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## Rediscovery of *Cnemaspis nilagirica* Manamendra-Arachchi, Batuwita and Pethiyagoda, 2007 (Squamata: Gekkonidae) from Kerala, India with notes on morphology and distribution

VIVEK PHILIP CYRIAC<sup>1,6</sup>, ALEX JOHNY<sup>1,2</sup>, PAVUKANDY UMESH<sup>3</sup>,  
MUHAMED JAFER PALOT<sup>4</sup> & PATRICK D CAMPBELL<sup>5</sup>

<sup>1</sup>IISER-TVM Centre for Research and Education in Ecology and Evolution (ICREEE) and School of Biology, Indian Institute of Science Education and Research Thiruvananthapuram, Kerala 695551, India

<sup>2</sup>National Centre for Biological Sciences, Tata Institute of Fundamental Research, Bangalore, 560065, India

<sup>3</sup>Pavukandy House, Moolad Post, Narayankulam, Kozhikode, Kerala 673614, India

<sup>4</sup>Zoological Survey of India- Western Ghats Regional Center, Kozhikode, Kerala 673006, India

<sup>5</sup>Life Sciences Department, Natural History Museum, Cromwell Road, South Kensington, London SW7 5BD, United Kingdom

<sup>6</sup>Corresponding author. E-mail: [vivek.philip14@iisertvm.ac.in](mailto:vivek.philip14@iisertvm.ac.in)

### Abstract

*Cnemaspis nilagirica* was described by Manamendra-Arachchi, Batuwita and Pethiyagoda in 2007 based on a single female specimen that was a syntype of *Gonatodes kandianus* var. *tropidogaster* described by Boulenger in 1885. However, a living population of this species has not been reported since its original description by Boulenger. Based on fresh material and comparisons with the holotype of *C. nilagirica*, we here report the collection of this species after over 130 years. We provide the first description of a male specimen and additional information on morphological variation, distribution and natural history.

**Key words:** Day geckos, Nilgiri Hills, Western Ghats

### Introduction

The genus *Cnemaspis* Strauch is a species-rich radiation of Old World gekkonids with over 130 recognized species (Uetz *et al.* 2018). Large-scale phylogenies of the Squamata have indicated that the genus is polyphyletic with three distinct lineages—an African clade, a Southeast Asian clade and a South Asian clade (Gamble *et al.* 2012; Pyron *et al.* 2013; Zheng & Wiens 2016). The Southeast Asian clade (ca. 70 species) (Iskandar *et al.* 2017; Wood *et al.* 2017) and South Asian clade (ca. 54 species) (Batuwita & Udugampala 2017; Cyriac *et al.* 2018; Sayyed *et al.* 2018) make up most of the species richness within this genus as compared to the African clade, with only 13 known species (Bauer *et al.* 2006). Although South Asian *Cnemaspis* are exceptionally diverse, recent taxonomic investigations have indicated that the diversity within this clade, and especially within its Indian members, remains incompletely documented (Srinivasulu *et al.* 2015; Sayyed *et al.* 2016, 2018; Agarwal *et al.* 2017; Cyriac *et al.* 2018). Although there has been a recent surge of taxonomic interest in the group (Cyriac & Umesh 2014; Mirza *et al.* 2014; Srinivasulu *et al.* 2015; Sayyed *et al.* 2016, 2018; Cyriac *et al.* 2018), a few species still remain known from a single individual each, with no information on their variation, natural history and distribution.

In a comprehensive review of Indian and Sri Lankan *Cnemaspis*, Manamendra-Arachchi *et al.* (2007) described three new species of *Cnemaspis* from Southern India which were among the syntypes of *Gonatodes kandianus* var. *tropidogaster* (Boulenger 1885). One of these species, *C. australis* Manamendra-Arachchi, Batuwita & Pethiyagoda was described based on a single male specimen, whereas the other two, *C. monticola* Manamendra-Arachchi, Batuwita & Pethiyagoda and *C. nilagirica* Manamendra-Arachchi, Batuwita & Pethiyagoda, were based on three female specimens and a single female specimen, respectively. Although

Manamendra-Arachchi *et al.* (2007) provided several diagnostic characters for the three species, their descriptions were based only on single specimens or on female specimens, leaving the variation within species and male-specific taxonomic characters obscure. Further, the three species are known only from their type specimens which were purchased from Colonel Beddome over 130 years ago (Manamendra-Arachchi *et al.* 2007). Based on recent field surveys, we here report the rediscovery of a living population of *C. nilagirica* and present additional data on male characters and intraspecific variation along with distribution and natural history.

## Materials and methods

Samples were collected as part of a herpetofaunal survey of Silent Valley National Park, in the Palakkad District of Kerala, India. Specimens were collected, photographed in life, euthanized and fixed in 10% formalin and subsequently transferred to 70% ethanol. Morphometric measurements were taken using a Mitutoyo™ digital vernier caliper (to the nearest 0.1mm). 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 tympanum distance; IN, internarial distance; TD, tympanum diameter; 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 are defined following that of Cyriac & Umesh (2013). Pholidosis recorded included the number of supralabials and infralabials on the left (L) and right (R) side; subdigital lamellae (Lam) on the IV manus and pes, and the number of femoral pores on the left and right femur. We compared our specimens with known Indian congeners based on data obtained from original descriptions (Inger *et al.* 1984; Das & Bauer 2000; Bauer 2002; Giri *et al.* 2009; Cyriac & Umesh 2014; Srinivasulu *et al.* 2015; Mirza *et al.* 2014; Sayyed *et al.* 2016, 2018; Cyriac *et al.* 2018) and from a taxonomic review of the Indian and Sri Lankan *Cnemaspis* by Manamendra-Arachchi *et al.* (2007). Specimens were deposited at the museum of the Zoological Survey of India, Western Ghats Regional Center (ZSI WGRC), Kozhikode, Kerala, India. Opportunistic natural history observations were made during our field visits. Measurements and pholidosis of the holotype of *Cnemaspis nilagirica* from the Natural History Museum, London (BMNH) were collected and compared with our samples.

## Results

Examination of our freshly collected specimens and the holotype of *Cnemaspis nilagirica* indicate that they share several characters in common. Our specimens are in close agreement with the morphology of *C. nilagirica* in overall size (see Table 1) and in several characters such as dorsal scales being homogenous; first postmentals separated by a single intermediate chin scale; presence of keeled scales on the throat, abdomen and ventral side of the forelimbs and hindlimbs; scales on dorsal side of tail homogenous with slightly enlarged tubercles on either sides; subcaudals enlarged, uniform and smooth; 15–18 lamellae on manus IV and 17–19 lamellae on pes IV (16 on manus and 19 on pes in holotype). In concert with these results, we ascribe our new specimens to *C. nilagirica* and provide below a detailed description of a male specimen along with a diagnosis of the species based on fresh materials.

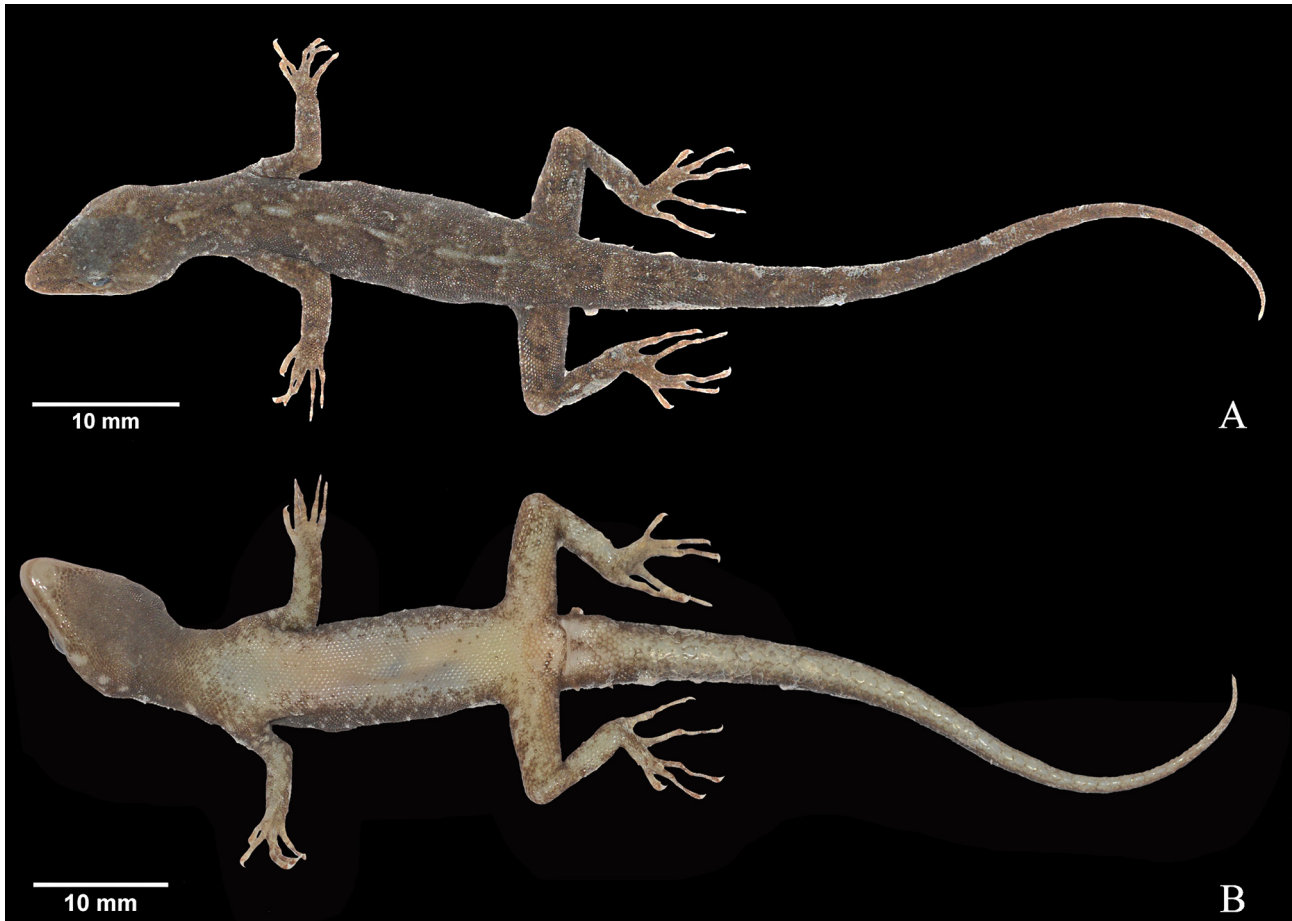
## Systematics

### *Cnemaspis nilagirica* Manamendra-Arachchi, Batuwita & Pethiyagoda, 2007

**Holotype:** BMNH 74.4.29.729, an adult female of SVL 42.1mm; collected from the “Nilgiris” (Nilgiri Hills, Tamil Nadu, India).

**Referred material:** ZSI/WGRC/IR.V/2710, an adult male of SVL 40.5 mm and ZSI/WGRC/IR.V/2714, an adult female of SVL 47.0 mm; collected from under a fallen log near Sispara (11.19717°N, 076.43117°E) at an elevation of 1728 m ASL in Silent Valley National Park on 13 February 2015 by Vivek Philip Cyriac. ZSI/WGRC/

IR.V/2711, an adult male of SVL 38.4 mm; collected on 3 May 2013 on a tree in Thudukki range (11.134792°N, 76.522514°E) at an elevation of 1600m ASL of Silent Valley National Park, Palakkad District, Kerala by Vivek Philip Cyriac and P. K. Umesh. ZSI/WGRC/IR.V/2712, an adult female of SVL 42.7 mm; collected from the same locality as ZSI/WGRC/IR.V/2711, from a network of roots adjoining a stream on 3 May 2013 by Vivek Philip Cyriac and P.K. Umesh. ZSI/WGRC/IR.V/2713, an adult male of SVL 39.8 mm; collected from under rock near Sispara (11.20050°N, 076.43577°E) at an elevation of 1937m ASL, Silent Valley National Park on 14 February 2015 by Vivek Philip Cyriac



**FIGURE 1.** Recently collected specimen of male *Cnemaspis nilagirica* (ZSI/WGRC/IR.V/2710). **A.** dorsal view; **B.** ventral view.

**Diagnosis:** *Cnemaspis nilagirica* may be diagnosed from all other congeners by the following set of characters. Maximum snout-vent length 47.0 mm. Mid-dorsal scales homogenous with spine-like tubercles present on flanks. Ventral scales of neck weakly keeled. Ventral scales of the pectoral and abdominal region are distinctly keeled and imbricate. Pre-cloacal scales are smooth and imbricate. Nasals surrounded by three scales—supranasal, one postnasal and rostral. Supralabials to the angle of jaw 7–8, infralabials 6–8. Subdigital lamellae under manus IV ranges between 15 and 18; under pes IV between 17 and 19. Dorsal scales of tail homogenous and granular. Subcaudals are enlarged, uniform and smooth. Males have 4–6 femoral pores and no pre-cloacal pores. Prominent orange spots present on the sides of the head and neck. Both males and females have a bright orange abdomen.

*Cnemaspis nilagirica* differs from all other congeners by the following characters: the presence of small, scattered spine-like tubercles present on flanks (*versus* absence of spine-like tubercles on the flanks in *C. beddomei* (Theobald), *C. nairi* Inger, Marx & Koshy, *C. adii* Srinivasulu, Kumar & Srinivasulu, *C. otai* Das & Bauer, *C. sisparensis* (Theobald), *C. wynadensis* (Beddome), *C. anaikattiensis* Mukherjee, Bhupathy & Nixon, *C. indica* (Gray), *C. yercaudensis* Das & Bauer, *C. giri* Mirza, Pal, Bhosale & Sanap, *C. australis*, *C. limayei* Sayyed, Pyron & Dileepkumar, *C. ajiijae* Sayyed, Pyron & Dileepkumar, *C. mahabali* Sayyed, Pyron & Dileepkumar); dorsal scales homogenous (*versus* dorsal scales heterogeneous in *C. indraneildasii* Bauer, *C. heteropholis* Bauer, *C.*

*gracilis* (Beddome), *C. ornata* (Beddome), *C. andersonii* (Annandale), *C. beddomei*, *C. yercaudensis*, *C. wicksii* (Stoliczka), *C. girii*, *C. kottiyooensis* Cyriac and Umesh, *C. monticola*, *C. australis* and *C. goaensis* Sharma; *C. limayei*, *C. ajiiae*, *C. amboliensis* Sayyed, Pyron & Dileepkumar, *C. mahabali*; median series of subcaudals enlarged, hexagonal (*versus* median series of subcaudals not enlarged in *C. gracilis*); ventral scales of gular, pectoral and abdomen region keeled (*versus* ventral scales smooth in *C. beddomei*, *C. mysoriensis* (Jerdon), *C. jerdonii* (Theobald), *C. nairi*, *C. otai*, *C. yercaudensis*, *C. sisparensis*, *C. anaikattiensis*, *C. wynadensis*, *C. heteropholis*, *C. kolhapurensis* Giri, Bauer & Gaikwad, *C. indica*, *C. gracilis*, *C. littoralis* (Jerdon), *C. giri*, *C. adii*, *C. flaviventralis* Sayyed, Pyron & Dahanukar, *C. anamudiensis* Cyriac, Johny, Umesh & Palot, and *C. maculicolis* Cyriac, Johny, Umesh & Palot, *C. limayei*, *C. ajiiae*, *C. amboliensis*, *C. mahabali*; pectoral and abdomen scales smooth in *C. monticola*, *C. goaensis*, *C. wicksii*); presence of 4 femoral pores (*versus* a continuous series of 24–28 precloacal-femoral pores in *C. kolhapurensis*; absence of femoral pores in males in *C. boiei* (Gray).

**Description of male specimen:** ZSI/WGRC/IR.V/2710 is an adult male of SVL 40.5 mm; head short (HL 26.0 % of SVL), broad (HW 66.5 % of HL), depressed (HD 41.4 % of HL), distinct from neck. Snout moderately long (ES 46.0% of HL). Scales on snout weakly keeled, larger than those on forehead and interorbital region. Eye relatively small (ED 23.0% of HL); pupils round; extra-brillar fringe scales small, larger anteriorly. Scales on interorbitals and supercilium smooth. The tympanum is small (TD 7.8% of HL), longer than broad. Rostral broader than long, almost completely divided by a median rostral groove. Two supranasals separated from each other by an internasal scale; nasal not in contact with the first labial; nostril circular, surrounded by a single postnasal, a supranasal and the rostral. Mental scale sub-triangular and broader than rostral. Three pairs of postmentals, first pair largest and separated from each other by an intermediate chin shield. First post mental surrounded by five scales—mental, first infralabial, second postmental and two chin shields. Supralabials to angle of jaw, seven on the right and eight on the left; infralabials to angle of jaw seven on each side. Gular scales granular. Ventral scales of neck weakly keeled. Lateral sides of neck with few small projecting spine-like tubercles.

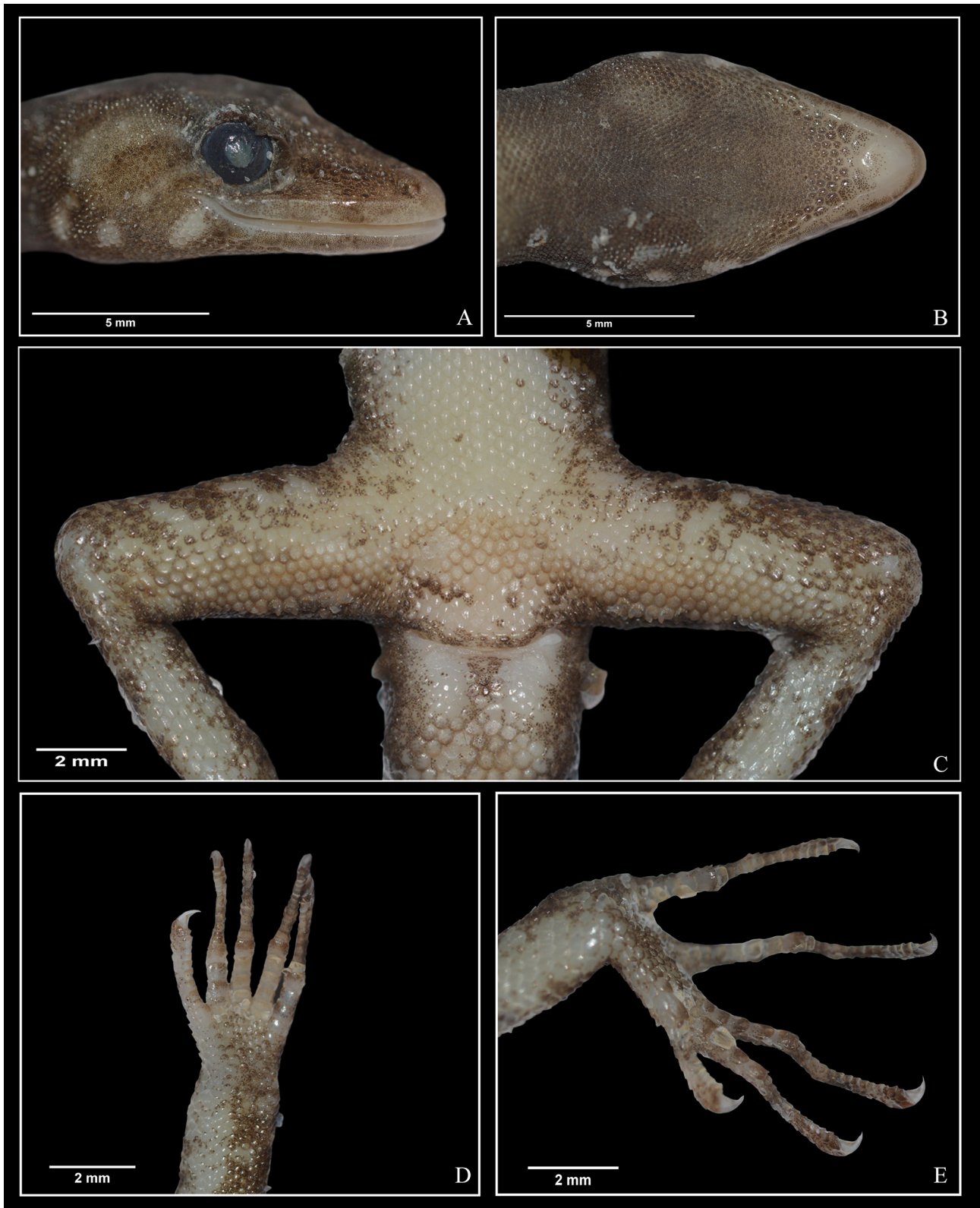
Body slender (TW 17.0 % of SVL), elongate (AG 42.8 % of SVL). Mid-dorsal scales are homogenous, granular, few carinate. Flanks have five small, sub-conical, spine-like tubercles. Ventral scales larger than dorsal scales. Pectoral and abdominal scales are keeled and imbricate. Pre-cloacal scales smooth, imbricate and subcircular.

Forelimbs moderately long (UAL 11.0 % of SVL, LAL 15.2% of SVL). Hindlimbs long, femur longer than tibia (FEL 17.7 % of SVL, TBL 16.9 % of SVL). Dorsal scales of forelimb and hindlimb keeled. Dorsal scales of manus and pes keeled. Ventral scales of forelimb weakly keeled and that of hindlimb, keeled. Femoral pores, four on the right and five on the left femur. No pre-cloacal pores. Subdigital lamellae entire, a few fragmented; lamellae on the basal phalanges, enlarged. Interdigital webbing is absent. Subdigital lamellae on finger I: 11; finger II: 15; finger III: 17; finger IV: 18; finger V: 15; toe I: 13; toe II: 16; toe III: 19; toe IV: 20; toe V: 17. Relative length of digits, fingers: IV (5.02mm) > III (4.6mm) > II (4.19mm) > V (3.9mm) > I (3.3 mm); toes: IV (6.6 mm) > III (5.8 mm) > V (5.2mm) > II (5.2 mm) > I (3.9 mm).

The original tail is subcylindrical, swollen at the base and longer than SVL (TL 131.0 % of SVL). Dorsal scales of tail homogenous, granular, with four slightly enlarged tubercles on either side. Ventral scales larger than dorsal scales; median subcaudals enlarged, subpentagonal, uniform, smooth. A post-cloacal spur present on either side of the base of the tail.

*Colouration in preservative.* Head grayish brown, with two whitish lines extending from the posterior of the eye to the sides of the head; sides of head and neck with three to four whitish spots. Gular scales grayish black. Dorsum grayish brown with a vertebral series of black edged light spots; sides mottled with light and dark markings. Tail grayish brown above, whitish below.

*Colouration in life.* Head brown with dark brown mottling and two dark-edged streaks extending from the posterior corner of the eye to the sides of the head. Lateral sides of the head and neck have several orange-yellow spots. Ventral side of the head and neck dark gray except for the mental, postmentals and a few infralabials are orange-yellow. Dorsum grayish brown with a vertebral series of black-edged light elongated spots. Flanks grayish brown having six to seven orange-yellow spots. Dorsal side of forelimbs and hindlimbs grayish brown with darker markings and few scattered orange-yellow patches. Ventral side of the body, forelimbs and hindlimbs bright orange-yellow with patches of grey towards the margins. Dorsal side of tail brown with darker irregular transverse bars; ventral side orange-yellow at the base and fading to a dull white colour towards the tip.



**FIGURE 2.** Pholidosis of male *Cnemaspis nilagirica* (ZSI/WGRC/IR.V/2710). **A.** lateral view of head; **B.** ventral of head; **C.** pre-cloacal and femoral region; **D.** lamellae under hand; **E.** lamellae under foot.

**Variation:** Variation in the pholidosis of this species is summarized in Table 1. Supralabials range between 7 and 8 with the ZSI/WGRC/IR.V/2710 having 7 on the right side and 8 on the left. There is considerable variation in the number of lamellae on the manus which ranges from 10–12 on manus I, 13–15 on manus II, 16–17 on manus III, 15–18 on manus IV and 14–15 on manus V; pes which ranges from 10–13 on pes I, 13–16 on pes II, 17–19 on

pes III, 18–20 on pes IV and 13–17 on pes V. Femoral pores range from 4–6 with ZSI/WGRC/IR.V/2711 having 4 and 5 on the right and left respectively and ZSI/WGRC/IR.V/2713 having 5 and 6 on the right and left respectively.

**TABLE 1.** Measurements (to the nearest 0.1 mm) and pholidosis of the holotype of *Cnemaspis nilagirica* and additional conspecific fresh material.

Character	Holotype BMNH 1874.4.29.729	ZSI/WGRC/ IR.V/2710	ZSI/WGRC/ IR.V/2712	ZSI/WGRC/ IR.V/2711	ZSI/WGRC/ IR.V/2713	ZSI/WGRC/ IR.V/2714
Sex	female	male	female	male	male	female
SVL	42.4	40.5	42.7	38.4	39.8	47.0
AG	18.1	17.3	18.8	15.4	17.1	21.8
TW	5.6	6.9	8.7	6.9	7.8	8.5
ED	1.6	2.4	2.5	1.7	2.4	2.7
EN	2.9	3.2	3.4	3.2	3.4	3.7
ES	5.0	4.8	4.6	4.4	5.1	5.0
ET	4.0	3.6	3.8	3.1	3.8	4.0
IN	1.4	1.3	1.2	1.2	1.5	1.6
TD	0.4	0.8	0.5	0.7	0.8	0.9
HL	10.1	10.5	11.1	9.3	11.1	11.3
HW	7.5	7.0	7.4	6.6	7.2	7.3
HD	5.1	4.3	4.3	3.9	4.4	4.5
IO	4.1	2.9	3.5	4.1	3.2	3.1
UAL	6.5	4.4	5.3	5.4	4.5	5.8
LAL	6.1	6.2	4.3	3.3	6.4	6.7
PAL	6.1	4.5	5.5	5.2	5.4	5.7
FL1	2.5	2.9	3.1	3.3	3.1	3.4
FL2	3.7	3.5	4.1	4.2	3.6	3.9
FL3	4.3	4.7	4.5	4.6	4.7	5.0
FL4	4.8	5.1	4.7	5.0	4.5	5.3
FL5	3.9	3.8	4.4	3.9	3.7	4.5
FEL	8.6	7.2	7.8	7.3	6.9	7.5
TBL	7.8	6.8	4.9	6.8	6.7	7.1
TOL1	2.9	2.2	3.5	3.9	2.5	2.5
TOL2	3.6	4.2	4.5	5.2	4.4	4.6
TOL3	4.9	4.9	5.5	5.8	5.3	5.3
TOL4	6.1	5.7	5.8	6.6	6.1	6.2
TOL5	4.9	5.0	4.9	5.2	5.1	5.3
TL	32.6	53.0	52.6	42.8	-	51.1
TBW	5.6	4.6	4.8	4.5	4.7	4.9
Supralabials(R/L)	8,8	7,8	7,7	7,7	7,7	8,8
Infralabials(R/L)	8,7	7,7	7,7	7,7	7,7	7,7
Lam IV manus	16	18	17	15	16	18
Lam IV pes	19	17	18	18	19	19
Femoral pores	none	5,5	none	4,5	5,6	none



**Distribution:** At present this species is only known from high elevation (between 1702–1937m ASL) evergreen forests of Silent Valley National Park, Palakkad District, Kerala, which is located just above the Palghat Gap in the northern part of the Southern Western Ghats. Since Silent Valley is continuous with Mukurthi Tiger Reserve of the Nilgiris of Tamil Nadu, it is possible that the range of this species may extend to parts of Tamil Nadu.



**FIGURE 3.** Colour in life of male *Cnemaspis nilagirica* (ZSI/WGRC/IR.V/2710) **A.** dorsal view; **B.** ventral view.

**Natural History** *Cnemaspis nilagirica* is a forest species and found only in thick evergreen forests at high elevations between 1700m and 1950m asl in the Nilgiri Hills. All individuals of this species were observed close to the ground either beneath fallen logs and rocks or at the base of trees, indicating that this species is primarily terrestrial but may also have arboreal habits. Like many other members of this genus, *C. nilagirica* appears to be a diurnal species as individuals were observed active during the day. Several clusters of eggs were found in rock crevices from where individuals were collected suggesting communal oviposition in this species. There is no



sexual dichromatism within this species and both males and females possess the characteristic dark grey gular region and the orange-yellow colour on the abdomen and tail ventrally.



**FIGURE 4.** Holotype (BMNH 1874.4.29.729) of *Cnemaspis nilagirica*. **A.** dorsal view; **B.** ventral view.

## Discussion

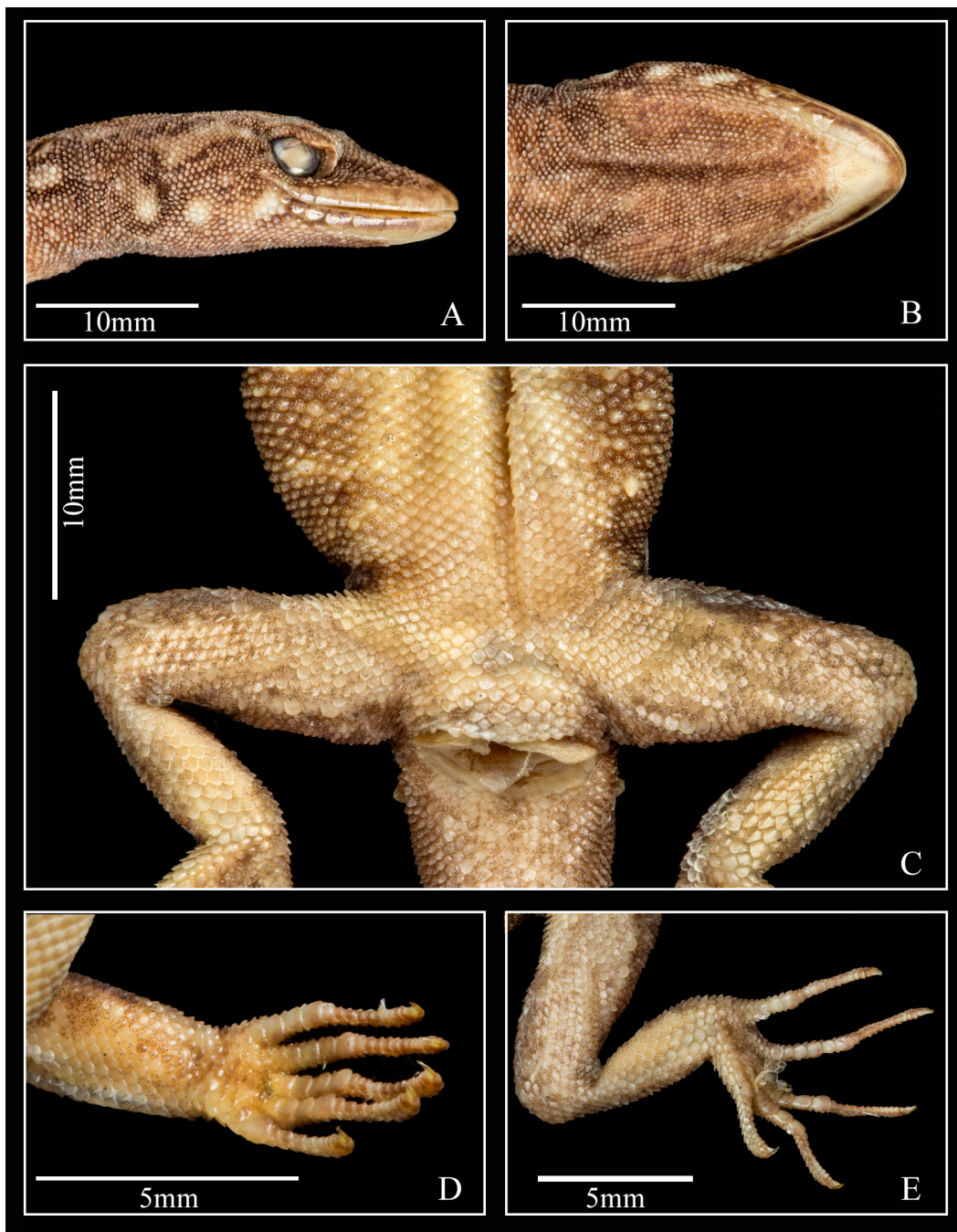
Our series of specimens collected from Silent Valley National Park, which we allocate to *Cnemaspis nilagirica* match the holotype of *C. nilagirica* in overall size (see Table 1) and several other key characters. Further, our specimens were collected from Silent Valley National Park, which forms a part of the Nilgiri Hill cluster and is contiguous with Mukurthi Tiger Reserve in the Nilgiri District of Tamil Nadu. The type locality of *C. nilagirica* is “Nilgherries” referring to the same Nilgiri Hills from where our specimens were collected. The close morphological similarities and the collection locality of our specimens indicate that our samples are indeed *C. nilagirica*.

The holotype of *Cnemaspis nilagirica* was originally part of the type series of *Gonotodes kandianus* var. *tropidogaster* described by Boulenger (1885) based on seven specimens collected from Ceylon (presently Sri Lanka), Tinnevely (presently Tirunelveli), Nilgherries (presently Nilgiris) and Wynaad (presently Wayanad), without exact locality information. Boulenger (1885) noted that *G. kandianus* var. *tropidogaster* varied from the typical form only by the presence of keeled ventral scales. Smith (1935) allocated this species to the genus *Cnemaspis* and considered *G. kandianus* var. *tropidogaster* as a synonym of *C. kandianus*. However, Taylor (1953), considering that the keeled form is distributed in lowland localities while *C. kandianus* is restricted to the mountainous regions of Sri Lanka, recognized the keeled form as a separate species and elevated it to *C. tropidogaster*. Subsequently, Inger *et al.* (1984), examined two syntypes each of *C. tropidogaster* (BMNH 82.5.22.61–62) and *C. kandianus* (BMNH82.5.22.70–71) from Tinnevely (presently Tirunelveli, in Tamil Nadu, India) and comparing these with the variation in keeled ventral scales in 137 specimens from the Ponnudi Hills (in Thiruvananthapuram, Kerala, India), suggested that the two forms (keeled ventrals/smooth ventrals) represent sibling species. To add to the confusion, Wickramasinghe & Munindradasa (2007) erroneously designated new syntypes deposited at the National Museum, Colombo (NMSL), which was later invalidated (Manamendra-Arachchi *et al.* 2007; Pethiyagoda 2007). Manamendra-Arachchi *et al.* (2007), however, recognized that the type



series of *C. tropidogaster* comprised four distinct species and designated the specimen from Ceylon as the lectotype for *C. tropidogaster* while describing the specimens from India as three separate species, namely *C. monticola* from Wayanad, *C. australis* from Tirunelveli and *C. nilagirica* from the Nilgiri hills.

The four species recognized by Manamendra-Arachchi *et al.* (2007) from the syntypes of *Cnemaspis tropidogaster* were all based on museum specimens deposited at the BMNH and information on living populations, morphological variation, colour in life and distribution remained lacking. Recently, however, a living population of *C. tropidogaster* has been rediscovered from a lowland wet zone in Sri Lanka (Amarasinghe *et al.* 2016). We here report the rediscovery of a living population of *C. nilagirica* nearly 130 years since its original discovery. Three other species of *Cnemaspis* from mainland India remain known only from their type specimens—*C. monticola*, *C. australis* and *C. boiei*—with no information on their distribution or natural history. Extensive field surveys along with the examination of type materials will be necessary to elucidate the taxonomic status and distributional range of these species.



**FIGURE 5.** Pholidosis of holotype (BMNH 1874.4.29.729) *Cnemaspis nilagirica*. **A.** lateral view of head; **B.** ventral of head; **C.** pre-cloacal and femoral region; **D.** lamellae under hand; **E.** lamellae under foot.

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