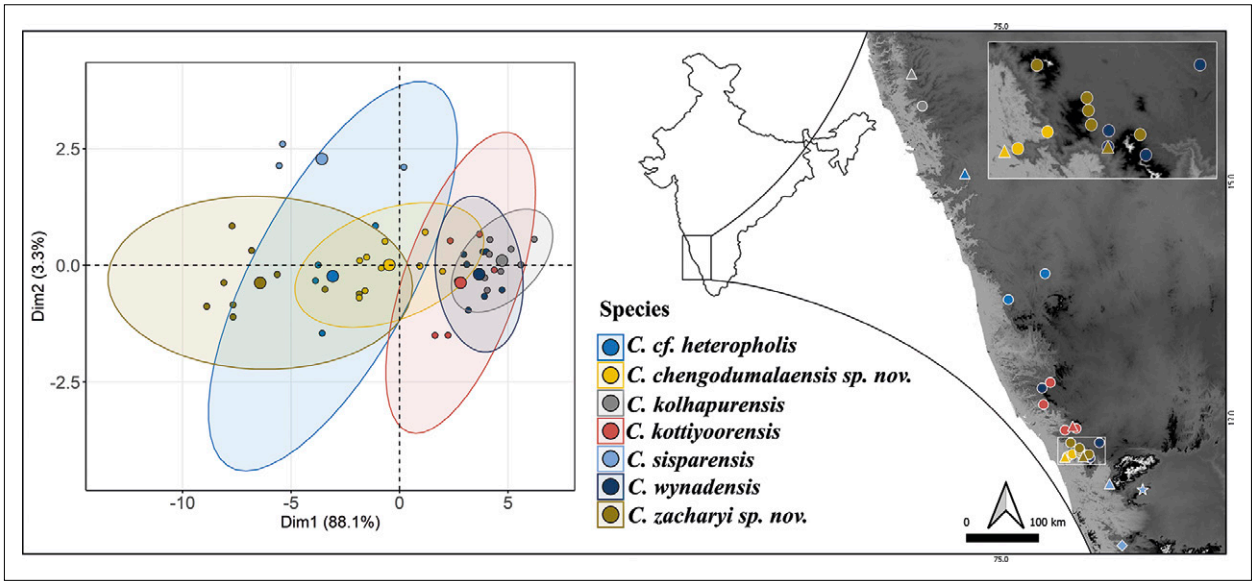

Fig. 2. Results of the Principal Component Analysis as indicated by the first two dimensions (PC1 and PC2). A – Morphospace occupied by *Cnemaspis zacharyi* **sp. nov.**, *C. chengodumalaensis* **sp. nov.** and other members of the *wynadensis* clade. B – Map showing the distribution of the two new species and voucher specimens of species in the *wynadensis* clade examined during this study; inset in the map shows an enlarged view of the distribution of species in the Wayanad region. The colour of the points in the PCA plot and map correspond to different species in the *wynadensis* clade. The triangle indicates type locality of the species. The star and diamond for *C. sisparensis* indicate the type locality of *C. anaikattiensis* and *Gonatodes bireticulatus*, respectively.

Systematics

Cnemaspis zacharyi sp. nov.

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Holotype. BNHS 2735, adult male of SVL 61.1 mm, collected from a rock crevice in Lakkidi, Wayanad (11°30′52.56″N; 76°2′20.4″E) at an elevation of 850 m ASL in Wayanad district of Kerala on 13 February 2014 by P.K. Umesh.

Paratypes. BNHS 2736, adult female of SVL 61.9 mm; BNHS 2737, adult male of SVL 59.3 mm; ZSI/WRC/R/1087, adult female of SVL 63.7 mm; ZSI/WRC/R/1088, subadult male of SVL 50.7 mm; all of which were collected on the same date and locality as that of the holotype. BNHS 2738, adult female of SVL 65.2 mm, collected from a small cave in Settukunnu, Wayanad District (11°37′8.15″N; 75°59′30.16″E), Kerala at an elevation of 894 m ASL on 26 April 2013 by Vivek Philip Cyriac. ZSI/WRC/R/1089, an adult male of SVL 62.5 mm and ZSI/WRC/R/1090, an adult female of SVL 58.2 mm, collected from a cave at Sugandhagiri, Wayanad District, Kerala (11°32′49.60″N; 76°0′9.79″E) at an elevation of 974 m ASL on 30 March 2013 by Vivek Philip Cyriac. BNHS 2739, an adult female of SVL 46.7 mm, collected from Elimbilerimala in Meppadi, Wayanad District, Kerala (11°32′41.50″N; 76°6′23.08″E) at an elevation of 1106 m ASL on 09 September 2018 by Vivek Philip Cyriac and Umesh P.K.

Diagnosis. A large-sized *Cnemaspis* with a maximum snout-vent length of 63.7 mm. Mid-dorsal scales are homogenous becoming more heterogeneous towards the flanks. Spine-like tubercles absent on flanks. Ventral scales of neck, pectoral and abdominal region smooth.

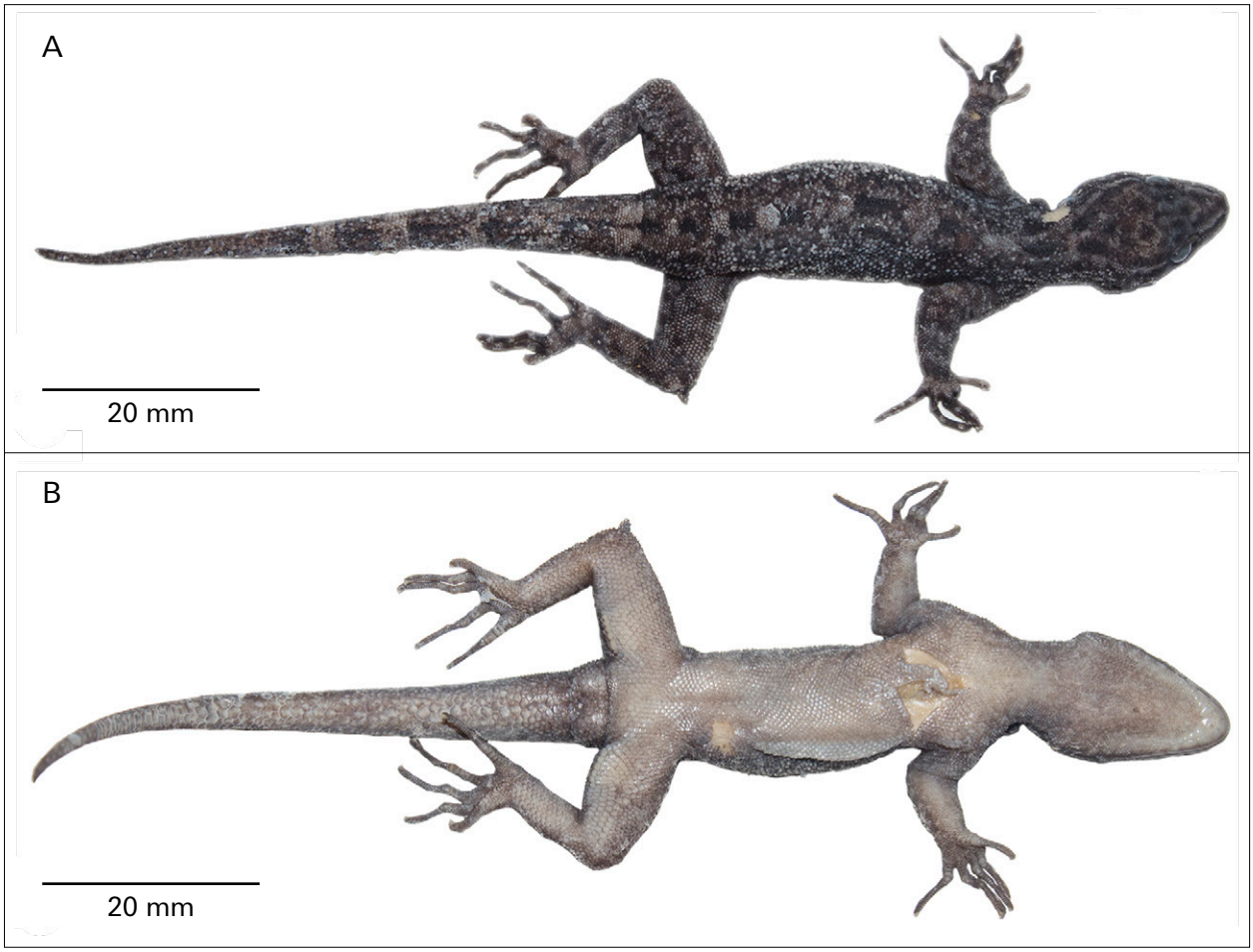

Fig. 3. Holotype of *Cnemaspis zacharyi* **sp. nov.** A – dorsal view. B – ventral view.

Mid-ventral scale rows range from 25 – 28. Supralabials to the angle of jaw 6 – 7, infralabials 7 – 8. Subdigital lamellae under manus IV ranges from 23 – 26; under pes IV ranges from 23 – 27. Dorsal scales of tail homogenous and sub-imbricate without whorls of enlarged tubercles. Subcaudals smooth and enlarged. Post-cloacal spur absent on either side of the tail. Males have 5 – 6 femoral pores, no pre-cloacal pores and 22 – 24 poreless scales between femoral pores.

Cnemaspis zacharyi **sp. nov.** differs from all other congeners by the following characters: mid-dorsal scales homogenous (*vs*. dorsal scales heterogeneous in *C. aaronbaueri* Sayyed, Grismer, Campbell & Dileepkumar, 2019, *C. agarwali* Khandekar, 2019, *C. ajijae* Sayyed, Pyron & Dileepkumar, 2018, *C. anandani* Murthy, Nitesh, Sengupta & Deepak, 2019, *C. andersonii* (Annandale, 1905), *C. amboliensis* Sayyed, Pyron & Dileepkumar, 2018, *C. anamudiensis* Cyriac, Johny, Umesh & Palot, 2018, *C. australis* Manamendra-Arachchi, Batuwita & Pethiyagoda, 2007, *C. beddomei* (Theobald, 1876), *C. flaviventralis* Sayyed, Pyron & Dileepkumar, 2016, *C. girii* Mirza, Pal, Bhosale & Sanap, 2014, *C. goaensis* Sharma, 1976, *C. gracilis* (Beddome, 1870), *C. limayei* Sayyed, Pyron & Dileepkumar, 2018, *C. maculicollis* Cyriac, Johny, Umesh & Palot, 2018, *C. mahabali* Sayyed, Pyron & Dileepkumar, 2018, *C. monticola* Manamendra-Arachchi, Batuwita & Pethiyagoda, 2007, *C. nairi* Inger, Marx & Koshy, 1984, *C. ornata* (Beddome, 1870), *C. otai* Das & Bauer, 2000, *C. shevaroyensis* Khandekar, Gaitonde & Agarwal, 2019, *C. thackerayi* Khandekar, Gaitonde & Agarwal, 2019, *C. wicksii* (Stoliczka, 1873) and *C. yercaudensis* Das & Bauer, 2000); the absence of spine-like tubercles on flanks (*vs.* presence of spine-like tubercles on the flanks in *C. anandani*, *C. andersonii*, *C. amboliensis*, *C. assamensis* Das & Sengupta, 2000, *C. flaviventralis*, *C. goaensis*, *C. gracilis*, *C. indraneildasii* Bauer, 2002, *C. jerdonii* (Theobald, 1868), *C. littoralis* (Jerdon, 1854), *C. monticola*, *C. mysoriensis* (Jerdon, 1853), *C. nilagirica* Manamendra-Arachchi, Batuwita & Pethiyagoda, 2007, *C. otai* and *C. wicksii*); presence of only 5 – 6 femoral pores and absence of pre-cloacal pores in males (*vs*. presence of ≤ 5 femoral pores in *C. ajijae*, *C. flaviventralis*, *C. girii*, *C. indica* Gray, 1846, *C. limayei* and *C. mahabali*; presence of both femoral and pre-cloacal pores in *C. adii* Srinivasulu, Kumar & Srinivasulu, 2015, *C. agarwali*, *C. andersonii*, *C. amboliensis*, *C. australis*, *C. goaensis*, *C. gracilis*, *C. mysoriensis*, *C. otai*, *C. shevaroyensis*, *C. thackerayi*, *C. wicksii* and *C. yercaudensis*; presence of only pre-cloacal pores in *C. aaronbaueri*, *C. anamudiensis*, *C. beddomei*, *C. maculicollis*, *C. nairi* and *C. ornata*; absence of both femoral and pre-cloacal pores in *C. boiei* (Gray, 1842) and *C. assamensis*; ven-

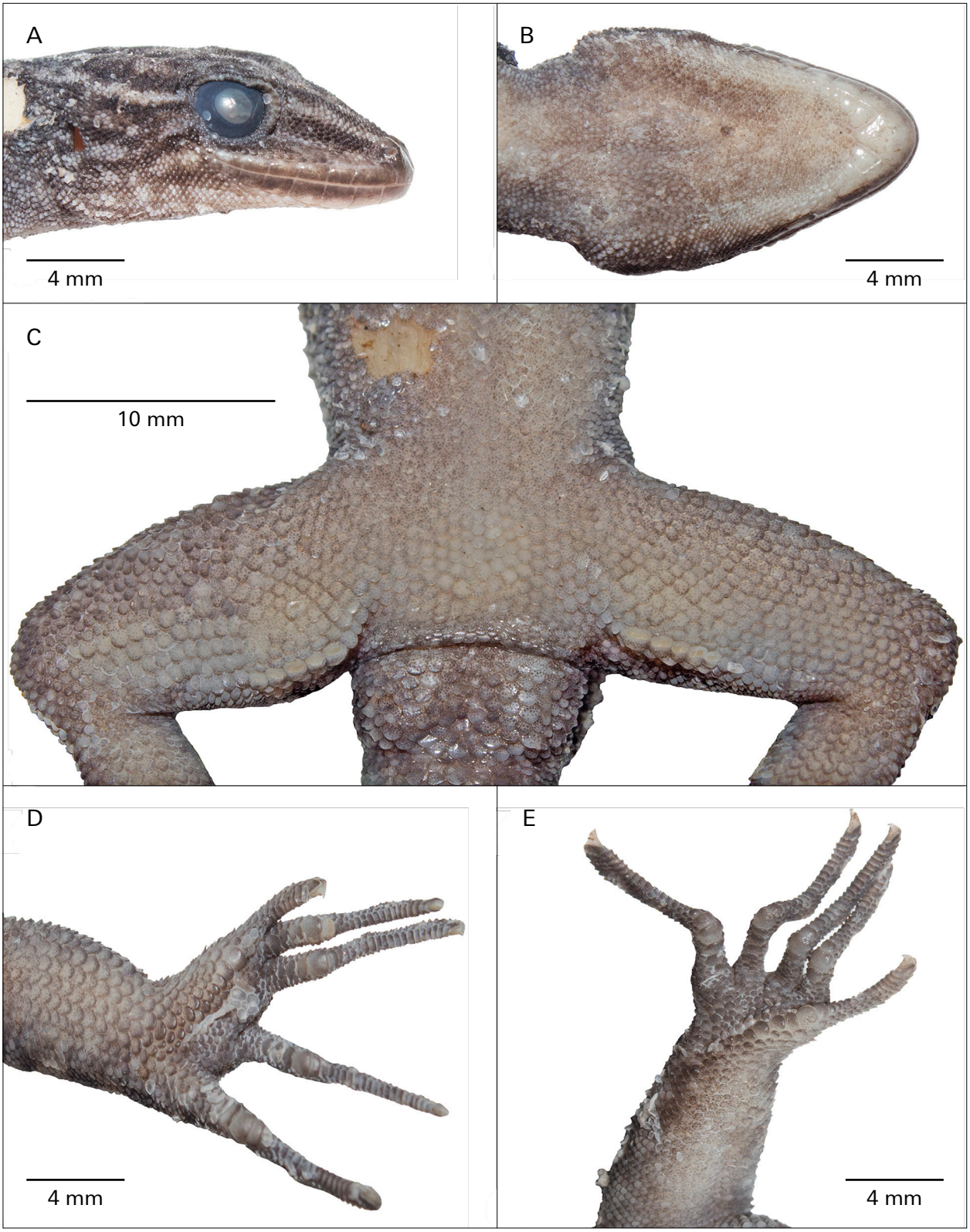

Fig. 4. Pholidosis of *Cnemaspis zacharyi* **sp. nov.** holotype. A – lateral view of head. B – ventral view of head. C – precloacal and femoral region. D – lamellae under hand. E – lamellae under foot.

tral scales smooth (*vs*. keeled ventrals in *C. anandani*, *C. nilagirica*, *C. australis* and *C. monticola*); median row of subcaudals enlarged (*vs*. median subcaudal scales not enlarged in *C. adii*, *C. ajijae*, *C. andersonii*, *C. australis*, *C. flaviventralis*, *C. girii*, *C. gracilis* and *C. limayei*).

Cnemaspis zacharyi **sp. nov.** closely resembles other members of the *wynadensis* clade which includes *C. wynadensis*, *C. kottiyoorensis C. kolhapurensis*, *C. chengodumalaensis* **sp. nov.**, *C. sisparensis* and *C. heteropholis*. It can be differentiated from *C. wynadensis*, *C. kot-*

tiyoorensis and *C. kolhapurensis* by its large adult size (51–65 mm) (*vs*. small to medium adult size ranging from ca 30–42 mm in all three species), greater number of lamellae on the IV manus (23–26) and IV pes (23–27) (*vs*. 18–20 on manus and 20–23 on pes in *C. kottiyoorensis*; 11–15 on manus and 15–17 on pes in *C. kolhapurensis*; 15–17 on manus and 16–19 on pes in *C. wynadensis*) and by the presence of 5–6 femoral pores in males (*vs*. 4–5 femoral pores in *C. kottiyoorensis* and a continuous series of 24–28 femoral-precloacal pores in *C. kolhapurensis*). *Cnemaspis zacharyi* **sp. nov.** can be differentiated from *C. chengodumalaensis* **sp. nov.**, *C. heteropholis* and *C. sisparensis* by its homogenous mid-dorsal scales (*vs*. mid-dorsal scales heterogenous in *C. chengodumalaensis* **sp. nov.**, *C. heteropholis* and *C. sisparensis*) and the larger number of mid-ventral scale rows (25–28) and poreless scales between femoral pores (21–24) (*vs*. 19–23 mid-ventral scale rows and 14–16 poreless scales between femoral pores in *C. chengodumalaensis* **sp. nov.** and *C. heteropholis*).

Description of Holotype (BNHS 2735) (Fig 3–4)**.** An adult male of SVL 61.1 mm; head short (HL 27.2% of SVL), broad (HW 75.3% of HL), slightly depressed (HD 47.1% of HL), distinct from neck. Snout short (ES 43.1% of HL). Scales on snout smooth to weakly keeled, larger than scales on the forehead and interorbital region. Eye small (ED 18.8% of HL); pupils round; extra-brillar fringe scales small, larger anteriorly. Scales on interorbitals and supercilium smooth. Ear opening comparatively very small (TD 5% of HL), longer than broad. Rostral broader than long, partially divided by a median rostral groove. Two supranasals in contact with each other; nasal not in contact with the first supralabial; nostril circular, surrounded by two large postnasals and separated by 2–3 small granular scales, a supranasal and the rostral. Mental scale is sub-triangular and broader than rostral. Three pairs of postmentals, first pair largest and separated from each other by two small intermediate chin shields. The first postmental surrounded by 5 scales – mental, first infralabial, second postmental and two chin shields; second postmentals bounded by 6 scales – first postmental, first infralabial, second infralabial and three chin shields. Supralabials to angle of jaw seven on the right and left side; infralabials to angle of jaw eight on each side. Gular scales granular, smooth. Ventral scales of neck imbricate.

Body moderately robust (TW 20.0% of SVL), elongate (AG 42.7% of SVL). Mid-dorsal scales homogenous, granular, few carinate. The para-vertebral region and the flanks are more heterogenous with large, granular scales, many of which are carinate. Spine-like tubercles absent on the flanks. Ventral scales larger than dorsal scales. Scales on the pectoral, abdominal and pelvic region smooth and imbricate. Pre-cloacal scales smooth, imbricate and larger than surrounding scales. Pre-cloacal pores absent. Five femoral pores on either side.

Forelimbs moderately long (UAL 12.2% of SVL, LAL 16.7% of SVL). Hindlimbs long, femur longer than tibia (FEL 20.9% of SVL, TBL 18.6% of SVL). Dorsal scales of forelimbs and hindlimbs granular and smooth. Dorsal scales of manus and pes smooth. Ventral scales of forelimb and hind limb imbricate and smooth. Subdigital lamellae entire, a few fragmented; lamellae on the basal phalanges, enlarged. Interdigital webbing is absent. Subdigital lamellae on finger I: 18; finger II: 20; finger III: 22; finger IV: 23; finger V: 20; toe I: 16; toe II: 21; toe III: 22; toe IV: 23; toe V: 21. Relative length of digits, fingers: IV (7.9 mm) > III (7.7 mm) > V (6.4 mm) > II (6.2mm) > I (5.5 mm); toes: IV (8.3 mm) > III (7.7 mm) > V (7.1 mm) > II (6.7 mm) > I (4.3 mm).

The tail is complete with the end portion being regenerated. Tail subcylindrical, swollen at the base and longer than SVL (TL 108.4% of SVL). Dorsal scales of tail homogenous, granular and sub-imbricate without whorls of enlarged tubercles. Ventral scales larger than dorsal scales; median subcaudals enlarged, subpentagonal to subhexagonal, smooth. Post-cloacal spur absent on either side of the base of the tail.

Colouration in preservative (Fig. 3)**.** Head grayish brown, with a dark-edged whitish line extending from the posterior of each eye to the nape; sides of head and neck with whitish spots. Gular scales grayish black. Dorsum grayish brown with a vertebral series of black spots intermixed with four broad grayish-white transverse bars that are thicker at the center; flanks mottled with several whitish spots. Forelimbs and hindlimbs grayish brown mottled with whitish spots. Fingers and toes brown with white crossbars. The tail is grayish brown above with transvers bars.

Colouration in life (Fig. 5)**.** Head brown with dark brown mottling and with two dark-edged yellowish lines extending from the anterior of the eye to the nares. Two dark-edged yellowish streaks extend from the posterior corner of each eye towards the nape. Another yellowish streak extends from the lower posterior portion of the eye to the ear opening and yet another from the lower posterior portion of eye to the angle of the jaw. Lateral sides of the head and neck are dark brown with several yellowish spots. Ventral side of the head and neck are dark grey. Mid-dorsum region light brown with a vertebral series of five black elongated spots, each interrupted in between by a broad yellowish transverse band that is thicker in the center. Lateral sides and flanks are dark brown mottled with several yellowish spots. Dorsal side of forelimbs and hindlimbs are brown with darker markings and few yellowish patches. Ventral side of the body, forelimbs and hindlimbs are greyish white. Dorsal side of the tail is brown with broad dark brown irregular transverse bars; ventral side is greyish white.

Variation. Variation in the pholidosis of this species (N = 9) is summarized in Table 2. Supralabials ranges from 6–7 with BNHS 2737 and ZSI/WRC/R/1087 having 7 on the right side and 6 on the left. Infralabials ranges from 6–8 with ZSI/WRC/R/1087 having 8 on the

Fig. 5. Colour in life of *Cnemaspis zacharyi* **sp. nov.** and habitat A – dorsal view of male. B – dorsal view of female. C – an individual of *C. zacharyi* **sp. nov.** (uncollected) resting on a leaf at a height of 1.5m from the ground.

right and 7 on the left. The number of post-mentals range from 2 – 3 pairs on each side with ZSI/WRC/R/1088 having 4 post-mentals on the right and 3 on the left. The first post-mental was not in contact in any of the specimens and was separated from each other by 2 or 3 chin shields. Supranasals usually separated by an internasal scale but was in contact with each other in the holotype (BNHS 2735). There is variation in the number of lamellae on the manus and pes which ranges from 15 – 19 on manus I, 20 – 24 on manus II, 22 – 26 on manus III, 23 – 26 on manus IV and 20 – 24 on manus V; and from 12 – 19 on pes I, 21 – 23 on pes II, 22 – 27 on pes III, 23 – 27 on pes IV and 21 – 26 on pes V. Femoral pores range from 5 to 6 with ZSI/WRC/R/1089 having 6 and 5 on the right and left, respectively.

Etymology. The species name *zacharyi* is derived from Zachary, an English variant of the name Zachariah, which is a patronym in honour of Dr Anil Zachariah for his contributions towards Indian herpetology, especially towards the conservation of amphibians in the southern Western Ghats. Dr Zachariah has also encouraged and supported the authors in organizing and planning several field visits across the Western Ghats of Kerala.

Distribution. At present this species is known from the mid to high elevation (between 850 – 1400 m ASL) evergreen forests of Wayanad district of north Kerala. Presently the species has been reported from the south-western region of Wayanad. The species can be commonly found in the forested hills around Sugandhagiri, Lakkidi, Elimbilerimala in Meppadi and from higher elevation in Kuruchiyarmala and Banasura in Wayanad district.

Natural history. *Cnemaspis zacharyi* **sp. nov.** is primarily terrestrial and saxicolous and is found only in thick evergreen forests and adjacent plantations close to streams. Most individuals of this species were observed within rock crevices in boulders adjoining forest streams. Few individuals were also observed in small cave systems in Sugandhagiri and Tholicode in Wayanad. Unlike many other members of this genus, *C. zacharyi* **sp. nov.** was found active and foraging during the night between 20 – 22 hrs suggesting that this species is predominantly nocturnal. However, some individuals were also observed to be active during the day. One individual was observed feeding on a cave cricket (Rhaphidophoridae) in Settukunnu in Pozhuthana in Wayanad at around 22hrs. Interestingly, one individual was found resting on a leaf at night at a height of about 1.5 m from the ground at around 22 hrs. (Fig. 5C). *C. zacharyi* **sp. nov.** also exhibits regional integumentary loss wherein individuals have fragile skin and exfoliate portions of their integument upon physical contact, which is thought to be a defense strategy against predators (see Bauer *et al.*, 1989). They

Table 2. Morphometric measurements (to the nearest 0.1 mm) and pholydosis of the type series of *Cnemaspis zacharyi* **sp. nov.**

Type	**Holotype**	**Paratype**							
Voucher	BNHS 2735	BNHS 2736	BNHS 2737	ZSI/ WRC/ R/1087	ZSI/ WRC/ R/1088	BNHS 2738	ZSI/ WRC/ R/1089	ZSI/ WRC/ R/1090	BNHS 2739
sex	male	female	male	female	male	female	male	female	female
SVL	61.1	61.9	59.3	63.7	50.7	65.2	62.5	58.2	46.7
AG	26.1	26.0	24.4	26.0	19.7	31.5	28.1	25.1	20.2
TW	12.3	15.2	13.2	13.1	11.5	12.1	11.4	11.3	9.4
ED	3.1	3.7	3.0	3.2	3.0	3.3	3.4	3.4	2.7
EN	5.4	5.5	5.1	5.8	4.6	5.7	5.8	5.3	4.0
ES	7.2	7.3	7.2	8.0	6.7	7.9	7.7	7.7	6.1
ET	5.4	5.6	5.1	5.9	4.3	5.1	5.6	5.3	3.7
IN	2.0	1.9	1.7	1.9	1.4	1.7	1.7	1.5	1.2
TD	0.8	1.2	0.9	1.4	1.1	1.3	1.2	0.9	1.0
HL	16.7	17.0	16.3	17.4	14.0	16.5	17.0	15.6	12.9
HW	12.5	12.8	12.1	13.5	10.1	12.2	12.2	11.6	8.9
HD	7.9	8.1	7.3	8.0	6.3	7.4	7.5	7.5	5.6
IO	6.1	5.4	5.6	6.3	4.3	5.2	5.2	4.2	3.4
UAL	7.5	7.7	7.9	7.3	6.8	7.1	6.5	5.5	5.4
LAL	10.2	9.6	9.8	9.7	7.3	10.0	9.4	8.7	7.9
PAL	8.3	9.0	9.6	9.2	7.5	9.1	9.2	8.3	7.8
FL1	5.5	4.4	4.8	5.1	3.9	4.8	5.3	4.8	4.2
FL2	6.2	6.5	6.2	6.4	5.2	6.2	6.6	6.4	5.2
FL3	7.7	7.3	6.8	7.8	5.5	6.4	7.2	6.7	5.8
FL4	7.9	7.3	7.1	8.1	5.8	6.9	7.8	7.0	6.1
FL5	6.4	6.8	6.3	7.0	5.5	6.3	7.0	6.3	5.2
FEL	12.8	11.8	11.5	13.5	10.1	13.1	11.9	10.0	10.0
TBL	11.4	11.0	10.7	11.5	8.8	11.5	11.2	10.3	8.0
TOL1	4.3	4.5	4.0	4.4	3.4	3.8	4.3	3.8	3.1
TOL2	6.7	7.4	6.3	6.9	5.8	6.8	6.6	6.5	6.0
TOL3	7.7	7.7	7.6	7.6	6.4	7.5	7.6	7.5	6.7
TOL4	8.3	8.5	8.4	9.1	7.4	8.1	8.6	7.9	7.1
TOL5	7.1	8.1	8.2	8.3	6.2	7.1	7.8	7.2	6.5
TL	66.3	83.9	69.0	80.0	46.1	—	44.4	63.4	29.7
TBW	7.6	8.9	8.2	7.8	6.7	6.1	7.6	6.7	5.4
SL (L,R)	7/7	7/7	6/7	6/7	6/6	6/7	6/6	6/7	6/7
IL (L,R)	8/8	7/7	7/7	7/8	6/7	8/8	7/7	7/7	7/7
Mid-ventral rows	27	28	28	26	26	27	25	26	25
LamM I	18	19	16	16	17	15	16	15	16
LamM II	20	24	22	21	21	20	21	21	21
LamM III	22	26	25	25	25	23	25	23	24
LamM IV	23	26	25	24	24	25	25	23	24
LamM V	20	24	22	22	22	22	24	21	21
LamP I	16	19	16	15	14	12	14	14	14
LamP II	21	22	21	21	22	21	23	20	22
LamP III	22	27	25	23	25	23	25	23	25
LamP IV	23	27	25	24	25	26	25	25	26
LamP V	21	26	24	23	24	24	24	24	25
FP (L,R)	5/5	nil	6/6	nil	6/6	nil	5/6	nil	nil
Pore-less scales b/w femoral pores	22	—	21	—	24	—	22	—	—

also emit a distress call when caught. *C. zacharyi* **sp. nov.** is sympatric with the ground-dwelling *C. wynadensis*, an unidentified small-sized *Cnemaspis* species which is predominantly arboreal and *Dravidogecko septentrionalis* Chaitanya, Giri, Deepak, Datta-Roy, Murthy & Karanth, 2019.

Cnemaspis chengodumalaensis sp. nov.

ZOOBANK urn:lsid:zoobank.org:act:9C36D247-BBBB-4961-B315-427328997D59

Holotype. BNHS 2740, adult male of SVL 48.1 mm, collected from a rock crevice in Chengodumala (11°30′19.08″N; 75°48′26.28″E)

Table 3. Morphometric measurements (to the nearest 0.1 mm) and pholydosis of the type series of *Cnemaspis chengodumalaensis* **sp. nov.**

Type	Holotype	Paratype							
Voucher	**BNHS 2740**	**BNHS 2741**	**BNHS 2742**	**BNHS 2743**	**BNHS 2744**	**ZSI/ WRC/ R/1091**	**ZSI/ WRC/ R/1092**	**ZSI/ WRC/ R/1093**	**ZSI/ WRC/ R/1094**
sex	male	female	male	female	male	male	female	female	male
SVL	48.1	47.2	39.3	49.1	45.7	39.8	44.8	37.2	49.4
AG	19.6	23.5	16.7	21.3	20.1	17.0	19.6	16.2	20.4
TW	8.9	11.4	8.0	9.3	8.5	8.4	9.8	7.9	10.1
ED	2.6	2.5	2.0	2.5	2.3	2.2	2.4	1.9	2.6
EN	4.7	4.2	3.9	4.6	4.5	3.8	4.4	3.5	4.7
ES	5.7	6.0	5.2	5.9	6.2	5.1	5.9	4.9	6.6
ET	3.8	4.1	3.6	4.1	4.1	3.8	4.0	3.7	4.0
IN	1.4	1.6	1.4	1.8	1.8	1.2	1.5	1.3	1.5
TD	0.8	0.8	0.6	0.9	1.1	0.8	0.7	0.8	1.1
HL	13.3	13.3	11.2	12.8	13.1	11.2	12.4	11.1	13.5
HW	9.4	9.4	7.7	9.2	9.0	8.2	8.9	7.8	9.7
HD	5.6	5.6	4.8	6.0	6.3	5.3	5.7	4.8	5.5
IO	3.7	4.1	3.2	4.3	4.3	3.4	3.5	3.1	4.1
UAL	5.0	4.8	4.2	5.8	5.7	4.3	4.5	3.5	5.2
LAL	6.9	7.3	5.9	6.7	6.6	6.0	6.6	5.4	7.0
PAL	5.7	6.5	6.1	7.1	6.2	5.7	7.0	5.1	6.4
FL1	3.0	3.0	2.7	3.2	3.2	2.5	2.9	2.3	3.1
FL2	3.9	4.5	3.9	3.2	3.0	4.0	4.5	3.5	4.1
FL3	4.3	5.0	4.7	4.3	4.5	4.7	5.0	4.3	5.5
FL4	4.6	5.3	5.1	4.7	5.0	4.9	5.2	4.4	5.0
FL5	4.1	4.9	4.3	4.8	5.3	4.3	4.3	4.1	4.6
FEL	8.9	9.8	8.5	5.0	4.9	8.5	9.0	7.3	9.3
TBL	8.2	7.2	6.8	8.3	9.8	7.0	7.9	6.5	8.2
TOL1	2.6	2.4	2.3	7.1	7.2	2.3	2.3	2.2	3.0
TOL2	4.5	4.6	4.4	2.8	2.4	4.6	4.3	3.9	5.4
TOL3	5.0	5.1	4.9	5.2	4.6	5.3	5.1	4.9	5.9
TOL4	5.8	5.6	5.4	5.9	5.1	5.4	5.6	5.1	6.3
TOL5	5.3	5.1	4.9	6.7	5.6	5.1	5.3	4.5	5.6
TL	47.8	40.0	44.2	55.4	52.9	43.9	14.1	43.7	62.6
TBW	5.0	4.8	4.0	4.9	5.7	4.3	4.8	4.1	5.8
SL (L,R)	6/7	7/8	7/7	7/7	7/7	6/8	6/6	6/6	7/7
IL (L,R)	6/6	8/9	8/8	8/8	9/8	7/8	8/8	6/8	7/8
Mid-ventral rows	21	22	23	22	23	21	19	23	22
LamM I	15	13	14	14	13	14	13	14	15
LamM II	17	18	19	17	20	18	20	20	20
LamM III	19	21	21	21	22	20	22	23	22
LamM IV	20	24	23	23	23	21	23	24	23
LamM V	18	20	20	18	20	18	20	20	21
LamP I	12	13	13	13	13	12	14	11	14
LamP II	18	21	20	17	20	19	21	20	21
LamP III	20	24	22	21	23	22	23	23	23
LamP IV	21	24	24	24	26	23	24	23	24
LamP V	20	22	23	23	22	21	24	21	19
FP (L,R)	7/8	nil	6/7	6/7	nil	7/7	nil	-nil	6/7
Pore-less scales b/w femoral pores	14	—	16	15	—	15	—	—	—

at an elevation of 215 m ASL in Kozhikode district of Kerala on 18 June 2014 by P.K. Umesh.

Paratypes. BNHS 2741, adult female of SVL 47.2 mm; BNHS 2742, adult male of SVL 39.3 mm; ZSI/WRC/R/1091, adult male of SVL 39.8 mm; ZSI/WRC/R/1092, adult female of SVL 44.8 mm; ZSI/WRC/R/1093, adult female of SVL 37.2 mm; all of which were collected on the same date and locality as that of the holotype. ZSI/WRC/R/1094, adult male of SVL 49.4 mm; BNHS 2743, an adult female of SVL 49.1 mm and BNHS 2744, an adult male of SVL 45.7 mm, collected from the walls of an abandoned building in Thuruthamala, Balussery (11°30′22.62″N; 75°50′22.41″E), of Kozhikode district in Kerala at an elevation of 579 m ASL on 10 April 2013 by Vivek Philip Cyriac.

Table 4. Comparative account of members of the *wynadensis* clade along with data on *Cnemaspis zacharyi* **sp. nov.** and *C. chengodumalaensis* **sp. nov.** For abbreviation, see methods. The arrangement of dorsal scales (DS) indicate homogenous (0) and heterogenous (1) scale arrangement in the mid-dorsal region. Hyphen (—) indicates unavailable data.

Species		Max SVL	SL	IL	DS	Lam I(M)	Lam IV(M)	Lam I(P)	Lam IV(P)	FP	PLFP	MVS
C. zacharyi **sp. nov.**		65.0	6–7	6–7	0	15–19	23–26	12–19	23–27	5–6	21–24	25–28
C. chengodumalaensis **sp. nov.**		49.0	6–8	6–9	1	13–15	20–24	11–14	21–26	6–8	14–16	19–23
C. sisparensis	Holotype (BMNH 74.4.29.383)	—	7	8	1	—	—	—	—	8	—	—
	C. anaikattiensis	60.7	6–7	6–8	1	11–13	21–24	11–12	21–24	7	16	25–27
	G. bireticulatus	43.7	7	7–8	1	16	24	14	28	7–8	16	26
C. cf. *heteropholis*		57.4	6–7	6–8	1	10–15	24–26	12–15	22–28	5–7	14–16	21–23
C. wynadensis		38.2	6–7	6–7	1	8–10	15–17	7–10	16–19	4	13–16	19–26
C. kottiyoorensis		41.6	6–7	6–8	1	10–12	18–20	8–13	20–23	4–6	13–16	21–23
C. kolhapurensis		40.0	6–7	6–8	0	8–10	11–15	8–10	15–17	23–30	0–1	19–23

Diagnosis. A medium-sized *Cnemaspis* with a maximum snout-vent length 49.4 mm. Mid-dorsal scales are heterogeneous, becoming more heterogeneous towards the flanks. Spine-like tubercles absent on flanks. Ventral scales of neck, pectoral and abdominal region smooth. Mid-ventral scales arranged in 19–23 rows. Supralabials to the angle of jaw 6–7, infralabials 6–8. Subdigital lamellae under manus IV ranges from 20–24; under pes IV from 21–26. Dorsal scales of tail homogenous and sub-imbricate without whorls of enlarged tubercles. Subcaudals smooth, enlarged and irregularly arranged. Post-cloacal spur absent on either side of the tail. Males have 6–8 femoral pores, no pre-cloacal pores and 14–16 poreless scales between femoral pores.

Cnemaspis chengodumalaensis **sp. nov.** differs from all other congeners by the following characters: mid-dorsal scales heterogenous (*vs*. dorsal scales homogenous in *C. adii*, *C. assamensis*, *C. boiei*, *C. indica*, *C. indraneildasii*, *C. jerdonii*, *C. littoralis*, *C. mysoriensis* and *C. nilagirica*); the absence of spine-like tubercles on flanks (*vs.* presence of spine-like tubercles on the flanks in *C. anandani*, *C. andersonii*, *C. amboliensis*, *C. assamensis*, *C. flaviventralis*, *C. goaensis*, *C. gracilis*, *C. indraneildasii*, *C. jerdonii*, *C. littoralis*, *C. monticola*, *C. mysoriensis*, *C. nilagirica*, *C. otai* and *C. wicksii*); presence of only 6–8 femoral pores and absence of pre-cloacal pores in males (*vs*. presence of ≤ 5 femoral pores in *C. ajijae*, *C. flaviventralis*, *C. girii*, *C. indica*, *C. limayei* and *C. mahabali*; presence of both femoral and pre-cloacal pores in *C. adii*, *C. agarwali*, *C. andersonii*, *C. amboliensis*, *C. australis*, *C. goaensis*, *C. gracilis*, *C. mysoriensis*, *C. otai*, *C. shevaroyensis*, *C. thackerayi*, *C. wicksii* and *C. yercaudensis*; presence of only pre-cloacal pores in *C. aaronbaueri*, *C. anamudiensis*, *C. beddomei*, *C. maculicollis*, *C. nairi* and *C. ornata*; absence of both femoral and pre-cloacal pores in *C. boiei* and *C. assamensis*); ventral scales smooth (*vs*. keeled ventrals in *C. anandani*, *C. nilagirica*, *C. australis* and *C. monticola*); median row of subcaudals enlarged (*vs*. median subcaudal scales not enlarged in *C. adii*, *C. ajijae*, *C. andersonii*, *C. australis*, *C. flaviventralis*, *C. girii*, *C. gracilis* and *C. limayei*)

Cnemaspis chengodumalaensis **sp. nov.** closely resembles other members of the *wynadensis* clade. It can be differentiated from *C. wynadensis*, *C. kottiyoorensis* and *C. kolhapurensis* by its larger adult size (37–49 mm) (*vs*. small to medium adult size ranging from ca 30–42 mm in all three species) and its highly heterogenous mid-dorsal scales (*vs*. homogenous in *C. wynadensis* and *C. kolhapurensis*). *C. chengodumalaensis* **sp. nov.** can be differentiated from *C. heteropholis* and *C. zacharyi* **sp. nov.** by its smaller adult size ranging from 37–49 mm (*vs*. larger adult size in *C. heteropholis* (47–57 mm) and *C. zacharyi* **sp. nov.** (46–65 mm)), its heterogenous mid-dorsal scales (*vs*. mid-dorsal scales homogenous in *C. zacharyi* **sp. nov.**) and in the smaller number of subdigital lamellae ranging from 20–24 on manus IV and 21–26 on pes IV (*vs*. 24–26 on manus IV and 22–28 on pes IV in *C. heteropholis* and 23–26 on manus IV and 23–27 on pes IV in *C. zacharyi* **sp. nov.**). *C. chengodumalaensis* **sp. nov.** most closely resembles *C. sisparensis* (see Fig. 9), but can be differentiated by its longer head length (HL 28.0 ± 0.01 % of SVL *vs.* HL 17.1 ± 0.01 % of SVL in *C. sisparensis*) and the smaller number of mid-ventral scale rows across the belly ranging from 19–23 (*vs*. 25–27 in *C. sisparensis*) (Table 4).

Description of Holotype (BNHS 2740) (Fig. 6–7)**.** An adult male of SVL 48.1 mm; head short (HL 27.61% of SVL), moderately broad (HW 70.4% of HL), slightly depressed (HD 42.01% of HL), distinct from neck. Snout short (ES 43.14% of HL). Scales on snout smooth, larger than scales on the forehead and interorbital region. Eye small (ED 19.42% of HL); pupils round; extra-brillar fringe scales small, larger anteriorly. Scales on interorbitals and supercilium smooth. Ear opening comparatively very small (TD 5.6% of HL), longer than broad. Rostral broader than long, partially divided by a median rostral groove. Two supranasals in contact with each other with no internasal scale; nasal not in contact with the first supralabial; nostril circular, surrounded by two large postnasal separated from each other by 2–3 small granular scales, a supranasal and the rostral. Mental scale

is sub-triangular and broader than the rostral. Two pairs of postmentals, first pair largest and separated from each other by three small intermediate chin shields. The first postmental surrounded by 5 scales – mental, first infralabial, second postmental and two chin shields; second postmentals bounded by 8 scales – first postmental, first infralabial, second infralabial and five chin shields. Supralabials to angle of jaw seven on the right and six on the left side; infralabials to angle of jaw six on each side. Gular scales granular but smooth. Ventral scales of neck sub-imbricate, smooth.

Body moderately robust (TW 18.5% of SVL), elongate (AG 40.07% of SVL). Mid-dorsal scales heterogenous with small, granular scales intermixed with large backward facing conical tubercles, few of which are keeled. The para-vertebral region and the flanks are more heterogenous with large granular scales. Spine-like tubercles absent on the flanks. Ventral scales larger than the small granular dorsal scales, 21 mid-ventral scale rows. Scales on the pectoral, abdominal and pelvic region smooth and imbricate. Pre-cloacal scales smooth, imbricate but not larger than surrounding scales. Pre-cloacal pores absent. Seven femoral pores on the left and eight on the right side. Femoral pores on each side separated by 14 poreless scales.

Forelimbs moderately long (UAL 10.45% of SVL, LAL 14.32% of SVL). Hindlimbs moderately long, femur longer than tibia (FEL 18.42% of SVL, TBL 16.96% of SVL). Dorsal scales of forelimbs and hindlimbs granular but smooth. Dorsal scales of manus and pes smooth. Ventral scales of forelimb and hind limb imbricate and smooth. Subdigital lamellae mostly entire, with those on the basal portion of both the proximal and distal phalanges fragmented. Interdigital webbing is absent. Subdigital lamellae on the proximal and distal phalange of finger I: 3 and 12; finger II: 4 and 13; finger III: 4 and 15; finger IV: 6 and 14; finger V: 4 and 14; toe I: 2 and 10; toe II: 5 and 13; toe III: 5 and 15; toe IV: 6 and 15; toe V: 5 and 15. Relative length of digits, fingers: IV (4.6 mm) > III (4.3 mm) >V (4.1 mm) > II (3.9 mm) > I (3.0 mm); toes: IV (5.8 mm) > V (5.3 mm) >III (5.0 mm) > II (4.5 mm) > I (2.6 mm).

The tail is complete, almost as long as the SVL (TL 99.35% of SVL) with the distal half portion being regenerated. Tail subcylindrical, swollen at the base. Dorsal scales of tail homogenous, granular and sub-imbricate without whorls of enlarged tubercles. Ventral scales larger than dorsal scales; median subcaudals enlarged, subpentagonal to subhexagonal, smooth and irregularly arranged with a series of two single smaller subcaudal scales followed by a large subcaudal scales. Regenerated portion of the tail with highly irregularly arranged subcaudal scales. Post-cloacal spur absent on either side of the base of the tail.

Colouration in preservative (Fig. 6)**.** Head, light brown with dark brown to black mottling and spots. Two to three thick dark brown lines extend from the posterior of each eye to the lateral sides of the head. Labial scales light brown to whitish. Gular scales are whitish with dark grey to brown mottling. Mid-dorsum light brown with a vertebral series of elongated rectangular black spots. The lateral sides of the body and flanks dark brown, interspersed with several light greyish enlarged flat or conical tubercles. Dorsal side of forelimbs and hindlimbs light brown with dark brown mottling. Dorsal sides of fingers and toes cross-bared with dark brown and greyish bands. Ventral side of body and limbs whitish. The tail dark brown above with light brown transverse bars.

Colouration in life (Fig. 8)**.** Head greyish brown mottled with lighter brown patches along with several irregularly shaped dark brown to black spots. Two thick dark brown to black lines extend from the posterior of the eye to the lateral sides of the head. The iris of the eye is orangish-red surrounded by yellowish brown superciliary scales. Labials with dark and light bands. Gular scales are whitish with dark grey to brown mottling. Nape with three to four dark brown to black spots. Mid-dorsum region light to dark brown sparsely speckled with yellowish spots and a vertebral series of six to seven black elongated spots, some of which are irregularly shaped. Paravertebral region dark brown sparsely speckled with yellowish spots along with a series of five to six large elongated brown spots, some of which appear as irregularly shaped blotches. Lateral sides and flanks are dark brown mottled with several yellowish-white spots. Dorsal side of forelimbs and hindlimbs are brown with darker markings. Fingers and toes with alternating light and dark bands. Ventral side of the body, forelimbs and hindlimbs are greyish. Dorsal side of tail is cross-barred with dark and light brown irregular transverse bands; ventral side is greyish white.

Variation. Variation in the pholidosis of this species (N = 9) is summarized in Table 3. Supralabials range from 6 and 8 with BNHS 2740 having 7 on the right side and 6 on the left; BNHS 2741 having 8 on the right and 7 on the left; ZSI/WRC/R/1091 having 8 on the right and 6 on the left. Infralabials 6–9 with ZSI/WRC/R/1094 and ZSI/WRC/R/1091 having 8 on the right and 7 on the left; BNHS 2744 having 8 on the right and 9 on the left; BNHS 2741 having 9 on the right and 8 on the left; ZSI/WRC/R/1093 having 8 on the right and 6 on the left. There is variation in the number of lamellae on the manus which ranges from 13–15 on manus I, 17–20 on manus II, 19–23 on manus III, 20–24 on manus IV and 18–21 on manus V; pes which ranges from 11–14 on pes I, 17–21 on pes II, 20–24 on pes III, 21–26 on pes IV and 19–24 on pes V. Femoral pores range from 6 to 8 with BNHS 2740 having 8 and 7 on the right and left respectively and ZSI/WRC/R/1094, BNHS 2743 and BNHS 2742 having 7 and 6 on the right and left, respectively.

Etymology. The species name *chengodumalaensis* is a toponym referring to Chengodumala, the type locality and area where this species was found in great abundance. Chengodumala, is a midland hillock with several

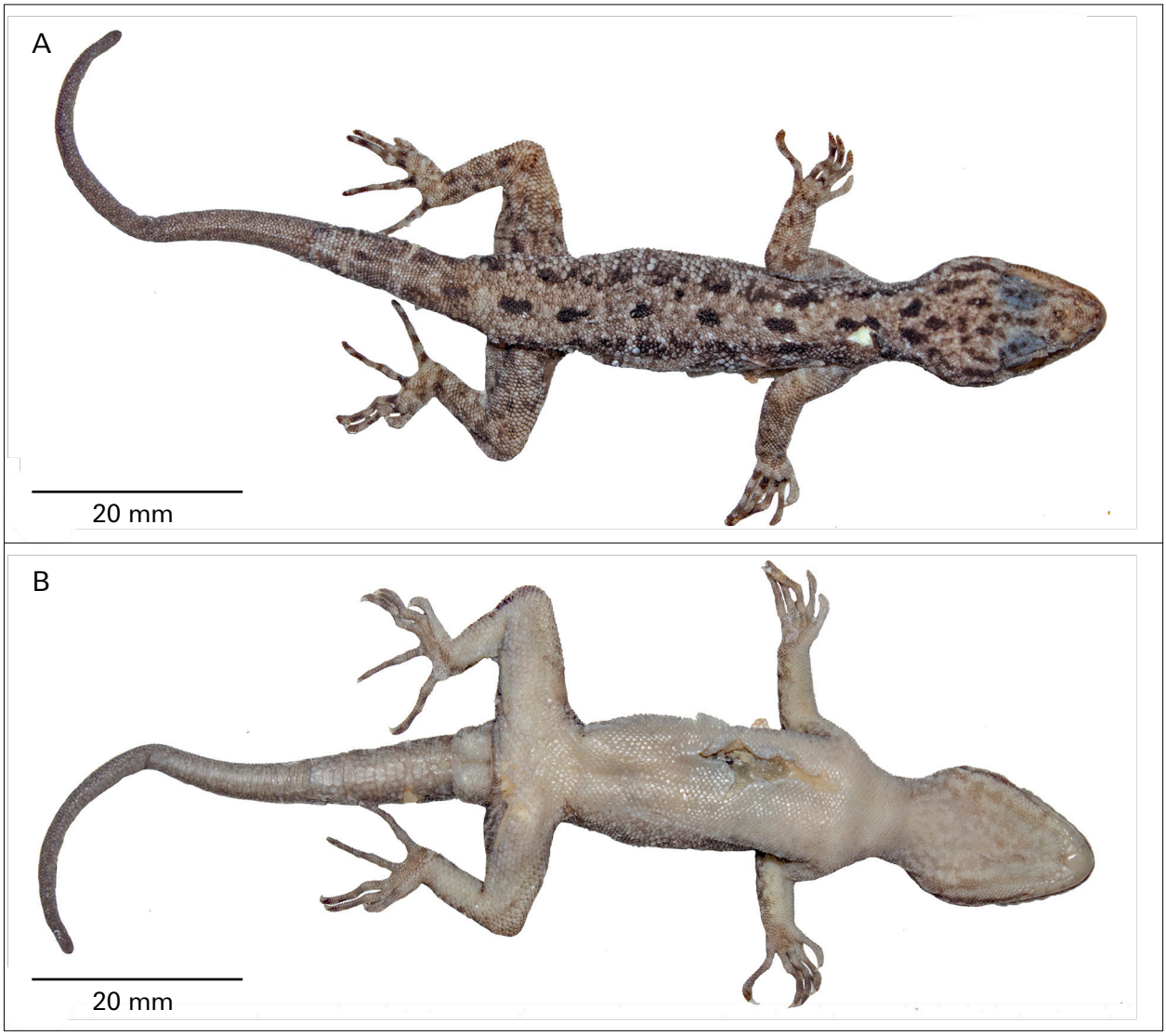

Fig. 6. Holotype of *Cnemaspis chengodumalaensis* **sp. nov.** A – dorsal view. B – ventral view.

rocky outcrops located ca. 8 km from Malabar Wildlife Sanctuary and falls outside the Protected Area network. Chengodumala is currently threatened by extensive illegal granite quarrying (see Fig. 10C, D).

Distribution. At present this species is mainly known from low to mid elevations (between ca. 200 – 600 m ASL) in the midland hillocks in Kozhikode district of Kerala. The species can be commonly found in agricultural plantations and forested patches in the Chengodumala and Thuruthamala Hills. The species has also been observed from few midland hillocks at lower elevations of Malabar Wildlife Sanctuary in Kozhikode district of Kerala.

Natural history. *Cnemaspis chengodumalaensis* **sp. nov.** is primarily terrestrial and saxicolous and found in low to mid-elevation forested patches and agricultural plantations harbouring rocky outcrops. Most individuals of this species were observed within rock crevices of boulders. *C. chengodumalaensis* **sp. nov.** was found active during the night between 19 – 23 hrs suggesting nocturnal habits like that of *C. zacharyi* **sp. nov.** *C. chengodumalaensis* **sp. nov.** was found to be common in Chengodumala, the type locality, and in Thuruthamala, both small hillocks with several rocky outcrops. Eggs of this species were found in clutches of two, and were observed in crevices in between a brick wall in Thuruthamala during February. Eggs were of a dirty white colour and oval in shape. Six eggs that were collected on 15th February 2012 measured on average 9.4 mm in length and 8.3 mm in width (N = 6) (Fig. 8C), two of which hatched 34 days later and another two which hatched 49 days later upon incubating at room temperature (18 – 26°C), indicating a gestation period of about two months. Like *C. zacharyi* **sp. nov.**, this species also exhibits regional integumentary loss. *C. chengodumalaensis* **sp. nov.** is found sympatric with the arboreal *C. littoralis*, another unidentified small-sized *Cnemaspis* species and *Hemidactylus frenatus* Duméril & Bibron, 1836, the ground-dwelling *Cyrtodactylus* (*Geckoella*) sp. and saxicolous species such as *Hemidactylus prashadi* Smith, 1935, and *Hemidactylus murrayi* Gleadow, 1887.

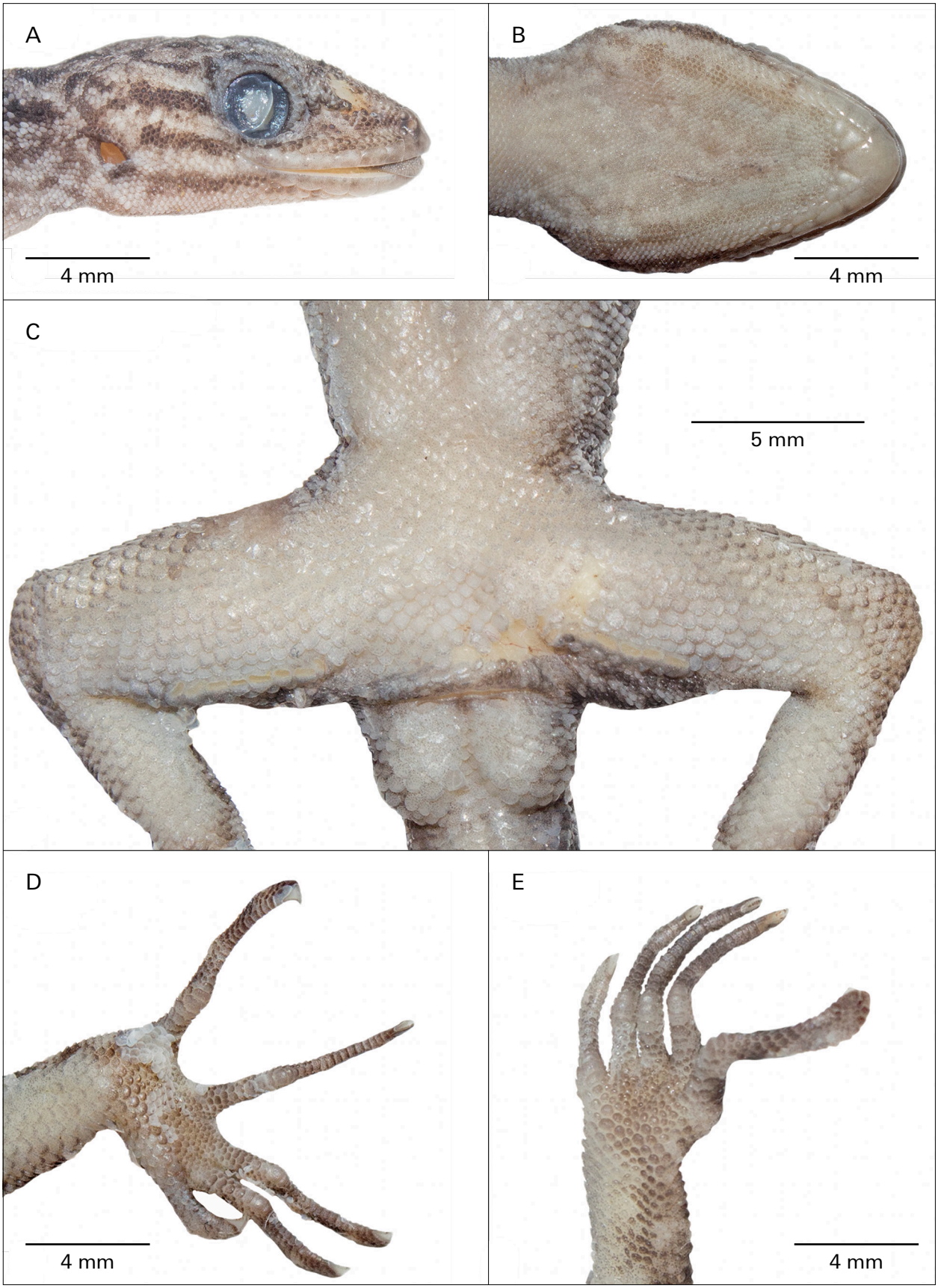

Fig. 7. Pholidosis of *Cnemaspis chengodumalaensis* **sp. nov.** holotype. A – lateral view of head. B – ventral view of head. C – precloacal and femoral region. D – lamellae under hand. E – lamellae under foot.

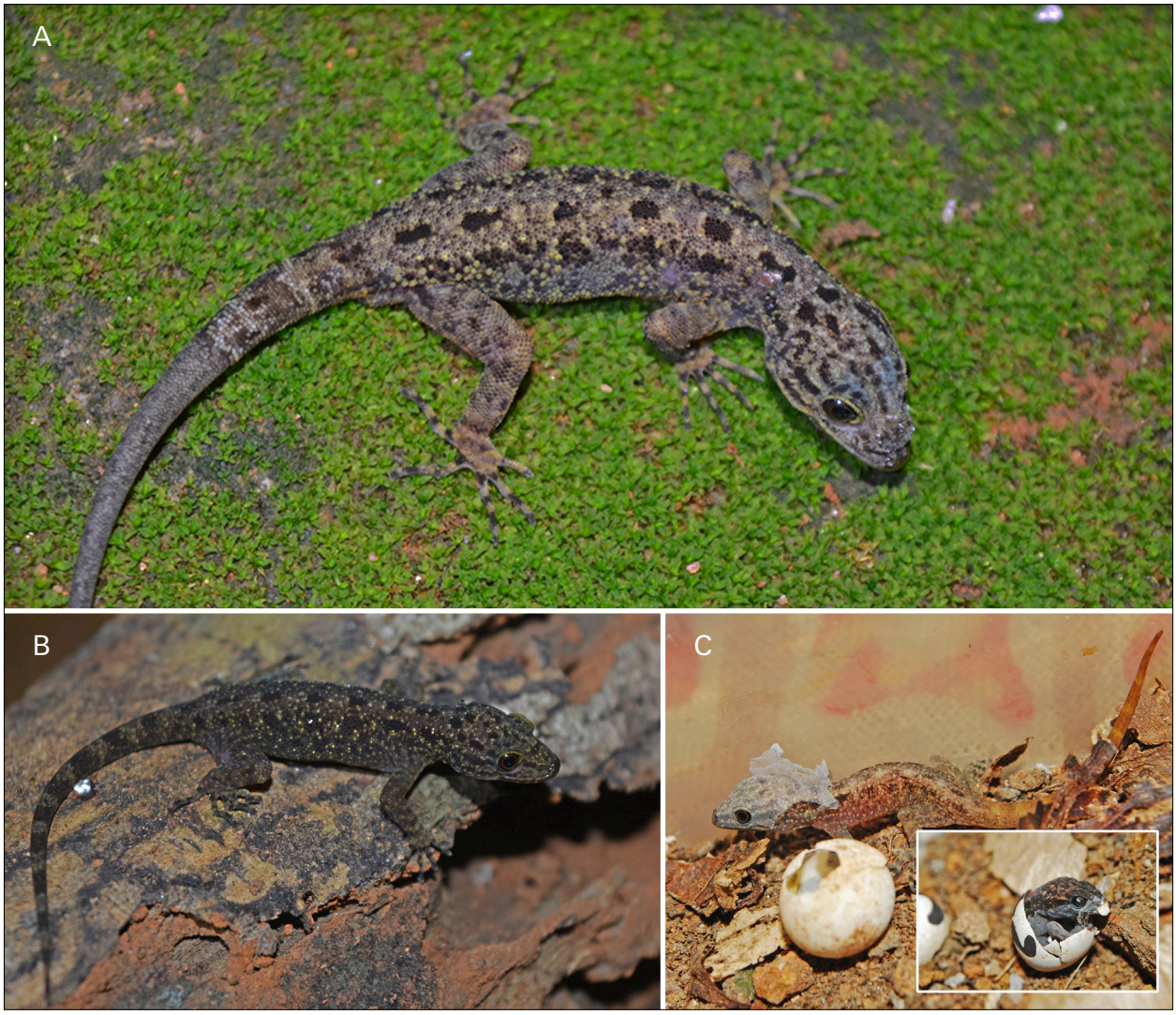

Fig. 8. Colour in life of *Cnemaspis chengodumalaensis* **sp. nov.** and habitat. A – dorsal view of male. B – dorsal view of female. C – newly hatched individual of *C. chengodumalaensis* **sp. nov.**; inset showing *C. chengodumalaensis* **sp. nov.** hatching from an egg.

Discussion

The phylogenetic analysis based on the 16S rRNA gene recovered a topology similar to Sayyed *et al.* (2018). However, there was discordance in the phylogenetic position of *C. amboliensis*, which was found to be sister to the *goaensis* clade + *gracilis* clade, albeit with low support as opposed to a sister relationship to the *goaensis* clade recovered by Sayyed *et al.* (2018) and Khandekar *et al.* (2019). Such incongruence could likely arise due to the difference in outgroup selection between our analysis and previous analysis. Several studies have indicated that outgroup selection can significantly influence phylogenetic reconstructions, where the use of distantly related outgroups generally result in unreliable phylogenetic hypotheses (Wheeler, 1990; Gatesy *et al.*, 2007; Wilberg, 2015; Grant, 2019). Large-scale phylogenies suggest that the genus *Cnemaspis* is polyphyletic with three distinct lineages – an African clade related to the Madagascan *Uroplatus*, a southeast Asian clade sister to the central Asian *Alsophylax* or the North African *Tropiocolotes* and a south Asian clade related to *Lygodactylus* and *Phelsuma* (Gamble *et al.*, 2012; Pyron *et al.*, 2013; Zheng & Wiens, 2016). Unlike previous analyses that use other distantly related members of *Cnemaspis* as the outgroup to reconstruct relationships between the south Asian clade, we use more closely related members of *Lygodactylus* and *Phelsuma* as outgroups. However, our approach does not substantially improve the resolution of the tree from that of Sayyed *et al.* (2018) but improves the support at deeper nodes.

The two new species were recovered as within the *wynadensis* clade with strong support. However, the relationships between *Cnemaspis chengodumalaensis* **sp. nov.**, *C. wynadensis* and *C. heteropholis* could not be resolved. While the genetic distance between C. *zacharyi* **sp. nov.** and the rest of the *wynadensis* clade was as high as 7 – 9%, the genetic distance between *C. chengodumalaensis* **sp. nov.** and *C. wynadensis*, *C. kottiyoorensis* and *C. heteropholis* were as low as 3.5 – 4%. Although there is no standard threshold to delimit species using genetic

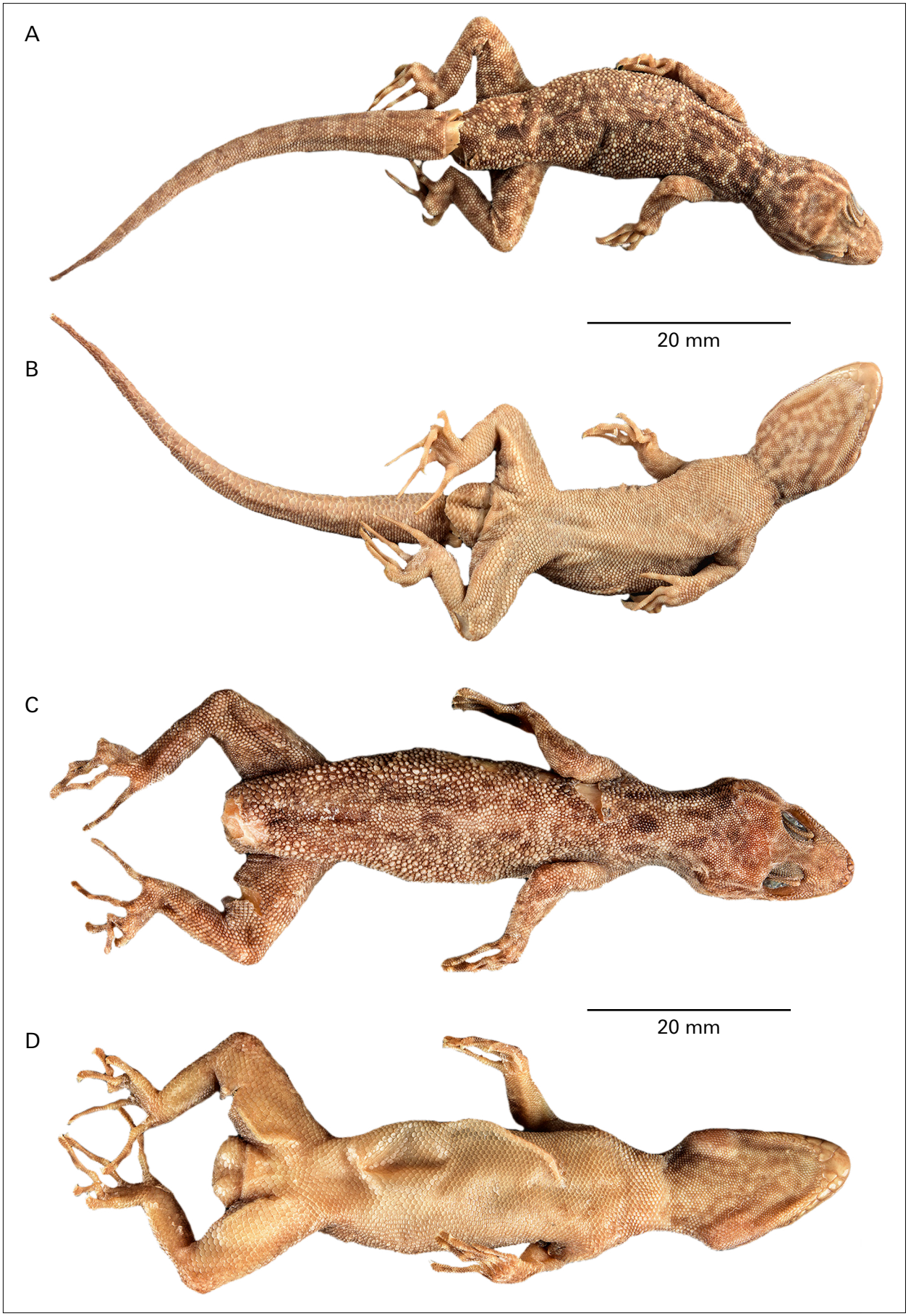

Fig. 9. Type specimens of *Cnemaspis sisparensis*. A & B – dorsal and ventral view of the holotype of *Gonatodes bireticulatus*. C & D – dorsal and ventral view of the holotype of *C. anaikattiensis*.

distance (Shanker *et al.*, 2017), divergence higher than 3% in the 16S rRNA gene can be a reliable threshold to delimit species (Fouquet *et al.*, 2007; Shanker *et al.*, 2017). Our analysis indicates that the two species described here, with > 3% divergence, are indeed genetically distinct from other members of the *wynadensis* clade. We acknowledge that we have not sampled *C. sisparensis* that very closely resemble *C. chengodumalaensis* **sp. nov.** in overall morphology and colouration (Fig. 9) and likely belong to the *wynadensis* clade. Nonetheless, our morphometric analysis reveals considerable differences in the morphospace of both the new species with *C. sisparensis.*

Examination of the two types of *C. anaikattiensis* and the holotype of *Gonatodes bireticulatus* indicate that all three specimens are morphologically indistinguishable and are indeed the same species (see Table 4). Manamendra-Arachchi *et al.* (2007), examined the holotype of *C. sisparensis* (BMNH 74.4.29.383) at the Natural History Museum, London and the types of *C. anaikattiensis* and *G. bireticulatus* at ZSI, Kolkata, and synonymized the latter two species with *C. sisparensis*. Although, we did not examine the heavily fragmented holotype of *C. sisparensis* (see Plate 2 a,b in Manamendra-Arachchi *et al.* (2007)), comparison of the types of *C. anaikattiensis* and *G. bireticulatus* with the description and illustrations of *C. sisparensis* from Manamendra-Arachchi *et al.* (2007) indicate that they all represent the same species. Further, Sholakkal, the type locality of *C. sisparenis* (Beddome, 1870) (currently Cholakkal in Malappuram district, Kerala) and Kavalai, the type locality of *G. bireticulatus*, which is 30 km east from Chalakudy, Thrissur district (Henderson, 1912; Annandale, 1915), are ca. 89 km apart (aerial distance) and are at a distance of ca. 47 km and 84 km respectively from the type locality of *C. anaikattiensis*. The geographic distance between the type localities of *C. sisparensis*, *C. anaikattiensis* and *G. bireticulatus* is similar to the geographic range inferred for *C. kottiyoorensis* from this study. Thus, based on the morphological similarity and geographic proximity, we consider *C. anaikattiensis* and *G. bireticulatus* as junior synonyms of *C. sisparensis* following Manamendra-Arachchi *et al.* (2007). *C. chengodumalaensis* **sp. nov.** most closely resembles *C. sisparensis* with the closest geographical distance between both species being ca. 70 km. Both species also occupy similar elevational ranges (200 – 600 m ASL). Although *C. chengodumalaensis* **sp. nov.** and *C. sisparensis* show such close geographical distribution, it should be noted that the Chaliyar river geographically separates the two species with *C. chengodumalaensis* **sp. nov.** distributed on the north of the river and *C. sisparensis* on the south. However, further studies will be necessary to understand the potential role of river systems in influencing the distribution and species diversification of south Indian *Cnemaspis*.

Interestingly, intraspecific genetic divergence between the widely distributed *C. heteropholis* from northern and southern populations was close to 5%. However, genetic divergence obtained from our analysis needs to be interpreted with caution since we have sequenced only one strand of the 16S rRNA gene, and there is the possibility of sequencing artefacts. Nonetheless, intraspecific divergences for three other species in the *wynadensis* clade are as little as 0.2 – 1.2%. Thus, the high intraspecific divergence between populations of *C. heteropholis* suggests the presence of multiple cryptic species within the *C. heteropholis* clade. On the other hand, our analyses indicate that *C. kotiyoorensis*, which is known from a few localities in Wayanad and Kannur district of Kerala (Cyriac & Umesh, 2014) has a much wider range. Our samples collected from Paithalmala in Kannur district of Kerala and Devarakolli in Kodagu district of Karnataka state extends the known range of *C. kottiyoorensis* to ca. 70 km northward. Given our limited sampling, we cannot, at this point determine the actual diversity within this clade; however, our analysis points towards high cryptic diversity within the *wynadensis* clade. Further studies with a finer sampling strategy will be required along with genetic and morphological analyses to uncover the cryptic diversity within *Cnemaspis* in the Western Ghats.

Importantly, both *Cnemaspis zacharyi* **sp. nov.** and *C. chengodumalaensis* **sp. nov.** described herein were found predominantly in rocky outcrops in forested patches and plantations outside protected areas. Specifically, *C. chengodumalaensis* **sp. nov.** is currently known only from midland hillocks of northern Kerala. The midlands, with several scattered and isolated hillocks are one of the most important landscape features of the State, between the high-rising Western Ghats and the low coastal area. The rocky outcrops, grasslands and the forest patches of these hillocks (Fig. 10) are rich in diverse microhabitats accommodating specialized ecosystems and many endemic plants and animals (e.g. Palot & Radhakrishnan, 2005; Pramod *et al.*, 2014). The midland hill system of northern Kerala has been facing serious danger of degradation over the years. Most part of the midland hillocks have been converted to plantations, building sites, mining sites, etc. The indiscriminate mining for granite and soil (Fig. 10C, D) has disrupted the water availability and supply within these hills and surrounding areas and has severely threatened the very existence of the biota and culture of Chengodumala, the type locality of *C. chengodumalaensis* **sp. nov.**

Our study highlights the presence of cryptic diversity present outside protected regions of the Western Ghats and understudied areas such as the midland hillocks of Kerala. The presences of new species outside protected areas that are currently under threat from intensive excavation and uncontrolled illegal quarrying, especially in midland hillocks, raises serious conservation concerns. Thus, emphasizing the urgent need for extensive surveys, not only within protected wildlife sanctuaries and national parks, but also in surrounding non-protected areas and plantations especially to the midland hillocks of Kerala, that could harbour cryptic diversity.

Fig. 10. Habitat of *C. chengodumalaensis* **sp. nov.** A, B – Rocky outcrops within forested patches of Chengodumala (images taken in 2013); C, D – Destruction of rocky outcrops in Chengodumala due to illegal granite quarrying (images by Biju Kolakkandi in 2019).

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Appendixes

Appendix 1: GenBank accession number and voucher information of Indian *Cnemaspis* and outgroups used in this study. Species highlighted in bold indicate new sequences generated in this study.

No	Species	Locality	Voucher	16S rRNA
1	*Cnemaspis mahabali*	Pune, Maharashtra	BNHS 2451	MH174353
2	*Cnemaspis mahabali*	Pune, Maharashtra	BNHS 2502	MH174352
3	*Cnemaspis mahabali*	Pune, Maharashtra	BNHS 2503	MH174354
4	*Cnemaspis amboliensis*	Sindhudurg, Maharashtra	BNHS 2458	MH174358
5	*Cnemaspis amboliensis*	Sindhudurg, Maharashtra	BNHS 2505	MH174355
6	*Cnemaspis amboliensis*	Sindhudurg, Maharashtra	BNHS 2507	MH174357
7	*Cnemaspis amboliensis*	Sindhudurg, Maharashtra	BNHS 2508	MH174356
8	*Cnemaspis ajijae*	Satara, Maharashtra	ZSI WRC R/1055	KX753650
9	*Cnemaspis ajijae*	Satara, Maharashtra	ZSI WRC R/1056	KX753651
10	*Cnemaspis ajijae*	Satara, Maharashtra	ZSI WRC R/1057	KX753652
11	*Cnemaspis ajijae*	Satara, Maharashtra	ZSI WRC R/1058	KX753653
12	*Cnemaspis ajijae*	Satara, Maharashtra	ZSI WRC R/1059	KX753648
13	*Cnemaspis ajijae*	Satara, Maharashtra	ZSI WRC R/1060	KX753649
14	*Cnemaspis limayei*	Sindhudurg, Maharashtra	ZSI WRC R/1052	KX753646
15	*Cnemaspis limayei*	Sindhudurg, Maharashtra	ZSI WRC R/1053	KX753647
16	*Cnemaspis yercaudensis*	Salem, Tamil Nadu	BNHS 2509	MH174359
17	*Cnemaspis yercaudensis*	Salem, Tamil Nadu	BNHS 2510	MH174360
18	*Cnemaspis otai*	Vellore, Tamil Nadu	BNHS 2511	MH174361
19	*Cnemaspis otai*	Vellore, Tamil Nadu	BNHS 2512	MH174362
20	*Cnemaspis gracilis*	Palakkad, Kerala	BNHS 2513	MH174369
21	*Cnemaspis gracilis*	Palakkad, Kerala	BNHS 2514	MH174370
22	*Cnemaspis indica*	Nilgiris, Tamil Nadu	BNHS 2515	MH174365
23	*Cnemaspis indica*	Nilgiris, Tamil Nadu	BNHS 2516	MH174366
24	*Cnemaspis littoralis*	Kozhikode, Kerala	BNHS 2517	MH174367
25	*Cnemaspis littoralis*	Kozhikode, Kerala	BNHS 2518	MH174368
26	*Cnemaspis kottiyoorensis*	Kannur, Kerala	BNHS 2519	MH174363
27	*Cnemaspis wynadensis*	Wayanad, Kerala	BNHS 2520	MH174364
28	*Cnemaspis indraneildasii*	Uttara Kannada, Karnataka	BNHS 2460	KX753656
29	*Cnemaspis indraneildasii*	Uttara Kannada, Karnataka	BNHS 2461	KX753657
30	*Cnemaspis indraneildasii*	Uttara Kannada, Karnataka	BNHS 2462	KX753658
31	*Cnemaspis indraneildasii*	Uttara Kannada, Karnataka	BNHS 2463	KX753659
32	*Cnemaspis goaensis*	Kolhapur, Maharashtra	CnKh 33	MH174375
33	*Cnemaspis goaensis*	Kolhapur, Maharashtra	ChKh 34	MH174376
34	*Cnemaspis goaensis*	Kolhapur, Maharashtra	CnKo 48	MH174377
35	*Cnemaspis goaensis*	Kolhapur, Maharashtra	CnKo 49	MH174378
36	*Cnemaspis goaensis*	Shimoga, Karnataka	CnInAr 1	MH174371
37	*Cnemaspis goaensis*	Shimoga, Karnataka	CnInAr 2	MH174372
38	*Cnemaspis goaensis*	Shimoga, Karnataka	CnInA 1	MH174373
39	*Cnemaspis goaensis*	Shimoga, Karnataka	CnInA 2	MH174374
40	*Cnemaspis flaviventralis*	Sindhudurg, Maharashtra	ZSI WRC R/1042	KX269819
41	*Cnemaspis flaviventralis*	Sindhudurg, Maharashtra	ZSI WRC R/1043	KX269820
42	*Cnemaspis girii*	Satara, Maharashtra	BNHS 2445	KX269823
43	*Cnemaspis girii*	Satara, Maharashtra	BNHS 2446	KX269824
44	*Cnemaspis kolhapurensis*	Sindhudurg, Maharashtra	BNHS 2447	KX269821
45	*Cnemaspis kolhapurensis*	Sindhudurg, Maharashtra	BNHS 2448	KX269822
46	*Cnemaspis heteropholis*	Shimoga, Karnataka	BNHS 2466	KX753660
47	*Cnemaspis adii*	Ballari, Karnataka	BNHS 2464	KX753654
48	*Cnemaspis adii*	Ballari, Karnataka	BNHS 2465	KX753655
49	*Cnemaspis goaensis*	Goa	ZSI WRC R/1044	KX269825
50	*Cnemaspis goaensis*	Goa	ZSI WRC R/1045	KX269826

Appendix 1 – continuation.

51	***Cnemaspis zacharyi* sp. nov.**	**Lakkadi, Wayanad, Kerala**	**BNHS 2735**	**MT217042**
52	***Cnemaspis zacharyi* sp. nov.**	**Lakkadi, Wayanad, Kerala**	**BNHS 2736**	**MT217041**
53	***Cnemaspis zacharyi* sp. nov.**	**Lakkadi, Wayanad, Kerala**	**BNHS 2737**	**MT217040**
54	***Cnemaspis chengodumalaensis* sp. nov.**	**Chengodumala, Kozhikode, Kerala**	**BNHS 2741**	**MT217043**
55	***Cnemaspis sp***	**Pepara WLS, Trivandrum, Kerala**	**VPCGK_014**	**MT217033**
56	***Cnemaspis anamudiensis***	**Anamudi RF, Idukki, Kerala**	**VPCGK_016**	**MT217034**
57	***Cnemaspis sp***	**Vagamon, Kerala**	**VPCGK_021**	**MT217035**
58	***Cnemaspis nilagirica***	**Silent Valley NP, Palakkad, Kerala**	**VPCGK_034**	**MT217036**
59	***Cnemaspis heteropholis***	**Devarakolli, Madikeri, Karnataka**	**BNHS 2745**	**MT217039**
60	***Cnemaspis kottiyoorensis***	**Devarakolli, Madikeri, Karnataka**	**BNHS 2747**	**MT217038**
61	***Cnemaspis kottiyoorensis***	**Paithalmala, Kannur, Kerala**	**VPCGK_052**	**MT217042**
62	*Phelsuma lineata*	Madagascar	ZCMV_2029	KC438463
63	*Phelsuma v-nigra*	Moheli, Comoros	MH10	FJ829967
64	*Phelsuma ornata*	Reunion	Sound_P7	DQ270577
65	*Lygodactylus picturatus*	Tanzania	LYG_4	HQ872462
66	*Lygodactylus miops*	Madagascar	LUS8	LN998673
67	*Lygodactylus madagascariensis*	Madagascar	LM1A	LN998665

Appendix 2: Comparative material examined

***C. heteropholis*:** BNHS2466 from the Shimoga, Karnataka; BNHS 2745, BNHS 2746 and ZSI/WRC/R/1095 collected from Devarakolli, Madikeri in Kodagu district of Karnataka.

***C. kolhapurensis*:** BNHS1855 (Holotype) from Dajipur, Kolhapur district, Maharashtra; BNHS1854, BNHS1844, BNHS1845, BNHS1846, BNHS1843 and BNHS1856 (Paratypes) from Dajipur, Kolhapur District, Maharashtra; BNHS2448 and BNHS2447 from Amboli, Sindhudurg district, Maharashtra

***C. kottiyoorensis*:** TNHM (H) 13.7.06/80 (Holotype) Perumalmudi, Kottiyoor Wildlife Sanctuary, Kannur District, Kerala; TNHM (H) 13.7.06/81 (Paratype) from same locality as holotype, TNHM (H) 13.7.06/82 (Paratype) from Chandanathodu, Periya Reserve Forest, Wayanad, Kerala; TNHM (H) 13.7.06/83 from Makkimala, Wayanad, Kerala; BNHS2519 from Kannur, Kerala; BNHS 2747 collected from Devarakolli, Madikeri in Kodagu district of Karnataka. VPC-GK-052 uncollected specimen from Paithalmala, Kannur, Kerala, used for molecular analysis.

***C. wynadensis*:** BNHS2520 from Vythiri, Wayanad, Kerala; BNHS 2748 from Kuruchiyad, Wayanad wildlife sanctuary, Wayanad, Kerala; ZSI/WRC/R/1096 and ZSI/WRC/R/1097 from Tholayiram, Mepadi, Wayanad, Kerala; BNHS 2749 from Lakkadi, Wayanad, Kerala.

***C.* cf. *wynadensis*:** ZSI/WRC/R/1098 and ZSI/WRC/R/1099 collected from Bhagamandala, Kodagu, Karnataka;

***C. sisparensis*:** ZSI 17970, holotype of *Gonatodes bireticulatus* from Kavalai, Kerala; *C. anaikattiensis*, ZSI 25601 (Holotype) ZSI 25602 (Paratype) collected from Anaikatti Hills, Coimbatore district, Tamil Nadu.

Appendix 3: Loadings of the morphological variables from the Principal Component Analysis. Bold values indicate strong loading with correlation > 0.35.

Character	Description	PC1	PC2
SVL	Snout-vent length	**−0.9802**	−0.0001
AG	Axilla-groin distance	**−0.9034**	−0.1700
TW	Trunk width	**−0.9369**	0.1640
ED	Eye diameter	**−0.9163**	−0.0079
EN	Eye-to-nasal distance	**−0.9639**	0.1072
ES	Snout length	**−0.9760**	0.0649
ET	Eye-to-ear distance	**−0.9412**	0.0299
IN	Inter-nasal distance	**−0.8536**	0.2320
TD	Horizontal diameter of ear opening	**−0.6650**	**−0.6326**
HL	Head length	**−0.8589**	**−0.3580**
HW	Head width	**−0.9765**	−0.1322
HD	Head depth	**−0.9823**	0.0150
IO	Inter-orbital distance	**−0.9119**	0.1156
UAL	Upper arm length	**−0.9519**	0.0316
LAL	Lower arm length	**−0.9837**	0.0472
PAL	Palm length	**−0.9763**	0.0295
FL1	Length of 1st finger	**−0.9703**	0.0223
FL4	Length of 4th finger	**−0.9697**	0.0301
FEL	Femur length	**−0.9684**	0.1304
TBL	Tibia length	**−0.9676**	0.0835
TOL1	Length of 1st toe	**−0.9714**	0.0346
TOL4	Length of 4th toe	**−0.9705**	−0.0467
Eigenvalues		**19.3890**	0.7185
Standard deviation		4.4033	0.8477
Proportion of Variance		0.8813	0.0327
Cumulative Proportion		0.8813	0.9140