



## The Re-discovery of live populations of *Cnemaspis tropidogaster* (Boulenger, 1885) (Sauria, Gekkonidae) from Sri Lanka after 120 years

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### Abstract

*Gonatodes kandianus* var. *tropidogaster* was described by Boulenger (1885) with only “Ceylon” (=Sri Lanka) as its locality. This taxon was later assigned to the genus *Cnemaspis* and then recorded from many different parts of the country. Misleading taxonomic publications and muddled nomenclatural issues has since rendered its taxonomic position unclear. Recent studies have revealed, however, that *C. tropidogaster* is a species complex, and the species and its types have been redescribed. Unfortunately, no live populations of this species have been recorded until now. Here we report the rediscovery of live populations of this species 120 years after its last collection date records. *C. tropidogaster* was rediscovered from a low elevation (50–80 m asl.) of the wet zone of Sri Lanka. The rediscovered population was attributed to *C. tropidogaster* on the basis of a suite of matching morphometric and meristic characters that distinguish *C. tropidogaster* from other Sri Lankan *Cnemaspis*.

**Key words:** *Cnemaspis tropidogaster*; *Cnemaspis kandiana*, distribution, conservation, taxonomy

### Introduction

The day-geckos in the Indian subcontinent were first recorded by Gray in 1842, who described the species *Goniodactylus boei* from India. Following this, all the nominal day gecko species were assigned to the genus *Cnemaspis* by Strauch (1887). During the past decade, the number of species in the genus has grown rapidly, and the genus currently contains more than 100 species (Grismer *et al.* 2014; Amarasinghe *et al.* 2015). It currently consists of 22 species in Sri Lanka, and all of them are endemic to the country (Vidanapathirana *et al.* 2014). The *Cnemaspis* species from Sri Lanka were extensively reviewed by Wickramasinghe & Munindradasa (2007) and Manamendra-Arachchi *et al.* (2007). In both reviews, some name-bearing type designations were invalidated or criticized (see also Pethiyagoda 2007, Amarasinghe & Bauer 2009, and Amarasinghe & Campbell 2016).

The syntypes (seven specimens) of *Gonatodes kandianus* var. *tropidogaster* Boulenger, 1885 were deposited at the British (Natural History) Museum, London (BMNH). However, Boulenger (1885) did not give a precise locality for the specimens and stated the type locality as “Ceylon [=Sri Lanka]” only. Although the syntypes are preserved at the BMNH, Wickramasinghe & Munindradasa (2007) designated new syntypes (sic!) for this species using material deposited at the National Museum, Colombo (NMSL) but this designation was subsequently invalidated by Manamendra-Arachchi *et al.* (2007) and criticised by Pethiyagoda (2007). Furthermore, Wickramasinghe & Munindradasa (2007) recorded *C. tropidogaster* from the lowland wet zone of Sri Lanka up to

386 m asl., and redescribed the species based on one specimen (NMSL 2004.11.01) collected from Kanneliya, Galle (140 m asl.). Subsequently, Manamendra-Arachchi *et al.* (2007) recognized *C. tropidogaster* as a species complex, and described a new species, *Cnemaspis silvula*, from the same area where Wickramasinghe & Munindradasa (2007) redescribed *C. tropidogaster*. This confusion over the taxonomy of *C. tropidogaster* began much earlier; Inger *et al.* (1984) examined two specimens (BMNH 82.5.22.61–62) from “Tinnevely, India” and restricted *C. tropidogaster* to India, after which, Manamendra-Arachchi *et al.* (2007) designated a lectotype (BMNH 71.12.14.49) and redescribed *C. tropidogaster*. However, they were unable to locate any living populations and thus were not able to describe its geographical distribution. Therefore, this species has only ever been known from its lectotype. The paralectotypes (six specimens) represent four different species three of which (*C. australis*, *C. monticola*, *C. nilagirica*) have been described as new species (Manamendra-Arachchi *et al.* 2007). In the 2007, the National Red List of threatened fauna and flora of Sri Lanka (IUCN & MENR 2007) regarded this species as Endangered (EN), but this was based on the syntype designation of Wickramasinghe & Munindradasa (2007). The 2012 National Red List (MOE 2012) has subsequently corrected it and listed this species as data deficient (DD) and the global conservation status has agreed (IUCN 2014).

During museum reference work in 2014, we found six specimens of unknown *Cnemaspis* species among the collections of NMSL which were collected from Pilikuttuwa and Maligatenna in Gampaha District, Western Province. We sought to compare the new specimens to the types of all Sri Lankan *Cnemaspis* to confirm the identity of the unknown specimens. Our results showed that they are comparable to *Cnemaspis tropidogaster* on the basis of sharing all examined morphometric and meristic characters to the exclusion of other Sri Lankan *Cnemaspis*.

## Materials and methods

Museum acronyms follow Sabaj Pérez (2014). Specimens were examined at the British Museum, London, UK (BMNH); National Museum of Sri Lanka, Colombo, Sri Lanka (NMSL); and Wildlife Heritage Trust, Colombo, Sri Lanka (WHT). The WHT collection has now been deposited at NMSL, but is currently uncatalogued. We examined 153 specimens representing all the Sri Lankan species including all the type materials; the examined specimens are listed in Appendix I. Assignment of unidentified specimens to species was based on the presence of shared morphometric and meristic characters. We used a Leica Wild M3Z and a ZEISS DCR dissecting microscopes to examine the external morphology of specimens and a Cannon EOS 7D SLR digital camera to take photographs. The map was made using ArcGis 10.1 (ESRI© 1995–2012) software. The conservation status of the species was evaluated using the IUCN Standards and Petitions Subcommittee (2013): the version 10.1 guide was used to assess their risk of extinction.

The following morphometric characters were taken with a Mitutoyo digital calliper to the nearest 0.1 mm, on the left side of the body for symmetrical characters: eye diameter (ED), horizontal diameter of orbit; eye–nostril length (EN), distance between anteriormost point of orbit and middle of nostril; snout length (ES), distance between anteriormost point of orbit and tip of snout; internarial distance (IN), shortest distance between inner margins of nares; interorbital width (IO), shortest distance between upper margins of orbits; tympanum–eye length (TYE), distance between anterior most margin of tympanum and posterior most margin of eye; head length (HL), distance between posterior edge of mandible and tip of snout; head width (HW), maximum width of head; snout–vent length (SVL), measured from tip of snout to anterior margin of vent; upper arm length (UAL), distance between axilla and angle of elbow; lower-arm length (LAL), distance from elbow to wrist with both upper arm and palm flexed; palm length (PAL), distance between wrist (carpus) and tip of longest finger, with both palm and lower arm flexed; finger length (FL), distance between tip of claw and the nearest fork; femur length (FEL), distance between groin and knee; tibia length (TBL), distance between knee and heel, with both tibia and tarsus flexed; foot length (FOL), distance between heel and tip of longest toe, with both foot and tibia flexed; toe length (TL IV), distance between tip of claw and nearest fork of the forth toe.

Meristic characters were taken as follows: supralabials (SUP) and infralabials (INF), counted from first labial scale towards gape up to distinctly larger scale than the granular scales at gape; scales from eye to tympanum (BET), counted from posterior-most point of orbit to anterior most point of tympanum; canthus rostralis scales (CR), counted from first scale posterior to supranasal, to end of supraciliary ridge; mid body scales (MBS), count of scales around midbody (across ventrals and dorsals); mid ventral scale row (MVS), there is no sharp transition

from scales on the lower flanks to the ventrals, nonetheless we estimated the number of longitudinal rows of ventrals at midbody; ventral scales (VEN), counted from first scale posterior to mental, to last scale anterior to vent; subdigital lamellae on toe IV (SDL), from first proximal enlarged scensor wider than twice the width of the largest palm scale, to distalmost lamella at tip of digit. We also evaluated the texture (smooth or keeled) of the ventral scales and the number of spinous scales on the flank.

We found three adult males (NMSL 5152, 5157, 5159) and three adult females (NMSL 5970, 5151, 5974) of *Cnemaspis tropidogaster* among the collections of NMSL which were collected at an elevation of 50–80 m a.s.l. from Pilikuttuwa (7°03'28.14" N, 80°02'53.18" E) and Maligatenna (7°04'04.46" N, 80°03'50.11" E) in Gampaha District, Western Province. These forested areas are of lowland tropical rainforest vegetation (Gunatilleke & Gunatilleke 1990) but the massive, rocky, habitats and caves create a dry-mixed habitat. The core study area was approximately 2.5 km x 1.5 km (~ 650 ha), at an elevation range at approximately 40–160 m asl. Sex was determined by the presence (male) or absence (female) of preloacal and femoral pores. Caudal scale characters are not given for specimens with regenerated tails. Natural history observations were made by looking at the animal at a distance of at least 3–4 m being careful not to create a disturbance.

## Results

### *Cnemaspis tropidogaster* (Boulenger, 1885)

(Figs. 1–4; Table 1)

**Lectotype.** (designated by Manamendra-Arachchi *et al.* 2007). Male, BMNH 71.12.14.49, 31.4 mm SVL, “Ceylon [= Sri Lanka]”, Presented by W. Thwaites.

**Other examined material.** Adult males, NMSL 5152, 30.8 mm SVL; adult female, NMSL 5151, 30.9 mm SVL both from Maligatenna, elevation 78 m asl.; adult males, NMSL 5159, 30.5 mm SVL, NMSL 5157, 29.9 mm SVL and two adult females, NMSL 5970, 30.4 mm SVL, NMSL 5974, 30.9 mm SVL, from Pilikuttuwa, Gampaha District, elevation 52 m asl., collected by Ansem de Silva on 22<sup>nd</sup> November 2005.

**Diagnosis.** *Cnemaspis tropidogaster* differs from its Sri Lankan congeners by a combination of the following characters: paired postmentals separated medially by a small scale; each postmental bounded by 3–4 scales including medial scale; ventrals, 133–146; 21–25 scale rows across venter at midbody; 92–98 scales around midbody; dorsal scales heterogeneous; 4–6 spine-like tubercles present on flanks; ventrals including pectoral, abdominal, preloacal and tail base area, carinate and imbricate; 2–3 preloacal pores; 3–5 femoral pores (each side); no enlarged tubercles on tail base; seven supralabials to angle of jaws; 18–19 subdigital lamellae on digit IV of pes.

**Description** (based on four adult males, including the lectotype). 29.9–31.4 mm SVL; head moderately large, elongate, narrow, distinct from neck; snout elongate, slightly concave in lateral profile; snout-eye length greater than eye diameter; eye diameter smaller than tympanum-eye length; canthus rostralis weak, 10–11 canthus rostralis scales; interorbital distance broad; eye large, pupil rounded; ear-opening deep, taller than wide; granules on snout keeled, larger than those of occipital region; scales on interorbital, supercilium and gular region granular; rostral concave, partially divided by a medial groove and a small internasal, postero-ventrally in contact with first supralabial; nasals separated by two enlarged supranasals and a single internasal scale, not in contact with supralabial; nostrils round in shape, dorsally orientated; nasal in contact with two postnasals, the lower one in full contact with first supralabial. Mental subtriangular, fairly truncate posteriorly, as wide as long, extending posteriorly to half level of 1<sup>st</sup> infralabial, postero-laterally in contact with two enlarged postmentals; postmentals bordered posteriorly by 3–4 smooth scales including medial scale; gular scales rather rounded; one scale row separates orbit from supralabials; seven supralabials (3<sup>rd</sup> largest, 6<sup>th</sup> at mid-orbital position); seven infralabials decreasing in size towards angle of jaw; ear opening oval; scales on ventral surface of neck carinate and imbricate; 20–22 scales between anterior margin of ear opening and posterior margin of eye.

Body slender, elongate; mid-dorsal granules, some fairly spinous, generally heterogeneous, intermixed with keeled, enlarged tubercles; scales on dorsum at midbody larger than those on ventral body surface at the same level; six spine-like tubercles on each flank; pectoral and abdominal scales not enlarged, strongly carinate, pointed, imbricate; approximately 23–25 ventral scales across midbody; 95–98 scales around midbody; ventro-lateral scales

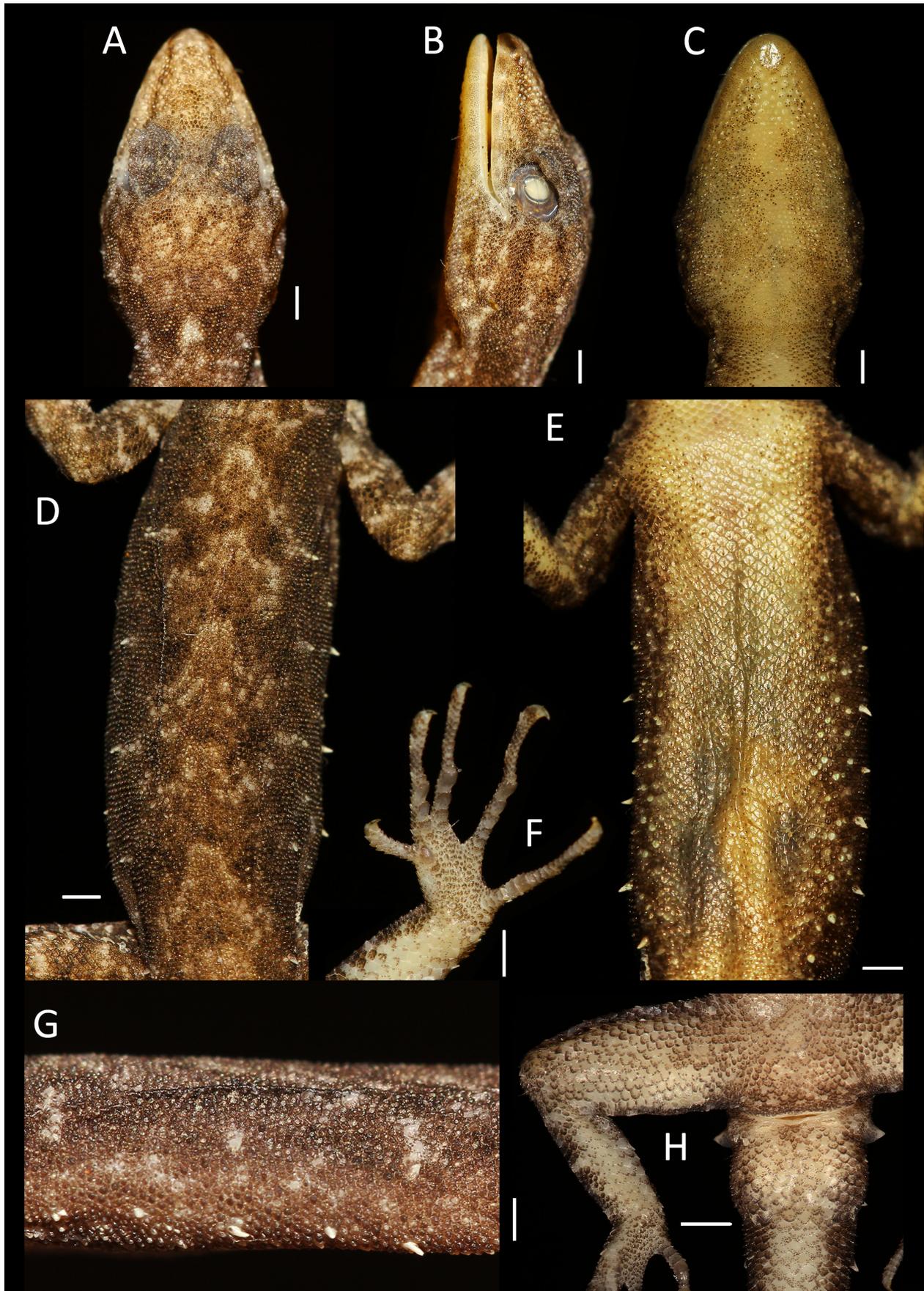
pointed and granular; 2–3 precloacal pores; 3–5 femoral pores (each side); scales around vent imbricate and strongly carinate, each scale with a single keel; ventrals 133–146.

**TABLE 1.** Morphometric and meristic characters for *C. tropidogaster*; NA, not applicable.

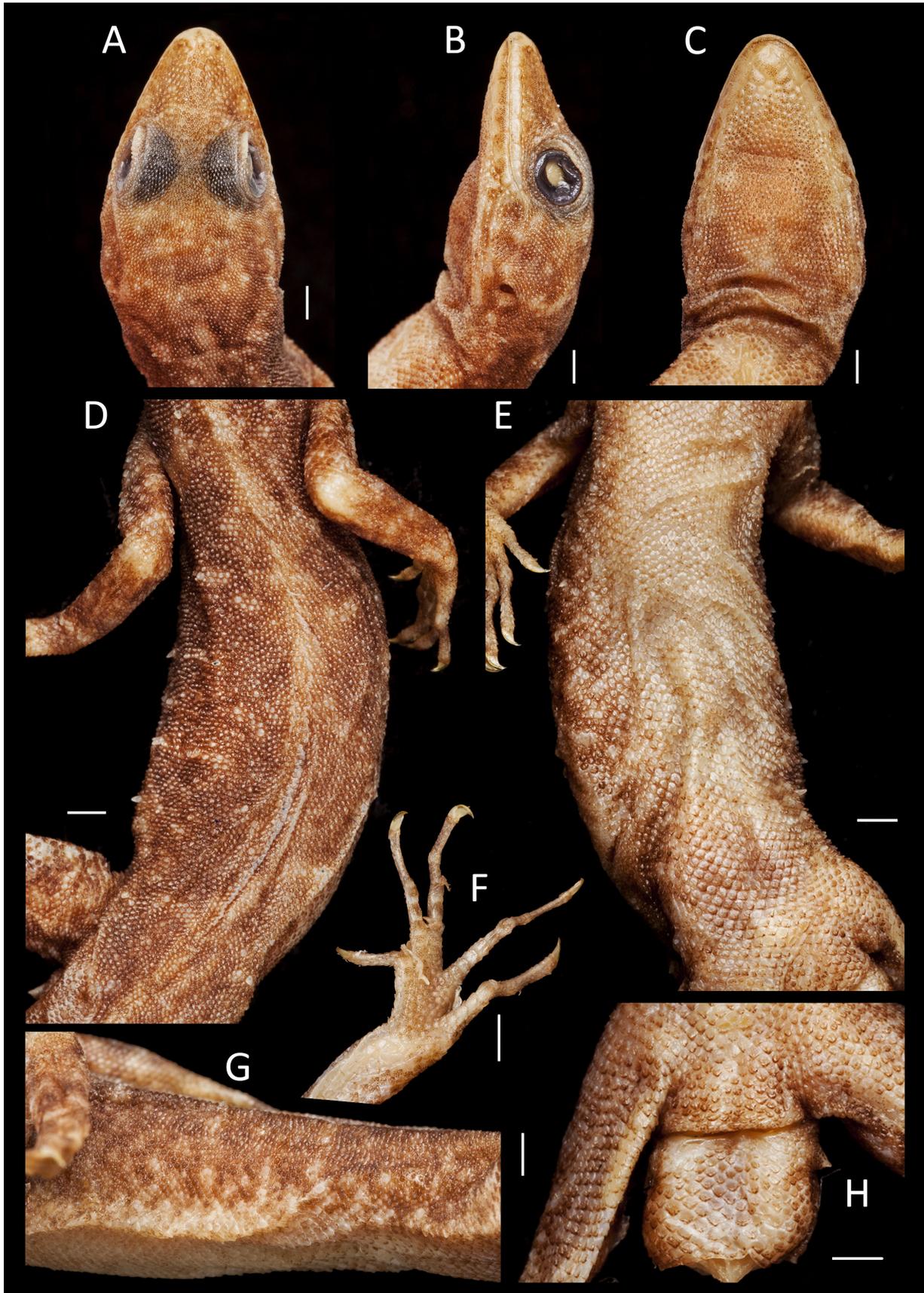
Character	male ( <i>n</i> = 3)		female ( <i>n</i> = 3)		Lectotype male
	Range	Mean ± SD	Range	Mean ± SD	
ED	1.5–1.8	1.7 ± 0.15	1.4–1.5	1.4 ± 0.1	1.6
EN	3.2–3.5	3.3 ± 0.17	3.1–3.3	3.2 ± 0.1	3.3
ES	4.3	4.3 ± 0	4.2–4.4	4.3 ± 0.1	4.1
IN	1.5	1.5 ± 0	1.4	1.4 ± 0	1.1
IO	1.0–1.2	1.1 ± 0.11	1.1	1.1 ± 0	0.8
TYE	2.8	2.8 ± 0	2.6–2.7	2.7 ± 0.1	2.9
HL	9.2–9.3	9.2 ± 0.06	8.6–8.9	8.8 ± 0.1	8.6
HW	5.2–5.4	5.3 ± 0.10	5.3–5.4	5.3 ± 0.1	5.5
SVL	29.9–30.8	30.4 ± 0.46	30.4–31.7	31.0 ± 0.6	31.4
UAL	4.2–4.5	4.3 ± 0.17	3.7–3.8	3.7 ± 0.1	3.7
LAL	4.4–4.8	4.5 ± 0.23	4.5–4.8	4.6 ± 0.1	4.4
PAL	4.4–4.8	4.6 ± 0.21	3.8–4.1	3.9 ± 0.1	3.7
FL1	1.9–2.0	1.9 ± 0.06	1.7–2.0	1.9 ± 0.1	2.2
FL2	2.0–2.3	2.2 ± 0.17	2.3–2.5	2.4 ± 0.1	2.7
FL3	2.3–2.8	2.6 ± 0.26	2.4–3.1	2.8 ± 0.4	2.9
FL4	2.6–3.0	2.8 ± 0.20	3.1	3.1 ± 0	2.9
FL5	2.0–2.6	2.3 ± 0.30	2.6–2.8	2.7 ± 0.1	2.6
FEL	5.4–5.6	5.5 ± 0.11	5.4–6.0	5.6 ± 0.3	6.4
TBL	5.7–6.5	6.0 ± 0.43	5.3–5.9	5.6 ± 0.3	6.8
FOL	5.8	5.8 ± 0	5.5–5.8	5.7 ± 0.1	6.0
TL4	3.7–3.9	3.8 ± 0.10	3.8	3.8 ± 0	3.6
SUP	7		7		7
INF	7		7		7
BET	20–22		20–21		20
CR	10–11		10–11		10
MBS	95–98		92–96		95
MVS	23–25		21–25		25
VEN	133–146		138–142		133
SDL	18–19		18–19		18
precloacal	2		NA		3
femoral	3		NA		4–5

Forelimbs moderately long; hind limbs relatively long; tibia longer than femur. Dorsal scales on both fore and hind limbs carinate; ventral scales on upper arm and lower arm carinate; scales on dorsal and ventral surface of thigh and shank carinate. Digits elongate, slender, all bearing slightly re-curved claws; subdigital lamellae entire, un-notched; subdigital lamellae on toe IV, 18–19; inter digital webbing absent; relative length of fingers: IV > III > II > V > I and of toes: IV > V > III > II > I.

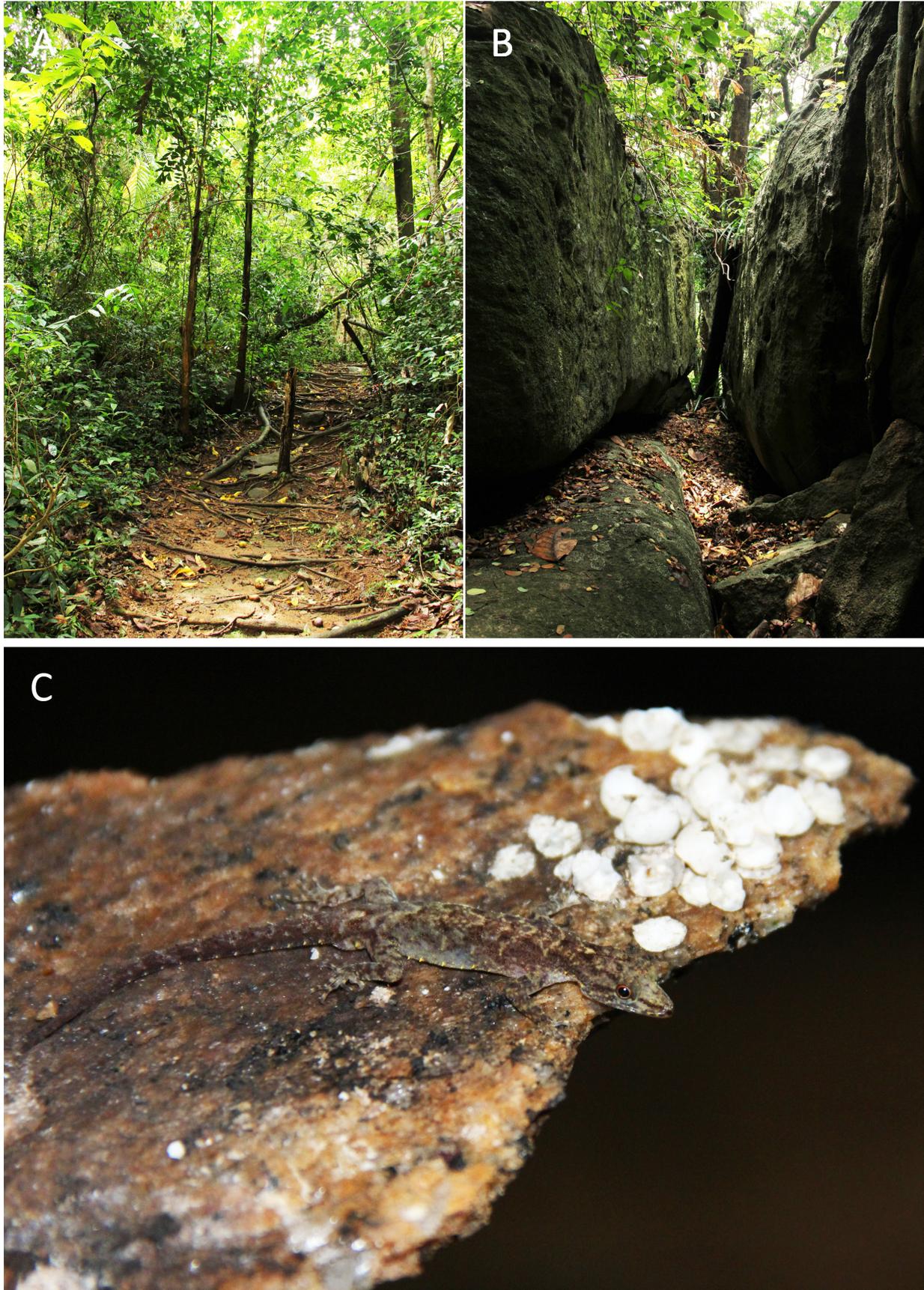
Caudal scales arranged in segmented whorls; tail base distinctly swollen and scales on ventral tail base smooth, intermixed with some slightly keeled scales. Dorsal scales on tail base with homogeneous scales and afterwards pointed and keeled; no enlarged tubercles on tail base; enlarged conical tubercles present on lateral side of the tail; a single conical post-cloacal spur present on each side; median row of subcaudals not comparatively enlarged, pointed, carinate, bordered by a pair of smaller flanking scales of similar size.



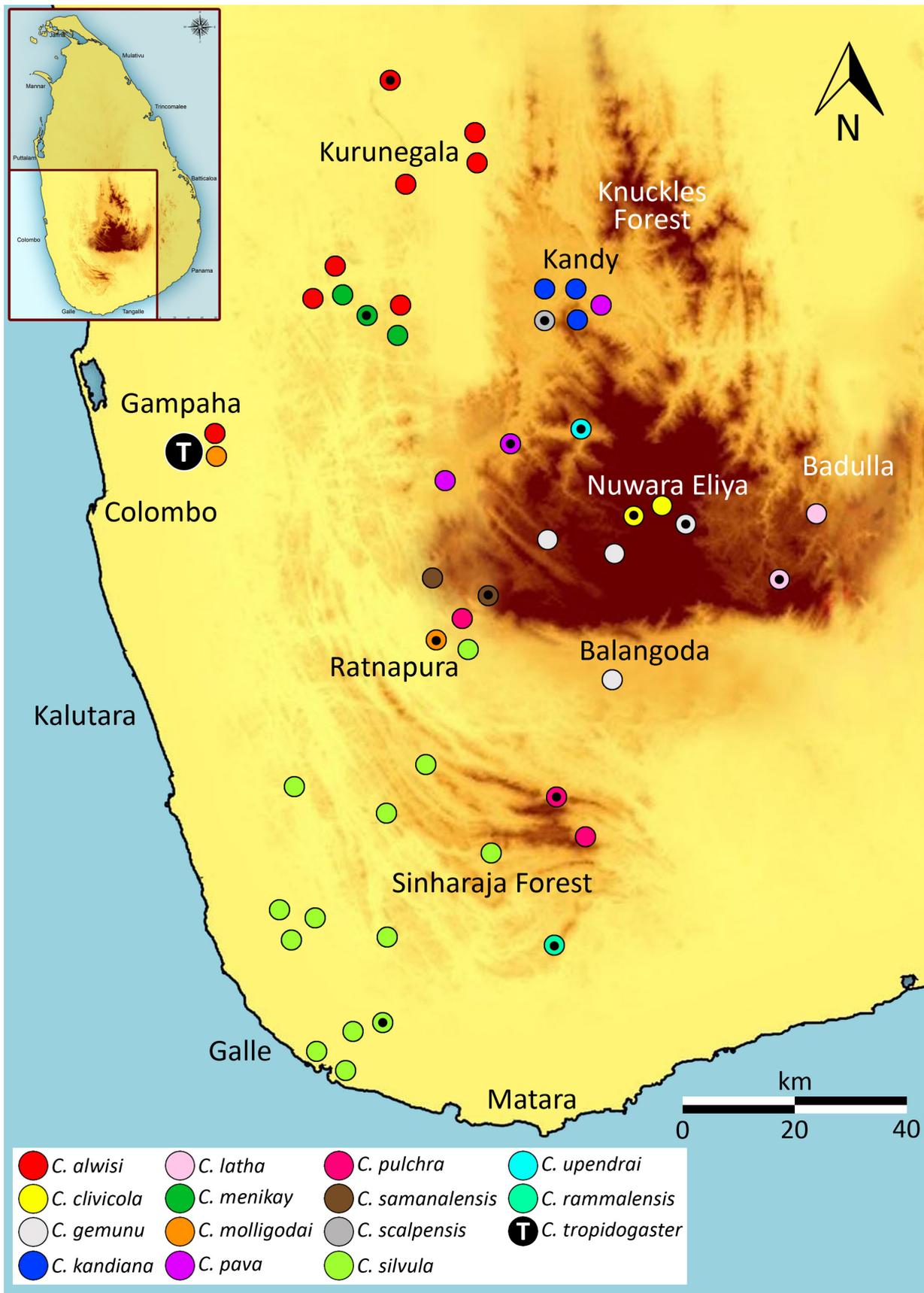
**FIGURE 1.** *Cnemaspis tropidogaster* male NMSL 5159, (a) dorsal head; (b) lateral head; (c) ventral head; (d) dorsal body; (e) ventral body; (f) subdigital lamellae on hind limb; (g) lateral body; (h) ventral tail and pelvic area.



**FIGURE 2.** *Cnemaspis tropidogaster* lectotype male (BMNH 71.12.14.49), (a) dorsal head; (b) lateral head; (c) ventral head; (d) dorsal body; (e) ventral body; (f) toes and subdigital lamellae; (g); lateral body (h) ventral tail base and pelvic area (photo courtesy of BMNH).



**FIGURE 3.** Habitat of *Cnemaspis tropidogaster* at Pilikuttuwa, Gampaha District, Sri Lanka (a) forest foot path; (b) caves and rock boulders; (c) egg-nesting habitat with an adult female (not collected; Photo: W.M.S. Botejue)



**FIGURE 4.** Current distribution pattern of *Cnemaspis tropidogaster*, with other lowland (wet and intermediate zones) and central highland *Cnemaspis* species. Type locality of each species marked with black dot centrally.

**Colour in life** (based on Fig. 3c). Dorsal surfaces of body, limbs and tail light brown; an oblique dark brown line with dull whitish spots in the interorbital area. A 'W' shaped, dark brown patch on the neck with a median dull white spot; six diffuse 'A' shaped, yellowish markings on trunk dorsum, and reddish brown band along the tail. Lateral sides of limbs and body golden yellowish, bright yellow lateral conical tubercles on tail and trunk. Canthus rostralis line present with a black stripe; two scattered, dark brown, postorbital stripes radiate from eyes; supraciliaries and nasals yellow; supralabials and infralabials with a median yellowish spot. Ventral surfaces of head, body and limbs beige to dull yellow with scattered, tiny black spots, ventral tail grey.

**Variation.** The colouration of female specimens is similar to the males. The variation of morphometric and meristic characters are shown in Table 1.

**Comparisons.** *Cnemaspis tropidogaster* is most similar to *C. silvula*, *C. pulchra*, *C. upendrai*, *C. clivicola*, and *C. pava*. The diagnostic characters are listed in Manamendra-Arachchi *et al.* 2007. All six species have at least some tubercles on the tail base, and *C. silvula*, *C. pulchra*, *C. upendrai*, and *C. pava* can also be distinguished by having a distinctly enlarged median row of subcaudal scales. Other congeners from Sri Lanka have more obvious morphological characters that distinguish them from *C. tropidogaster*. Compared to *C. tropidogaster*, *C. kandiana*, *C. scalpensis*, *C. podihuna*, *C. gemunu*, *C. alwisi*, *C. kumarasinghei*, *C. molligodai*, *C. retigalensis*, *C. phillipsi*, *C. punctata*, *C. latha*, *C. kallima*, *C. menikay*, *C. amith*, and *C. rammalensis* all have smooth abdominal scales (vs. keeled). *Cnemaspis samanalensis* has tricarinate ventrals (unicarinate).

**Habitat and natural history.** *Cnemaspis tropidogaster* is only known from Maligatenna and Pilikuttuwa forested areas (Fig. 4) and all specimens were found in very dry, shaded, cool crevices of large caves, rock boulders, leaf litter, tree barks, and cement walls. We observed this species from 27 different caves in the above forested areas. In April and May hatchlings were observed along with juveniles and gravid females carrying two or three eggs. Eggs were pure white (mean diameter  $4.97 \pm 0.03$  mm), almost completely round in shape and with a slightly flattened side which was often the side attached to the substrate or the side in between each egg. Usually 8–12 geckos (individuals per man-hour of search) were recorded at both locations.

**Conservation status.** The application of the IUCN Red List criteria (2013: version 10.1) shows that *C. tropidogaster* is Critically Endangered (CR) and it is restricted to an area of occupancy (AOO)  $< 1$  km<sup>2</sup> and the extent of occurrence (EOO)  $< 2$  km<sup>2</sup> in the Wet Zone [Applicable criteria is B2-b (iii)] assuming that the two sites documented here are the extent of the species' range. However, confirmation that the species does not occur in adjacent areas should be sought before a final determination on conservation status is made. See the map (Fig. 4) for known distribution.

## Discussion

Prior to our discovery of a living population of *Cnemaspis tropidogaster*, the species was generally considered as possibly extinct due to the lack of documented sightings over 120 years. Boulenger (1885) noted the presence of a female specimen from Sri Lanka in the type series, but it has subsequently been lost or misplaced (Manamendra-Arachchi *et al.* 2007). Manamendra-Arachchi *et al.* (2007) attempted to ascertain the identity of the specimens assigned to *C. tropidogaster* by previous authors, e.g., Deraniyagala (1953), Wickramasinghe (2006) and Wickramasinghe & Munindradasa (2007). However, the collection manager of NMSL was unable to locate the specimens for Manamendra-Arachchi *et al.* (2007) despite an extensive search. Therefore, we decided not to attempt an in depth search for the voucher specimens deposited at NMSL, however, we did examine all the relevant type specimens deposited at the BMNH.

The newly discovered *C. tropidogaster* populations are sympatric with two other *Cnemaspis* species: *C. alwisi* Wickramasinghe & Munindradasa, 2007 and *C. molligodai* Wickramasinghe & Munindradasa, 2007. Maligatenna and Pilikuttuwa are new site records for these two species and they extend their distribution range. *Cnemaspis alwisi* has been previously recorded from several localities in dry and intermediate zones, but this is the first record from the wet zone. *Cnemaspis molligodai* is so far only known from the type locality and this is the first record from low altitudes of the wet zone.

It is clear that extensive fieldwork is still needed to clarify some of the issues raised in this discussion, especially those concerning the biogeography and the effect of land use and habitat loss surrounding this species.

## Acknowledgements

We thank S. Kasthuriarachchi (Director, NMSL) for granting research permission. M. Nandasena, L. Somarathna, C. Munasinghe, R. Dasanayake, M.B. Vaidyashekhara, C. Kotalawala, A. Samanthika, P. Gunasiri, R. Dasanayake and R. Wickramanayake are acknowledged for assisting while examining collections under NMSL. Ansem de Silva thanks the Director General of Department of Wildlife Conservation (DWC permit No: WL/3/2/1/14/12) and the Director General of Department of Forestry (FD Permit Nos: FRC/5, FRC/6) for collection permits. We thank Stephen J. Mullen for providing some literature. Stephen Mahony and Olivier S. G. Pauwels are acknowledged for their valuable comments which helped to improve the earlier draft of the manuscript.

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## APPENDIX I. Comparative material examined.

*Cnemaspis kandiana*: BMNH 53.4.1.1 (lectotype), WHT 7212-13, 7267, 7305, 7307-08, 7310, 7313, 7319, 7322; *C. scalpensis*: NMSL 2004.1.1 (neotype), 2004.2.1, 2004.3.1, 2004.4.1, WHT 7265, 7268-7269, 7274-76, 7320; *C. tropidogaster*: BMNH 71.12.14.49 (lectotype); *C. podihuna*: BMNH 1946.8.1.20 (*vide* Amarasinghe & Campbell 2016); *C. gemunu*: WHT 7221, 7347-7348, NMSL 2006.11.01-4; *C. alwisi*: NMSL 2004.9.1 (holotype), 2004.9.2-3 (paratypes), WHT 5918, 6518-19, 7336-38, 7343-46; *C. kumarasinghei*: NMSL 20061301 (holotype), NMSL 20061302 (paratype); *C. molligodai*: NMSL 2006.14.01 (holotype), 2006.14.02-5 (paratypes); *C. retigalensis*: NMSL 20061201 (holotype), NMSL 20061202-4 (paratypes); *C. samanalis*: NMSL 2006.15.01 (holotype), 2006.15.02-5 (paratypes); WHT 0691; *C. phillipsi*: WHT 7248 (holotype), WHT 7236-38 (paratypes); *C. punctata*: WHT 7256 (holotype), WHT 7223 (paratype), 7226 (paratype), 7243-44 (paratypes); *C. upendrai*: WHT 7189 (holotype), 7184 (paratype), 7187-88 (paratypes), 7181-83 (paratypes), 7185 (paratype), 7190-97 (paratypes), 7260 (paratype); *C. clivicola*: WHT 7204 (holotype), 7178-80 (paratypes), 7205 (paratype), 7215 (paratype); *C. silvula*: WHT 7208 (holotype), 7206-7 (paratypes), 7209-10 (paratypes), 7216-17 (paratypes), 7018, 7027, 7202-3, 7220, 7354, 7333; *C. latha*: WHT 7214 (holotype); *C. kallima*: WHT 7245 (holotype), 7227-30 (paratypes), 7251-55 (paratypes); *C. pulchra*: WHT 7023 (holotype), 1573a (paratype), 7011 (paratype), 7021-22 (paratypes); *C. menikay*: WHT 7219 (holotype), 7218 (paratype), 7349 (paratype); *C. pava*: WHT 7286 (holotype), WHT 7281-83 (paratypes), 7285 (paratype), 7288-89 (paratypes), 7290-99 (paratypes), 7300-02 (paratypes); NMSL 2004.11.04-5; *C. amith*: BMNH 63.3.19.1066A (holotype), 63.3.19.1066B-C (paratypes).