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CNEMASPIS FLAVIVENTRALIS, A NEW SPECIES OF GECKO (SQUAMATA: GEKKONIDAE) FROM THE WESTERN GHATS OF MAHARASHTRA, INDIA

Amit Sayyed¹, Robert Alexander Pyron² & Neelesh Dahanukar³

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¹Wildlife Protection and Research Society, 40, Rajaspura Peth, Satara, Maharashtra 415002, India

²Department of Biological Sciences, The George Washington University, 2023 G St. NW, Washington, D.C. 20052, USA

³Indian Institute of Science Education and Research, G1 Block, Dr. Homi Bhabha Road, Pashan, Pune, Maharashtra 411008, India

³Systematics, Ecology and Conservation Laboratory, Zoo Outreach Organization (ZOO), 12 Thiruvannamalai Nagar, Saravanampatti-Kalapatti Road, Saravanampatti, Coimbatore, Tamil Nadu 641035, India

¹amitsayyedsatara@gmail.com, ²rpyron@colubroid.org, ³n.dahanukar@iiserpune.ac.in (corresponding author)

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Abstract: *Cnemaspis flaviventralis*, a new species of day gecko, is described from the forests of Amboli, Sindhudurg District, Maharashtra State, northern Western Ghats, India. The new species was previously confused with the sympatric species *Cnemaspis girii*, *C. indraneildasii*, *C. kolhapurensis* and *C. goaensis*. It is distinguished from *C. girii* by having spine-like tubercles on flanks, granular dorsal scales intermixed with large, depressed, slightly keeled scales (vs. lack of spine-like tubercles on flanks, granular dorsal scales, intermixed with large smooth scales); from *C. indraneildasii* by having dorsal scales heterogeneous (vs. homogenous), lacking a series of enlarged median sub-caudal scales, and 28–29 (vs. 20) ventral scales across mid-body; from *C. kolhapurensis* by having heterogeneous (vs. homogenous) dorsal scalation, lacking spine-like tubercles on flanks and lacking pre-cloacal pores (vs. 24–28 pre-cloacal-femoral pores); and from *C. goaensis* by lacking pre-cloacal pores and lacking a series of enlarged median sub-caudal scales. We further provide partial mitochondrial 16S rRNA gene sequences for the new species and for the sympatric species *C. girii*, *C. kolhapurensis* and *C. goaensis*, and show that the new species is genetically distinct.

Keywords: Amboli, Maharashtra, molecular phylogeny, new species, taxonomy.

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Author Contribution: AS conducted field work, took photographs, studied museum specimens, diagnosed the species and performed taxonomic studies; ND performed phylogenetic analysis; AS, RAP and ND wrote the paper.

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INTRODUCTION

The species-rich lizard genus *Cnemaspis* Strauch, 1887 in the family Gekkonidae includes at least 120 Old World species (Uetz & Hošek 2015) distributed from Africa to South-east Asia. As presently understood, the widespread genus *Cnemaspis* appears to be polyphyletic (Gamble et al. 2012; Pyron et al. 2013; Grismer et al. 2014). Further, cryptic and underestimated diversity is also very high in *Cnemaspis* (e.g., Manamendra-Arachchi et al. 2007; Grismer et al. 2014; Amarasinghe et al. 2015). The Western Ghats-Sri Lanka biodiversity hotspot is becoming a hotspot for *Cnemaspis* with several new species described in recent years (e.g., Manamendra-Arachchi et al. 2007; Giri et al. 2009; Cyriac & Umesh 2014; Mirza et al. 2014; Vidanapathirana et al. 2014; Srinivasulu et al. 2015). Given the extreme morphological similarity among species within the group, their small size and the generally overlooked nature of the South Asian herpetofauna, discovering new species is not surprising.

Based on a new collection from the northern Western Ghats of Maharashtra, India, we describe here a new species of *Cnemaspis* to make a name available and facilitate their conservation. We also provide a molecular analysis based on 16S rRNA genomic sequences that may facilitate future studies in the region.

MATERIALS AND METHODS

Specimen collection

Specimens of the type series were collected from Amboli (15.960°N & 73.999°E, elevation 735m), Sindhudurg District, Maharashtra, India. Four males and four female specimens were collected during night. Two specimens of *Cnemaspis girii* Mirza, Pal, Bhosale & Sanap, 2014 were collected from Kaas plateau (17.724°N & 73.819°E), the type locality of the species; two specimens of *C. kolhapurensis* Giri, Bauer & Gaikwad, 2009 were collected from Amboli (15.971°N & 73.979°E); and two specimens of *C. goaensis* Sharma, 1976, were collected from Goa (15.290°N & 74.006°E). They were anaesthetized, fixed in formalin, and preserved in 70% ethyl alcohol. Geographic coordinates and atmospheric temperature readings were taken at the collection localities with the aid of a Kestrel 4500 weather meter.

Museum details

Specimens from the current study are deposited in

the collections of the Bombay Natural History Society, Mumbai (BNHS) and the Zoological Survey of India, Western Regional Center (ZSI-WRC), Pune, Maharashtra. Comparative materials were examined at the Zoological Survey of India, Kolkata (ZSI-K).

Morphometric and meristic data collection

Following measurements were taken using a Yamayo digimatic caliper to the nearest 0.1mm following Giri et al. (2009) and Mirza et al. (2014), and include snout vent length (SVL, from tip of snout to vent), trunk length (TRL, distance from axilla to groin measured from posterior edge of forelimb insertion to anterior edge of hind limb insertion), trunk width (TrW, maximum width of body), tail length (TL, from vent to tip of tail), tail width (TaW, measured at widest point of tail), head length (HL, distance between retroarticular process of jaw and snout-tip), head width (HW, maximum width of head), head depth (HD, maximum depth of head, from occiput to underside of jaws), forearm length (FL, from base of palm to elbow), tibia length (TBL, knee to tarsal), eye to nares distance (E-N, distance between anteriormost point of eye and nostril), eye to snout distance (E-S, distance between anteriormost point of eye and tip of snout), eye to ear distance (E-E, distance from anterior edge of ear opening to posterior corner of eye), Ear length (EL, greatest diameter of ear opening), internarial width (IN, distance between nares), orbital diameter (OD, greatest diameter of orbit), inter orbital distance (IO; greatest distance between left and right supraciliary scale rows). Following meristic data were taken for all specimens under a Leica stereo microscope: supralabial scales (SupraL), infralabial scales (InfraL), femoral pores (FPores), lamellae under digits of manus (MLam) and pes (PLam) for both left (L) and right (R) sides (lamellae counts taken from the scale just behind claw to first interphalangeal joint excluding large scancers), longitudinal scale rows across the belly (in between the lowest rows of lateral granular scales (MVS).

Genetic analysis

Muscle tissue harvested from two fresh specimens of the new species (ZSI-WRC 1042, 1043) collected from same locality of holotype, two specimens of *C. girii* (BNHS 2445, 2446), two specimens of *C. goaensis* (ZSI R/1044 and 1045) and two specimens of *C. kolhapurensis* (BNHS 2447, 2448). Tissue samples were digested at 55°C using STE buffer (50 mM Tris-HCl, 20 mM EDTA and 50µl of 10% SDS) with 10 µL of 20 mg/ml Proteinase K. RNase treatment was given for two hours at 37°C. Final extraction process was done using

phenol-chloroform method. Polymerase Chain Reaction was performed for amplification of mitochondrial 16S rRNA gene using the primer pair 16SF (5'-CCC GCC TGT TTA CCA AAA ACA-3') and 16SR (5'-GGT CTG AAC TCA GAT CAC GTA-3'). PCR reaction was performed in a 25µl reaction volume containing 5µl of template DNA (~200ng), 2.5µl of 10X reaction buffer (100 mM Tris pH 9.0, 500 mM KCl, 15 mM MgCl₂, 0.1% Gelatin), 2µl of 25 mM MgCl₂, 1µl of 10 mM dNTPs, 1µl of each primer, 1µl Taq polymerase and 16.5µl nuclease free water. The thermal profile was 10 minutes at 95°C, and 35 cycles of one minute at 94°C, one minute at 52°C and two minutes at 72°C, followed by extension of 10 minutes at 72°C. Amplified DNA fragments were purified using the 'Promega Wizard Gel and PCR clean up' system. The purified PCR products were sequenced using ABI prism 3730 sequencer (Applied Biosystems, USA) and Big dye terminator sequencing kit (ABI Prism, USA). Sequences were analyzed by BLAST tool (Altschul et al. 1990) for similar sequences in the NCBI (www.ncbi.gov) database. These sequences have been deposited in GenBank under the accession numbers KX269819-KX269826.

Additional sequences for phylogenetic analysis were downloaded from NCBI database. *Eublepharis macularius* (Blyth, 1854), a member of family Eublepharidae, was used as an outgroup. Gene sequences were aligned using MUSCLE (Edgar 2004). Best fit nucleotide substitution model was selected from 56 models available in PhyML (Guindon et al. 2010) using TOPALi v2 (Milne et al. 2008) based minimum Bayesian Information Criterion (BIC) value (Schwarz 1978; Nei & Kumar 2000). Best nucleotide substitution matrix was used to perform maximum likelihood analysis using PhyML (Guindon et al. 2010). Reliability of the phylogenetic tree was estimated using bootstrap values run for 1000 iterations. Phylogenetic tree was edited in FigTree v1.4.2 (Rambaut 2009). Raw (p) distances between pairs of sequences were calculated in MEGA 6 (Tamura et al. 2013).

RESULTS

Cnemaspis flaviventralis sp. nov. (Images 1–3)

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Holotype: BNHS 2442, 21.x.2012, adult male, India: Maharashtra: Sindhudurg District, Amboli (15.960°N & 73.999°E; 735m), coll. Amit Sayyed and Jitendra Patole.

Paratypes: BNHS 2443 (male), BNHS 2444 (female),

ZSI-WRC R/1039 (male) and ZSI-WRC R/1040 (female), 9.xi.2013, same locality as holotype, collected by Amit Sayyed, Abhiji Nale, Jitendra Patole, Mangesh Karve, and Kapil Taple; 23.x. 2015, ZSI-WRC R/1042 (male), ZSI-WRC R/1041 (female) and ZSI-WRC R/1043 (female), same locality as holotype, coll. Amit Sayyed, Abhiji Nale, Jitendra Patole, Mangesh Karve, and Kapil Taple.

Diagnosis: A medium-sized *Cnemaspis*, maximum known SVL less than 37.0mm (30.4–36.4, n = 8), granular dorsal scales on trunk heterogeneous, intermixed with large depressed slightly keeled scales, large keeled conical tubercles present on flanks, postcloacal spurs in both sexes, ventral scales larger than dorsal scales, imbricate, smooth, without a series of enlarged median sub-caudal scales, 28–29 scales across the belly, 8–9 lamellae under first digit and 10–11 lamellae under fourth digit of manus, 8–9 lamellae under first digit and 10–12 lamellae under fourth digit of pes, males with three femoral pores on each side and no pre-cloacal pores.

Description of holotype BNHS 2442 (Image 1): Adult male, in good condition with original tail. Medium sized, SVL 31.8 mm. Head moderately short (HL/SVL = 0.20), wide (HW/HL = 0.98), fairly burly (HD/HL = 0.63), distinct from neck. Loreal region not inflated, canthus rostralis not prominent. Snout slightly long; much longer than eye diameter (OD/ES = 0.29); scales on snout, canthus rostralis and forehead region granular; interorbital and occipital region with smaller, granular scales (Image 2). Eye relatively small (OD/HL = 0.23); pupil rounded; supraciliary scales granular. Ear opening semicircular, oblique, minute (EL/HL = 0.03); eye to ear distance much greater than diameter of eyes (E-E/OD = 2.73). Rostral wider (1.2mm) than deep (0.9mm), swollen, partially divided mid-dorsally by well developed rostral groove; internasals rounded; nostrils not in contact with first supralabial; rostral in contact with first supralabial, two rows of scales separate eye from supralabial row. Mental sub-triangular, slightly wider (1.6mm) than long (1.4 mm); three pairs of postmentals, primary postmentals enlarged, each surrounded laterally by first infralabial; a single enlarged gular scale separates postmentals (Image 2b). Infralabials bordered by a row of slightly enlarged scales, decreasing in size posteriorly. Enlarged supralabials to angle of jaw 8 (right) – 9 (left) (Image 2a), to mid-orbit position 6 (on both sides); infralabials 8 (on both sides). Body relatively slender, not elongate (TRL/SVL = 0.47) without a ventrolateral fold. Granular dorsal scales on trunk heterogeneous, intermixed with large, depressed, slightly keeled scales; large keeled conical tubercles on flanks (Image 3a). Ventral scales larger



Image 1. *Cnemaspis flaviventralis* sp. nov. holotype (male, BNHS 2442) a - dorsal view; b - ventral view.

than dorsal scales, smooth; 28–29 mid-body scale rows across belly (Image 1b). Three femoral pores on each side (Image 3c, 4b). Forelimbs and hind limbs relatively short, slender; forearm and tibia short ($FL/SVL = 0.16$; $TBL/SVL = 0.19$), interdigital webbing absent. Sub-digital lamellae under fourth digit of right manus, 8,9,11,11,9 (Image 3d), fourth digit of right pes, 8,9,11,11,11 (Image 3e); relative length of digits (measurements in mm): IV (3.93) > III (3.61) > V (3.14) > II (2.77) > I (2.07) (right manus); IV (3.99) > III (3.83) > V (3.76) > II (3.38) > I (1.73) (right pes) (Image 3d,e). Tail sub-cylindrical, tail longer than SVL ($TL/SVL = 1.45$); tail base swollen when viewed ventrally (Image 3b); post cloacal spurs present (Image 1a,b, 3b,c, 4b); dorsal scales of tail granular, with carinated enlarged tubercles, ventral scales imbricate, smooth, without a series of enlarged median sub-caudal scales (Image 3b).

Coloration: In life (Image 4a), dorsum ground color reddish-brown; dorsal and lateral tubercles, including flank tubercles, bright yellow. Transverse brown line

present in interorbital area. Irregular dark brown patches scattered on head dorsally. Lateral view of head with a faded brown line from posterior border of eye to ear. Curved black marking surrounded by orange scales present on nape. Black arrowhead shape patch present on posterior side of neck. Supraciliaries brown. Pupil black with orange surrounding. Supralabials in a yellow background with faded black spots. Throat white. Ventral view of arm dust yellow; belly including thighs bright yellow (Image 4b). Mid-dorsal area of body reddish-brown, with three faded 'W' shaped brownish-black markings on thoracic vertebral region, between fore- and hind limbs; horseshoe shaped brownish-black markings present on lumbar vertebral region (Image 4a). Black and yellow colored spots on each digit of fore limbs and hind limbs. Tail dorsally brown, with faded yellow transverse marks; ventral tail greyish. In preservative (Image 1a, b), dorsum ground color brown, dorsal tubercles dusky white; ventral sides white with scattered black spots.

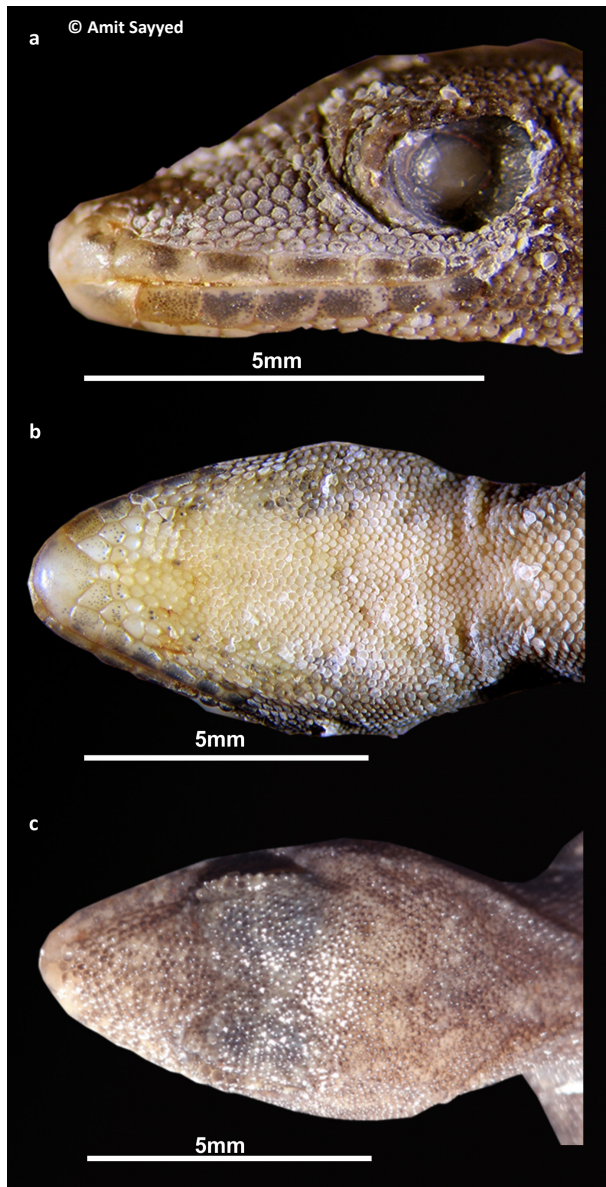


Image 2. *Cnemaspis flaviventralis* sp. nov. holotype (male, BNHS 2442, 31.8mm SVL)
a - lateral; b - ventral; c - dorsal views of head respectively.

Variation

Variation in mensural and meristic data as in Table 1. Some paratypes are duller than the holotype in overall appearance.

Etymology

The species epithet is a combination name derived from the Latin words 'flavus' meaning yellow and 'ventralis' meaning ventral or pertaining to the belly, referring to the distinct yellow colouration of the ventral part of the body of the new species.

Suggested common name: Yellow-bellied Day Gecko.

Distribution

Cnemaspis flaviventralis sp. nov. is known only from its type locality (Image 5).

Natural history

Cnemaspis flaviventralis sp. nov. is a semi-arboreal species. Four specimens were collected from a tree trunk about two metres above ground level, another two found in leaf litter, and two specimens were collected from rock surfaces. All specimens were collected in October 2012 and in November 2013 between 2200 and 0200 hr (atmospheric temperature was 22–27 °C). Individuals were found to be more active between 22°C and 25°C at dusk. The specimens were observed in a dense forest (Image 6) in Amboli. Field observations suggest that September to November is the breeding season for the species and egg laying occurs in October and November. After mating females deposit two eggs under rocks, on boulders, or in tree holes. Co-occurring herpetofauna include: *Bungarus caeruleus* (Elapidae); *Trimeresurus malabaricus* (Viperidae); *Lycodon travancoricus* and *Macropisthodon plumbicolor* (Colubridae); *Uropeltis* sp. (Uropeltidae); *Hemidactylus prashadi*, *H. cf. brookii*, *Geckoella albofasciatus* and *Cnemaspis kolhapurensis* (Gekkonidae); *Raorchestes ghatei*, *Pseudophilautus amboli* and *Rhacophorus malabaricus* (Rhacophoridae); *Indirana chiravasi* (Ranixalidae); and *Xanthophryne tigerina* (Bufonidae).

Molecular analysis

Model selection suggested general time reversible with gamma distribution (GTR+G, lnL = -2672.85, BIC = 5548.48, G = 0.283, df = 32, n = 565) as the best fit model for nucleotide substitution. Maximum likelihood analysis (Image 7) suggested that *Cnemaspis flaviventralis* sp. nov. forms a monophyletic group with other species of *Cnemaspis* found in sympatry, with *C. girii* as its sister taxon. Uncorrected raw genetic distance between the two specimens of *C. flaviventralis* was 0.6%, whereas the distances between *C. flaviventralis* and other northern Western Ghats congeners was 7.5–8.1% with *C. girii*, 9.1–10.1% with *C. goensis* and 15.4–15.7% with *C. kolhapurensis*.

Comparisons

Cnemaspis flaviventralis sp. nov. can be distinguished from its congeners from the northern Western Ghats on the basis of the following characters: presence of spine-like tubercles on flanks, granular dorsal scales intermixed with large, depressed, slightly keeled scales (vs. lack of

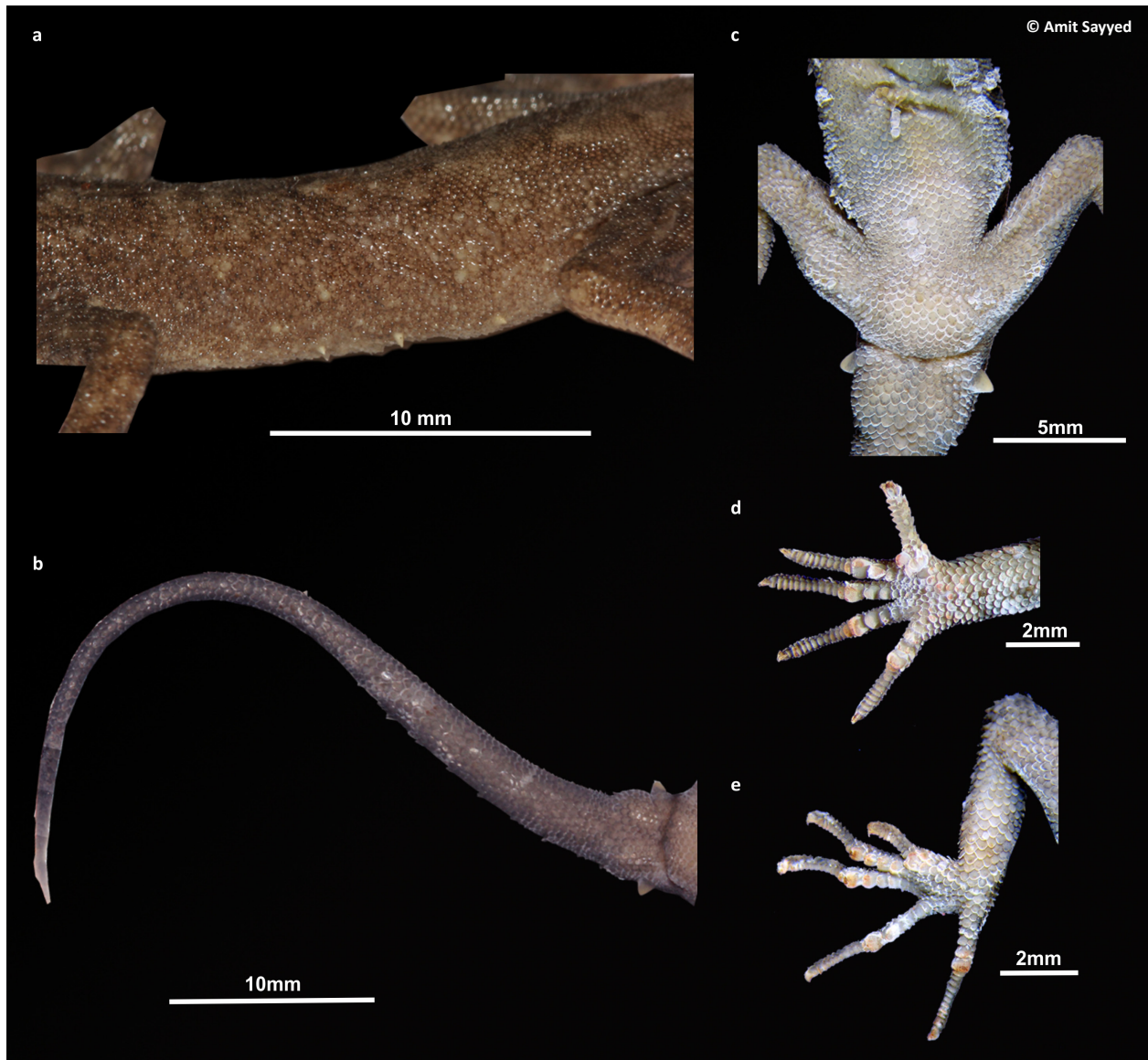


Image 3. *Cnemaspis flaviventralis* sp. nov. holotype (male, BNHS 2442). (a) Lateral view of trunk, (b) ventral view of tail, (c) ventral view of pre-cloacal region showing femoral pores, (d) ventral view of right manus and (e) ventral view of right pes.

spine-like tubercles on flanks, granular dorsal scales, intermixed with large smooth scales in *C. girii*); dorsal scales heterogeneous, 28 or 29 ventral scales across mid-body (vs. dorsal scales homogenous, 20 ventral scales across mid-body in *C. indraneildasii* Bauer, 2002); dorsal scales heterogeneous, lacking spine-like tubercles on flanks and lacking pre-cloacal pores (vs. dorsal scales homogenous, spine-like tubercles absent on flanks, a continuous series of pre-cloacal femoral pores in *C. kolhapurensis*); and pre-cloacal pores and series of enlarged median sub-caudal scales absent (vs. present in *C. goaensis*). From its other congeners from India, *Cnemaspis flaviventralis* can be distinguished based

on characters such as: presence of spine-like tubercles on flanks (vs. absent in *C. heteropholis* Bauer, 2002, *C. anaikattiensis* Mukherjee, Bhupathy & Nixon, 2005, *C. adii* Srinivasulu, Kumar & Srinivasulu, 2015); males with femoral pores (vs. pre-anal and femoral pores absent in *C. boiei* (Gray, 1842), *C. assamensis* Das & Sengupta, 2000); dorsal scales heterogeneous (vs. dorsal scales homogenous in *C. indica* (Gray, 1831), *C. boiei*, *C. mysoriensis* (Jerdon, 1853), *C. littoralis* (Jerdon, 1854), *C. jerdonii* (Theobald, 1868), *C. wynadensis* (Beddome, 1870), *C. sisparensis* (Theobald, 1876), *C. nilagirica* Manamendra-Arachchi, Batuwita & Pethiyagoda, 2007); dorsal scales of tail granular, small keeled scales with

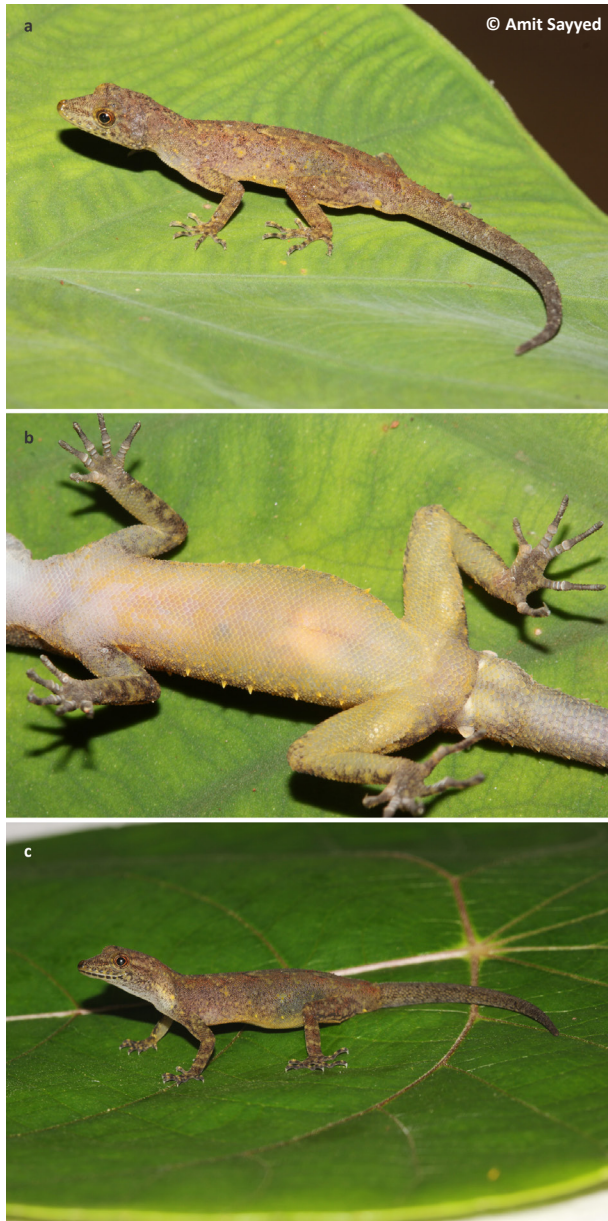


Image 4. *Cnemaspis flaviventralis* sp. nov. in life, (a) holotype (male, BNHS 2442), (b) ventral side of body of holotype and (c) paratype (female, BNHS 2444).

carinated enlarged tubercles, three femoral pores on each side (vs. dorsal scales of tail granular and smooth, four or five femoral pores on each side in *C. kottiyorensis* Cyriac & Umesh, 2014); pre-cloacal pores absent (vs. present in *C. gracilis* (Beddome, 1870), *C. wicksi* (Stoliczka, 1873), *C. tropidogaster* (Boulenger, 1885), *C. andersonii* (Annandale, 1905), *C. otai* Das & Bauer, 2000, *C. yercaudensis* Das & Bauer, 2000, *C. australis* Manamendra-Arachchi, Batuwita & Pethiyagoda, 2007, *C. monticola* Manamendra-Arachchi, Batuwita & Pethiyagoda, 2007, *C. nilagirica*); femoral pores present

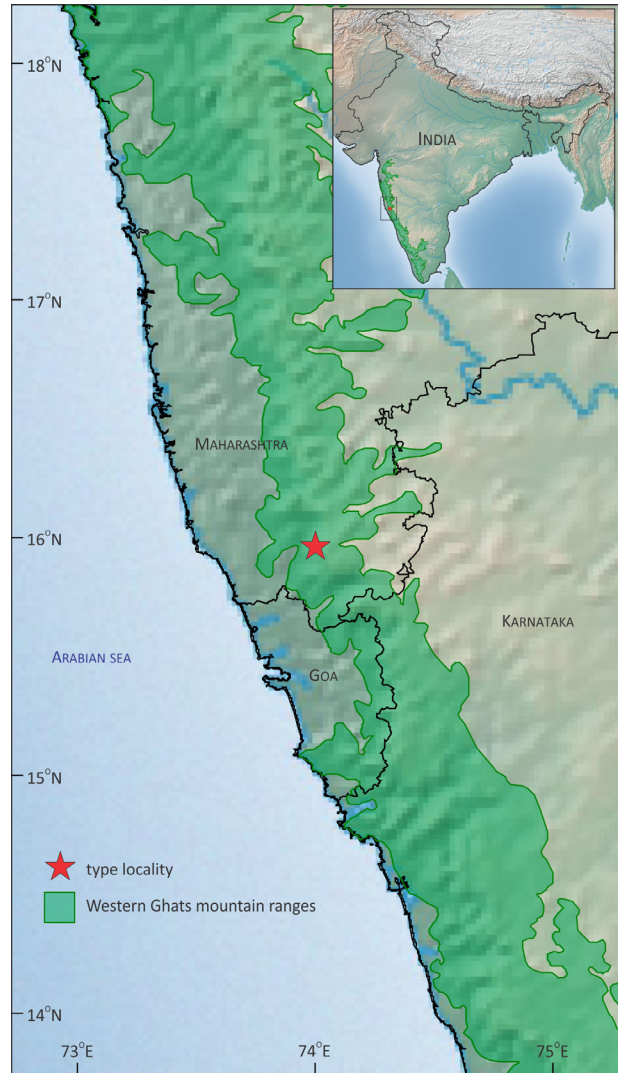


Image 5. Type locality of *Cnemaspis flaviventralis* sp. nov.

while pre-cloacal pores absent (vs. femoral pores absent while pre-cloacal pores present in *C. ornata* (Beddome, 1870), *C. beddomei* (Theobald, 1876), and *C. nairi* Inger, Marx & Koshy, 1984); series of enlarged median sub-caudal scales absent (vs. smooth enlarged median row of sub-caudals in *C. indica*, *C. boiei*, *C. jerdonii*, *C. gracilis*, *C. wynadensis*, *C. ornata*, *C. sisparensis*, *C. nairi*, *C. heteropholis*, *C. nilagirica*).

DISCUSSION

It is already established that the *Cnemaspis* species in the Western Ghats and Sri Lanka are distinct (Manamendra-Arachchi et al. 2007). Nevertheless, it is essential to note that Giri & Vithoba (2001) reported *Cnemaspis kandiana* (Kelaart, 1852), a species restricted

Table 1. Mensural and meristic data of type series of *Cnemaspis flaviventralis* sp. nov. (measurements are in mm). Abbreviations as stated in Materials and Methods; * = regenerated tail, ** = broken tail; values for SupraL and InfraL are provided left/right

Character	Holotype	Paratypes						
	BNHS 2442	BNHS 2443	ZSI-WRC R/1039	ZSI-WRC R/1042	BNHS 2444	ZSI-WRC R/1040	ZSI-WRC R/1041	ZSI-WRC R/1043
	Male	Male	Male	Male	Female	Female	Female*	Female**
SVL	31.8	30.4	31.3	31.5	33.0	36.4	33.7	34.9
TRL	14.9	14.2	13.6	12.5	15.6	16.8	15.6	15.6
TrW	6.9	6.3	6.5	6.7	8.0	9.5	9.6	9.0
TL	46.1	40.8	37.6	37.4	39.7	43.1	31.5	16.6
TaW	2.3	1.7	2.0	2.9	2.4	2.4	2.4	2.6
HL	6.5	5.6	6.7	8.0	6.2	8.7	8.7	7.7
HW	6.4	5.4	5.5	5.2	5.9	6.0	5.9	6.2
HD	4.1	3.7	4.1	3.3	4.6	4.1	4.3	4.0
FL	5.1	4.8	4.7	5.2	5.6	4.8	5.4	5.9
TBL	5.9	5.5	5.3	5.6	5.4	5.9	6.0	6.4
E-N	4.0	3.9	3.9	4.3	4.5	4.5	4.3	4.2
E-S	5.2	4.9	4.5	4.9	5.1	5.4	5.1	5.4
E-E	4.1	3.8	3.8	3.3	3.8	3.9	3.6	3.4
EL	0.2	0.2	0.2	0.4	0.3	0.3	0.2	0.3
IN	1.1	1.0	1.2	1.1	1.0	1.2	1.2	1.1
OD	1.5	1.4	1.5	1.0	1.4	1.2	1.2	1.4
IO	5.3	4.5	4.4	3.3	4.4	4.7	4.8	4.2
HL/SVL	0.20	0.18	0.21	0.25	0.19	0.24	0.26	0.22
HW/SVL	0.20	0.18	0.18	0.17	0.18	0.16	0.18	0.18
HW/HL	0.98	0.96	0.82	0.65	0.95	0.69	0.68	0.81
HD/HL	0.63	0.66	0.61	0.41	0.74	0.47	0.49	0.52
E-S/HW	0.81	0.91	0.82	0.94	0.86	0.90	0.86	0.87
OD/E-S	0.29	0.29	0.33	0.20	0.27	0.22	0.24	0.26
OD/HL	0.23	0.25	0.22	0.13	0.23	0.14	0.14	0.18
EL/HL	0.03	0.04	0.03	0.05	0.05	0.03	0.02	0.04
E-E/OD	2.73	2.71	2.53	3.30	2.71	3.25	3.00	2.43
TRL/SVL	0.47	0.47	0.43	0.40	0.47	0.46	0.46	0.45
FL/SVL	0.16	0.16	0.15	0.17	0.17	0.13	0.16	0.17
TBL/SVL	0.19	0.18	0.17	0.18	0.16	0.16	0.18	0.18
TL/SVL	1.45	1.34	1.20	1.19	1.20	1.18	0.93	0.48
MVS	29	28	29	29	29	29	28	29
SupraL	8/9	8/8	8/7	8/8	8/8	8/9	8/8	8/8
InfraL	8/8	8/8	8/8	8/8	8/8	8/9	8/8	8/9
FPores	3 on each side	3 on each side	3 on each side	3on each side	-	-	-	-
MLam R	8-9-11-11-9	8-9-11-10-9	9-9-12-11-10	8-8-11-11-9	9-9-11-11-9	8-8-11-11-9	9-9-11-11-10	8-8-10-11-9
PLam R	8-9-11-11-11	8-8-11-10-10	9-10-11-11-10	8-8-11-10-9	8-9-11-12-11	8-9-11-10-10	8-8-11-10-10	8-8-11-10-11
MLam L	8-9-11-11-9	8-9-11-10-9	9-9-12-11-10	8-8-11-11-10	8-9-12-11-9	8-8-11-11-9	8-9-10-11-9	8-8-10-11-9
PLam L	8-9-11-10-11	8-8-11-10-11	9-10-11-12-10	8-8-11-10-9	8-9-12-11-11	8-9-11-10-10	8-8-11-10-10	8-8-10-11-10



Image 6. Habitat of *Cnemaspis flaviventralis* sp. nov. at Amboli, (a) view of the moss covered boulders and rocky outcrops in the dense evergreen forest, and (b) view of dense evergreen forest.

to Sri Lanka (Manamendra-Arachchi et al. 2007), from Amboli, the type locality of the new species. Manamendra-Arachchi et al. (2007) have already suggested that records of *C. kandiana* outside Sri Lanka are based on misidentifications. Further, Mirza et al. (2014) suggested that reports of *C. kandiana* from southern Maharashtra should be attributed either to *C. indraneildasii* or are likely to belong to an undescribed species. *Cnemaspis flaviventralis* sp. nov. cannot be confused with either *C. kandiana* or *C. indraneildasii*. *Cnemaspis flaviventralis* differs from *C. kandiana* in having 28–29 ventral scales across mid-body (vs. 19); conical (vs. spine-like) tubercles present on flanks; pre-cloacal pores absent (vs. present); and sub-digital lamellae on digit IV of pes 10–12 (vs. 18–20). *Cnemaspis flaviventralis* differs from *C. indraneildasii* based on characters provided in the comparison section above.

As presently understood, 28 species of *Cnemaspis* are known from India (Uetz & Hošek 2015). The description of a new species has elevated the number of Indian species to 29. Within the genus *Cnemaspis*, more work remains to be done at both the species

and the generic level to resolve their taxonomy. In our genetic analysis (Image 7), *Cnemaspis* species from northern Western Ghats formed a monophyletic clade that was well separated from Southeast Asian *C. limi* Das & Grismer, 2003, with a species of *Hemidactylus* in between. Although the current placement could be an artifact of limited genetic data for 16S rRNA, previous molecular studies (Pyron et al. 2013) with other genetic markers have also shown similar trends. More extensive molecular work and comprehensive taxonomic revisions are therefore essential to understand and to resolve the taxonomy of this group. Moreover, the species diversity within the Western Ghats/Sri Lanka biodiversity hotspot is obviously high.

Given that several species of Western Ghats *Cnemaspis* are globally threatened (Srinivasulu et al. 2014), understanding both the unknown diversity and assessment of distribution of previously recognized species is essential to design and implement future conservation.

Comparative material and data sources

Cnemaspis girii: Holotype, BNHS 2299 (male), India: Maharashtra: Satara District, Kaas Plateau (17.724°N & 73.819°E, elevation 1,203m), coll. A. Sayyed. Paratypes, BNHS 2081 (male) and BNHS 2078 (female), collection data same as holotype; India: Maharashtra: Satara District, Kaas Plateau (17.724°N & 73.819°E), coll. A. Sayyed.

Cnemaspis goaensis: Holotype, ZSI-K 22110 (male), India: Goa: “ca. 3 km S. of Forest Rest House, Canacona (Poinguinim), Goa”. Paratypes, ZSI-K 22213–22216 (4 ex.), same data as holotype; ZSI R/1044 (male) and ZSI R/1045 (female), India: Goa (15.290°N & 74.006°E), coll. A. Sayyed.

Cnemaspis gracilis: BNHS 1182 (male), Goa.

Cnemaspis indica: BNHS 1252-10 (male) and BNHS 1252-1 (female), India: Tamil Nadu: Parson Valley, Nilgiris.

Cnemaspis kolhapurensis: Holotype, BNHS 1855 (male), India: Maharashtra: Kolhapur district, Dajipur; BNHS 2447–2448 (both males), India: Maharashtra: Sindhudurg District, Amboli (15.971°N & 73.979°E), coll. A. Sayyed.

Cnemaspis littoralis: BNHS 1150 (male), India: Nilambur, Malabar.

Cnemaspis mysoriensis: Neotype, BNHS 1830 (male), India: Karnataka: Agara Village near Bangalore (designated by Giri et al. 2009).

Cnemaspis wynadensis: BNHS 1042 (male) and BNHS 1043 (male), Kerala: Mannarghat, Palghat.

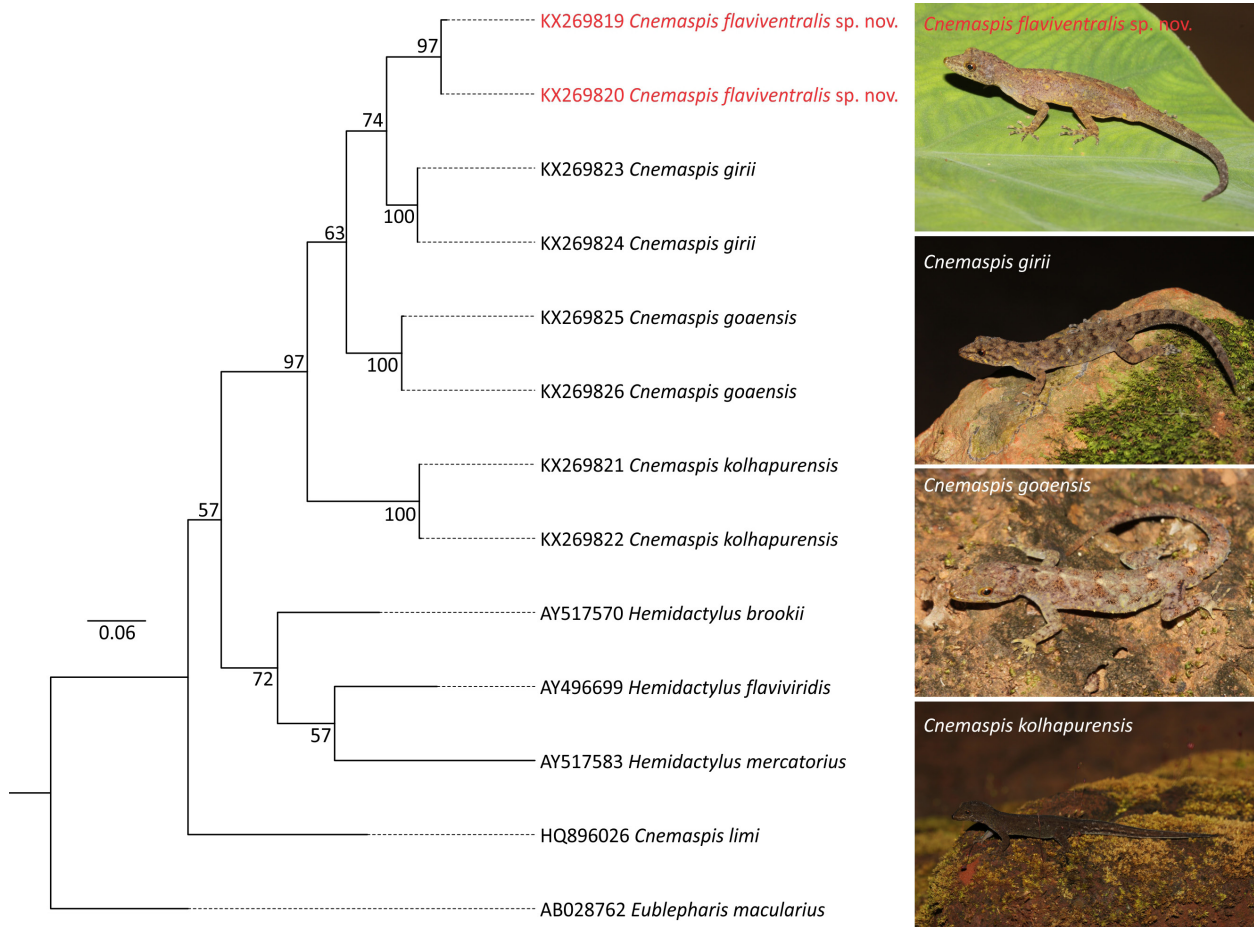


Image 7. Maximum likelihood tree based on 16S rRNA gene showing the phylogenetic placement of *Cnemaspis flaviventralis* sp. nov. with its sympatric species, *C. girii*, *C. kolhapurensis* and *C. goaensis*, southeast Asian *C. limi* and a *Hemidactylus* species. *Eublepharis macularius* is used as an outgroup. Values along the node are percent bootstraps for 1000 bootstrap iterations. Photo credit: Amit Sayyed.

Data for *C. adii* from Srinivasulu et al. (2015); for *C. australis*, *C. monticola*, *C. nilagirica*, *C. beddomei*, *C. boiei*, *C. ornata*, *C. andersonii*, *C. jerdonii*, *C. wicksi* and *C. sisparensis* from Manamendra-Arachchi et al. (2007); for *C. indraneildasii* from Bauer (2002); for *C. heteropholis* from Bauer (2002) and Ganesh et al. (2011); for *C. otai* and *C. yercaudensis* from Das & Bauer (2000); for *C. anaikattiensis* from Mukherjee et al. (2005); for *C. kottiyooensis* from Cyriac & Umesh (2014); for *C. assamensis* from Das & Sengupta (2000); and for *C. nairi* and *C. tropidogaster* from Inger et al. (1984).

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Author Details: AMIT SAYYED is head of research department at Wildlife Protection and Research Society. He works on faunal diversity, ecology, taxonomy, distribution and evolution of Reptiles and Amphibians. ROBERT ALEXANDER PYRON is an Assistant Professor of Biology at The George Washington University. He works on theoretical and applied methods in statistical phylogenetics, using reptiles and amphibians as model groups. NEELESH DAHANUKAR works in ecology and evolution with an emphasis on mathematical and statistical analysis. He is also interested in taxonomy, distribution patterns and molecular phylogeny of ichthyo- and herpetofauna.





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