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A new species of karst dwelling gecko (genus *Cnemaspis* Strauch 1887) from the border region of Thailand and Peninsular Malaysia

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Abstract

A new species of karst dwelling gecko, *Cnemaspis biocellata* **sp. nov.** is described from the border region in the Satun Province of southern Thailand and the state of Perlis in northern Peninsular Malaysia. *Cnemaspis biocellata* **sp. nov.** is differentiated from all other species of Southeast Asian *Cnemaspis* by having a maximum SVL of 40.1 mm; 6–10 supralabials; 5–7 infralabials; weakly keeled scales on anterior portion of forearm; smooth ventral scales; no femoral pores; 8–12 precloacal pores; smooth subcaudals with an enlarged median row; one or two cloacal tubercles; 29–37 subdigital lamellae on fourth toe; no dark bands encircling tail; two distinct, white, well defined, occipital ocelli; a black occipital band bordering a series of closely spaced, large, white to yellow spots which form a nuchal band and a small, black shoulder patch enclosing a single white to yellow ocellus. This species is restricted to the karst formations of the Nakawan Range spanning the Thai-Malaysian border and has been misidentified as *C. siamensis* by previous authors.

Key words: Malaysia, Thailand, Taxonomy, new species, Gekkonidae, *Cnemaspis biocellata,* karst, Nakawan Range

Introduction

In Southeast Asia, the gekkonid genus *Cnemaspis* Strauch, 1887 currently contains a minimum of 23 nominal species (Chan & Grismer, 2008; Grismer & Chan, 2008) whose disjunct distribution extends from southern Vietnam (Grismer & Ngo, 1997), southwestern Cambodia (Grismer *et al*., 2008) and Thailand (Bauer & Das, 1998), southward through the Malay Peninsula and its associated islands (Das & Leong, 2004; Das & Grismer, 2003; Grismer & Chan, 2008; Grismer & Das, 2006) to Singapore, Sumatra, Borneo and their associated islands (Das, 2005; Das & Bauer 1998). Despite the diversity and wide, fragmented distribution of this genus, all its species share a general body plan of having a broad, flattened head; large, somewhat forward and upwardly directed eyes with round pupils; a flattened body; long, widely splayed limbs; and long, inflected digits. Such characters are suited for a scansorial life style on large, flat surfaces (usually rocks but sometimes trees) and for seeking refuge within crevice microhabitats. Although these species are generally nocturnal, many are also abroad during the day in microhabitats under low illumination such as the shaded surfaces of large rocks and tree trunks. This secretive, scansorial life style has undoubtedly contributed to the basic body plan of this genus as well as to its complicated taxonomic history (Bauer & Das, 1998; Das, 2005; Dring,

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1979) and the confusion and conflation of many species with one another (e.g., Manthey & Grossmann, 1997; Cox *et al.,* 1998; Grossmann & Tillack, 2001). Additionally, ongoing studies are revealing that several undescribed species are still masquerading under the names of known taxa (Grismer *et al*., in prep.).

There are at least 16 species of *Cnemaspis* on the Malay Peninsula and its associated islands (see Grismer & Chan, 2008) and two of these, *C. kumpoli* Taylor, 1963 from southernmost Thailand and northern Peninsular Malaysia (Chan & Grismer, 2008; Dring, 1979) and *C. siamensis* (Smith, 1925) from southernmost Thailand, have recently been confused with previously undescribed species. In describing *C. flavigaster,* Chan and Grismer (2008) removed it from its inclusion within *C. kumpoli* by Dring (1979). A specimen of "*Cnemaspis siamensis*" was figured (Manthey & Grossmann, 1997 Fig. 152:215) from Thale Ban National Park, Satun Province in southern Thailand (followed by Cox *et al.,* 1998:91 using the same photograph), however, based on the examination of additional material from peninsular Thailand as well as new material collected and observed from the border region of northern Perlis, Peninsular Malaysia (Fig. 1), we have concluded that the specimen illustrated in Manthey and Grossmann (1997) is not *C. siamensis* but a male of a new karst dweling species which is described herein.

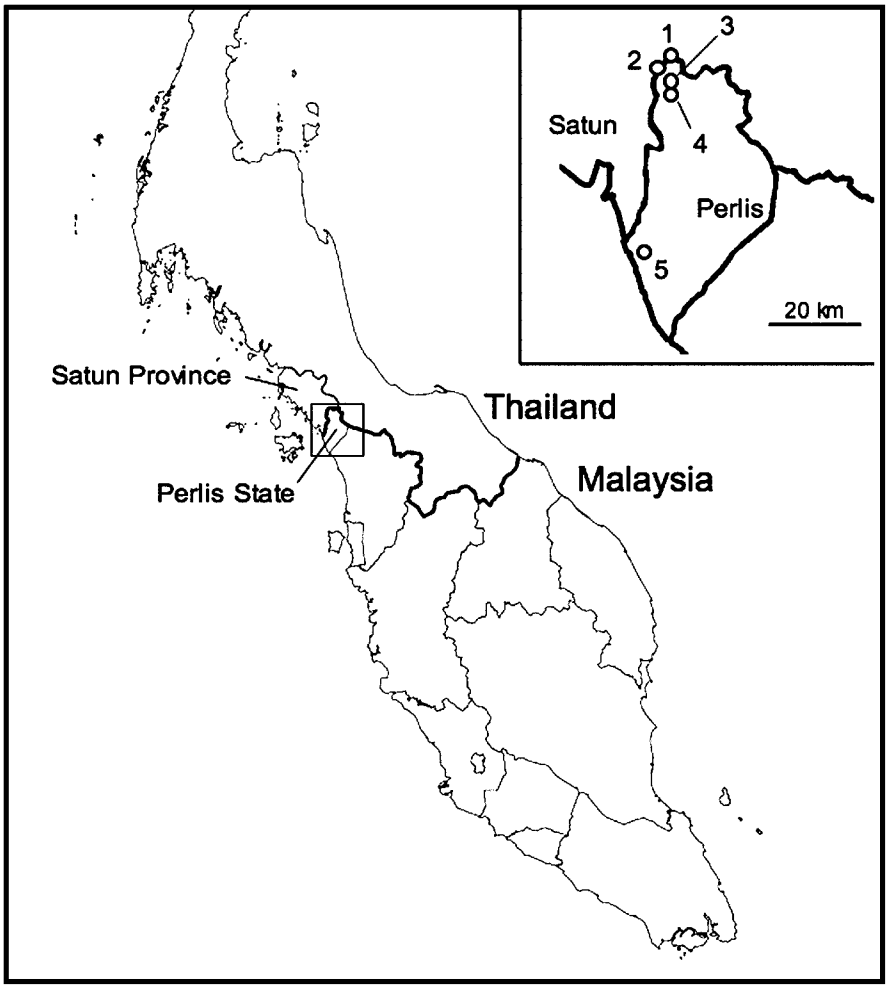

FIGURE 1. Distribution of *Cnemaspis biocellata* in Satun Province, southern Thailand and Perlis Sate, Peninsular Malaysia. 1 = Thale Ban National Park, 2 = Wang Kelian, 3 = Gua Kelam, 4 = Tasik Meranti, and 5 = Kuala Perlis.

Materials and methods

Field work was conducted in northern Perlis, Peninsular Malaysia at Wang Kelian (06°40.893'N 100°11.244'E), Gua Kelam (06°38.404'N 100°12.103'E), Tasik Meranti (06°39.129'N 100°11.145"E), and

Kuala Perlis (06°24.437N 100°08.564'E) from 2–23 March 2008. Specimens were collected, photographed, and liver tissue was taken from each specimen prior to preservation and stored in 100% ethanol. All specimens were fixed in 10% formalin and transferred to 70% ethanol. Color notes were taken from digital images of living specimens. The following measurements on the type series of the new species were taken with Mitutoyo dial calipers to the nearest 0.1 mm under a Nikon SMZ 1500 dissecting microscope on the left side of the body where appropriate: snout-vent length (SVL), taken from the tip of snout to the vent; tail length (TL), taken from the vent to the tip of the tail, original or regenerated; tail width (TW), taken at the base of the tail immediately posterior to the postcloacal swelling; forearm length (FL), taken on the dorsal surface from the posterior margin of the elbow while flexed 90º to the inflection of the flexed wrist; tibia length (TBL), taken on the ventral surface from the posterior surface of the knee while flexed 90º to the base of the heel; axilla to groin length (AG), taken from the posterior margin of the forelimb at its insertion point on the body to the anterior margin of the hind limb at its insertion point on the body; head length (HL), the distance from the posterior margin of the retroarticular process of the lower jaw to the tip of the snout; head width (HW), measured at the angle of the jaws; head depth (HD), the maximum height of head from the occiput to the throat; eye diameter (ED), the greatest horizontal diameter of the eye ball; eye to ear distance (EE), measured from the anterior edge of the ear opening to the posterior edge of the eye ball; eye to snout distance (ES), measured from anteriormost margin of the eye ball to the tip of snout; eye to nostril distance (EN), measured from the anterior margin of the eye ball to the posterior margin of the external nares; inner orbital distance (IO), measured between the anterior edges of the orbit; ear length (EL), the greatest horizontal distance of the ear opening; and internarial distance (IN), measured between the nares across the rostrum. Additional character states evaluated were numbers of supralabial and infralabial scales counted from below the middle of the orbit to the rostral and mental scales, respectively; the texture of the scales on the anterior margin of the forearm; the number of paravertebral tubercles between limb insertions counted in a straight line immediately left of the vertebral column; the presence or absence of a row of enlarged, widely spaced, spinose tubercles along the ventrolateral edge of the body between the limb insertions; the number of subdigital lamellae beneath the fourth toe counted from the base of the first phalanx to the claw; the total number of precloacal pores, their orientation; the degree and arrangement of body and tail tuberculation; the relative size and morphology of the subcaudal scales, subtibial scales, and submetatarsal scales beneath the first metatarsal; the number of precloacal tubercles on each side of the tail base; the presence or absence of large, dark, isolated, round spots on the nape and anterior portion of the body; the presence or absence and color of dorsal blotching on the head, body, limbs, and tail; the presence or absence and position of ocelli; coloration of dorsal body blotches; coloration of gular and abdominal region; the presence or absence of wide, dark bands on an original tail; and the coloration of the posteriormost 25% of the tail.

Some of the information on character states and their distribution in other species was obtained from Bauer and Das (1998), Cox *et al*. (1998), Das (2005), Das and Bauer (1998), Das and Grismer (2003), De Rooij (1915), Dring (1979), Grismer and Chan (2008); Grismer and Das (2006), Grismer and Ngo (2007), Grossmann and Tillack (2001), Manthey and Grossmann (1997), Nichols (1949), Rösler (1981), Smith (1935), Taylor (1963) and Wermuth (1966). These data were added to an expanded and revised data set of Chan and Grismer (2008; Table 1). Additional specimens examined are listed in the appendix. Institutional abbreviations follow Leviton *et al*. (1985), except we retain ZRC for USDZ, following conventional usage. DWNP refers to the Department of Wildlife and National Parks collection, Krau, Pahang, West Malaysia; LSUHC refers to the La Sierra University Herpetological Collection, La Sierra University, Riverside, California, USA; LSUDPC refers to the La Sierra University Digital Photo Collection; MS refers to the private collection of Montri Sumontha, Ranong Marine Fisheries Station, Ranong 85000, Thailand; and UNS refers to the University of Natural Sciences, Ho Chi Minh City, Vietnam.

Systematics

***Cnemapsis biocellata* sp. nov.**
Figures 2,3

Cnemaspis siamensis Manthey & Grossmann 1997:215; Cox *et al.* 1998:91.

Holotype. Adult male (ZRC 2.6693) collected on 3 March 2008 by Chan Kin Onn, L. Lee Grismer, and Rick Gregory at 2330 h at 37 m a.s.l. from Kuala Perlis, Perlis, Peninsular Malaysia (06°24.437N 100°08.564E).

Paratypes. Five paratypes (ZRC 2.6694, 2.6696 adult females and ZRC 2.6695, 2.6697–98 adult males) have the same collection data as the holotype. THNHM 8895 is from Khao Tohphayawang, Muang Satun District, Satun Province, Thailand collected in August 2003 by M. Sumontha.

Diagnosis. *Cnemaspis biocellata* differs from all other Southeast Asian *Cnemaspis* in having the unique combination of a maximum SVL of 40.1 mm; 6–10 supralabials; 5–7 infralabials; scales of anterior portion of forearm weakly keeled; ventral scales smooth; no femoral pores; 8–12 precloacal pores; no row of linearly arranged tubercles on flanks; paravertebral, longitudinal rows of caudal tubercles present but no lateral caudal rows; smooth subcaudals with an enlarged median row; one or two cloacal tubercles; no large, shield-like subtibial or submetatarsal scales; 29–37 subdigital lamellae on fourth toe; no distinct, large, dark spots on neck and back alternating with transverse, white markings; no white markings on flanks alternating with dark blotches; no dark bands encircling tail; two distinct, white, well defined occipital ocelli; black occipital band bordering a series of closely spaced, large, white to yellow spots which form a nuchal band extending from posterior margin of one eye to the other eye; small, black shoulder patch enclosing a single white to yellow ocellus; shoulder patches not meeting middorsally; posterior 25% of tail not white. These differences are summarized across all Southeast Asian species in Table 1.

FIGURE 2. Upper left: male holotype of *Cnemaspis biocellata* ZRC 2.6693. Upper right: female paratype of *C. biocellata* ZRC 2.6694. Lower left: male *C. kumpoli* (LSUDPC 4163) from Perlis State Park. Lower right: male *C. siamensis* from Surat Thani province, Thailand (photo by Montri Sumontha).

TABLE 1.— Diagnostic characters of Southeast Asian species of Cnemaspis. / = character not applicable; ? = character could not be evaluated from specimens or literature.

	affinis	*argus*	*aurantiacopes*	*baueri*
Maximum SVL (mm)	49.0	65.8	56.6	64.9
Supralabials	8–11	8–10	9–11	11–13
Infralabials	8–10	10–12	8–10	10–12
Forearm scales keeled (1) or not (0)	1	0	1	0
Ventral scales keeled (1) or not (0)	1	1	0	1
Femoral pores present (1) or absent (0)	0	0	0	0
No. of femoral pores	/	/	/	/
Precloacal pores present (1) or absent (0)	1	0	0	0
No. of precloacal pores	5–6	/	/	/
Tubercles of ventralmost row on flank linearly arranged and in contact or nearly so (1) or tubercles on flank widely spaced and more randomly distributed (0)	0	0	1	0
Caudal tubercles present (1) or absent (0)	1	1	1	1
Lateral caudal tubercles present (1) or not (0)	1	1	1	1
Ventrolateral caudal tubercles anteriorly (1) or not (0)	1	1	1	1
Caudal tubercles restricted to a single Paravertebral row on each side (1) or not (0)	0	0	0	0
Subcaudals keeled (1) or not (0)	1	1	0	0
Single median row of keeled subcaudals (1) or not (0)	0	0	1	0
Caudal tubercles encircle tail (1) or not (0)	1	0	0	1
Enlarged median subcaudal scale row (1) or not (0)	0	0	1	0
Postcloacal tubercles present (1) or absent (0)	1	1	1	1
Shield-like subtibial scales present (1) or absent (0)	0	0	0	0
Subtibial scales keeled (1) or not (0)	1	0	1	1
Enlarged submetatarsal scales on 1st toe (1) or not (0)	0	0	1	0
No. of 4th toe lamellae	25–32	23–24	28–30	26–27
White markings on flanks (1) or not (0)	1	0	0	0
Distinct, large, dark spots on neck (1) or not (0)	0	0	0	1
Dark caudal bands present (1) or absent (0)	1	1	0	0
Posterior 25% of tail white (1) or not (0)	0	0	0	0

..... continued

TABLE 1 (continued)

	boulengeri	*caudanivea*	*chanthaburiensis*	*dezwaani*
Maximum SVL (mm)	66.0	44	41.0	31.4
Supralabials	8–11	8–9	8–9	6–7
Infralabials	7–8	8	8–9	7
Forearm scales keeled (1) or not (0)	0	1	1	1
Ventral scales keeled (1) or not (0)	0	0	0	1
Femoral pores present (1) or absent (0)	0	0	0	1
No. of femoral pores	/	/	/	3
Precloacal pores present (1) or absent (0)	0	1	1	1
No. of precloacal pores	/	2	7–9	8–12
Tubercles of ventralmost row on flank linearly arranged and in contact or nearly so (1) or tubercles on flank widely spaced and more randomly distributed (0)	1	0	0	0
Caudal tubercles present (1) or absent (0)	1	1	1	1
Lateral caudal tubercles present (1) or not (0)	0	1	1	?
Ventrolateral caudal tubercles anteriorly (1) or not (0)	0	0	0	?
Caudal tubercles restricted to a single Paravertebral row on each side (1) or not (0)	1	0	0	0
Subcaudals keeled (1) or not (0)	0	0	0	1
Single median row of keeled subcaudals (1) or not (0)	0	0	0	1
Caudal tubercles encircle tail (1) or not (0)	0	0	0	0
Enlarged median subcaudal scale row (1) or not (0)	1	0	0	1
Postcloacal tubercles present (1) or absent (0)	1	1	1	1
Shield-like subtibial scales present (1) or absent (0)	1	1	0	0
Subtibial scales keeled (1) or not (0)	0	0	0	1
Enlarged submetatarsal scales on 1st toe (1) or not (0)	1	1	0	0
No. of 4th toe lamellae	16–19	24–29	17–20	18–19
White markings on flanks (1) or not (0)	0	0	0	0
Distinct, large, dark spots on neck (1) or not (0)	1	0	0	0
Dark caudal bands present (1) or absent (0)	0	1	1	1
Posterior 25% of tail white (1) or not (0)	1	1	0	0

..... *continued*

TABLE 1 (continued)

	dringi	*flavolineata*	*jacobseni*	*kendallii*
Maximum SVL (mm)	45.5	46.7	30.5	58.0
Supralabials	11	9–11	6–7	10–12
Infralabials	11	8–10	7–8	7–9
Forearm scales keeled (1) or not (0)	0	1	1	1
Ventral scales keeled (1) or not (0)	0	1	1	1
Femoral pores present (1) or absent (0)	0	0	0	0
No. of femoral pores	/	/	/	/
Precloacal pores present (1) or absent (0)	1	1	0	0
No. of precloacal pores	6	7	/	/
Tubercles of ventralmost row on flank linearly arranged and in contact or nearly so (1) or tubercles on flank widely spaced and more randomly distributed (0)	0	0	0	0
Caudal tubercles present (1) or absent (0)	1	1	1	1
Lateral caudal tubercles present (1) or not (0)	?	1	?	1
Ventrolateral caudal tubercles anteriorly (1) or not (0)	?	1	?	1
Caudal tubercles restricted to a single Paravertebral row on each side (1) or not (0)	?	0	0	0
Subcaudals keeled (1) or not (0)	1	1	1	1
Single median row of keeled subcaudals (1) or not (0)	?	0	1	1
Caudal tubercles encircle tail (1) or not (0)	?	1	0	1
Enlarged median subcaudal scale row (1) or not (0)	/	0	1	1
Postcloacal tubercles present (1) or absent (0)	0	1	1	1
Shield-like subtibial scales present (1) or absent (0)	0	0	0	0
Subtibial scales keeled (1) or not (0)	1	1	1	1
Enlarged submetatarsal scales on 1st toe (1) or not (0)	1	0	0	0
No. of 4th toe lamellae	13	25–31	16-18	18–23
White markings on flanks (1) or not (0)	1	1	0	0
Distinct, large, dark spots on neck (1) or not (0)	0	0	0	0
Dark caudal bands present (1) or absent (0)	1	1	1	0
Posterior 25% of tail white (1) or not (0)	?	0	0	0

..... continued

TABLE 1 (continued)

	kumpoli	*limi*	*modiglianii*	*nigridius*
Maximum SVL (mm)	60.0	88.2	33.7	69.8
Supralabials	9–11	11–14	6–7	11
Infralabials	8–11	8–10	6–8	12
Forearm scales keeled (1) or not (0)	1	1	1	0
Ventral scales keeled (1) or not (0)	0	1	1	1
Femoral pores present (1) or absent (0)	0	0	1	0
No. of femoral pores	/	/	8	/
Precloacal pores present (1) or absent (0)	1	0	1	1
No. of precloacal pores	7–8	/	2	16
Tubercles of ventralmost row on flank linearly arranged and in contact or nearly so (1) or tubercles on flank widely spaced and more randomly distributed (0)	0	0	0	0
Caudal tubercles present (1) or absent (0)	1	1	1	1
Lateral caudal tubercles present (1) or not (0)	1	1	1	1
Ventrolateral caudal tubercles anteriorly (1) or not (0)	0	1	0	1
Caudal tubercles restricted to a single Paravertebral row on each side (1) or not (0)	0	0	0	0
Subcaudals keeled (1) or not (0)	0	0	1	0
Single median row of keeled subcaudals (1) or not (0)	0	0	0	0
Caudal tubercles encircle tail (1) or not (0)	0	0	0	0
Enlarged median subcaudal scale row (1) or not (0)	0	weakly	1	1
Postcloacal tubercles present (1) or absent (0)	1	1	1	1
Shield-like subtibial scales present (1) or absent (0)	0	0	0	0
Subtibial scales keeled (1) or not (0)	1	1	0	?
Enlarged submetatarsal scales on 1st toe (1) or not (0)	0	0	0	?
No. of 4th toe lamellae	31–32	20–30	14	17–24
White markings on flanks (1) or not (0)	1	0	0	0
Distinct, large, dark spots on neck (1) or not (0)	1	0	0	0
Dark caudal bands present (1) or absent (0)	1	0	1	0
Posterior 25% of tail white (1) or not (0)	0	0	0	0

..... continued

TABLE 1 (continued)

	nuicamensis	*pemaggilensis*	*phuketensis*	*siamensis*
Maximum SVL (mm)	47.5	76.0	29.1	39.7
Supralabials	8	10–13	6–7	9–11
Infralabials	6–7	10–14	6–7	8–10
Forearm scales keeled (1) or not (0)	weak	0	1	0
Ventral scales keeled (1) or not (0)	0	1	0	1
Femoral pores present (1) or absent (0)	0	0	0	0
No. of femoral pores	/	/	/	/
Precloacal pores present (1) or absent (0)	1	0	0	1
No. of precloacal pores	4–6	/	/	4–16
Tubercles of ventralmost row on flank linearly arranged and in contact or nearly so (1) or tubercles on flank widely spaced and more randomly distributed (0)	0	0	0	0
Caudal tubercles present (1) or absent (0)	1	1	0	1
Lateral caudal tubercles present (1) or not (0)	0	1	1	1
Ventrolateral caudal tubercles anteriorly (1) or not (0)	1	1	1	1
Caudal tubercles restricted to a single Paravertebral row on each side (1) or not (0)	0	0	0	0
Subcaudals keeled (1) or not (0)	0	1	0	1
Single median row of keeled subcaudals (1) or not (0)	weak	1	1	0
Caudal tubercles encircle tail (1) or not (0)	0	1	1	0
Enlarged median subcaudal scale row (1) or not (0)	1	1	1	1
Postcloacal tubercles present (1) or absent (0)	1	1	1	1
Shield-like subtibial scales present (1) or absent (0)	0	0	0	0
Subtibial scales keeled (1) or not (0)	0	0	1	0
Enlarged submetatarsal scales on 1st toe (1) or not (0)	0	0	0	0
No. of 4th toe lamellae	30-31	27–31	16–17	17–22
White markings on flanks (1) or not (0)	0	1	0	0
Distinct, large, dark spots on neck (1) or not (0)	0	0	0	0
Dark caudal bands present (1) or absent (0)	0	1	0	1
Posterior 25% of tail white (1) or not (0)	0	0	0	0

..... continued

TABLE 1 (continued)

	tucdupensis	*whittenorum*	*perhemtianensis*	*flavigaster*	*biocellata*
Maximum SVL (mm)	51	31.5	47	50.1	40.1
Supralabials	10	5–6	8–10	9-10	6-10
Infralabials	8	7	7–8	8-10	5-7
Forearm scales keeled (1) or not (0)	1	1	1	1	1
Ventral scales keeled (1) or not (0)	0	1	0,1	0	0
Femoral pores present (1) or absent (0)	0	0	0	0	0
No. of femoral pores	/	/	/	/	/
Precloacal pores present (1) or absent (0)	0	0	0	1	1
No. of precloacal pores	/	/	/	7-8	8-12
Tubercles of ventralmost row on flank linearly arranged and in contact or nearly so (1) or tubercles on flank widely spaced and more randomly distributed (0)	1	0	0	0	0
Caudal tubercles present (1) or absent (0)	1	1	1	1	1
Lateral caudal tubercles present (1) or not (0)	0	?	1	1	0
Ventrolateral caudal tubercles anteriorly (1) or not (0)	0	?	1	1	0
Caudal tubercles restricted to a single Paravertebral row on each side (1) or not (0)	1	0	0	0	0
Subcaudals keeled (1) or not (0)	0	0	1	0	0
Single median row of keeled subcaudals (1) or not (0)	1	0	0	0	0
Caudal tubercles encircle tail (1) or not (0)	0	0	0	0	0
Enlarged median subcaudal scale row (1) or not (0)	1	1	0	0	1
Postcloacal tubercles present (1) or absent (0)	1	0	1	1	1
Shield-like subtibial scales present (1) or absent (0)	0	0	0	0	0
Subtibial scales keeled (1) or not (0)	0	?	1	1	0
Enlarged submetatarsal scales on 1st toe (1) or not (0)	1	0	0	1	0
No. of 4th toe lamellae	27-30	18–19	28–31	29-34	29–37
White markings on flanks (1) or not (0)	0	0	1	1	1
Distinct, large, dark spots on neck (1) or not (0)	0	0	1	1	0
Dark caudal bands present (1) or absent (0)	1	1	1	1	0
Posterior 25% of tail white (1) or not (0)	0	0	0	0	0

Description of holotype. Adult male; snout-vent length 36.8 mm; head oval in dorsal profile, moderate in size (HL/SVL 0.23), somewhat narrow (HW/SVL 0.20), flattened (HD/HL 0.39), distinct from neck; snout short (ES/HL 0.48), slightly concave in lateral profile, longer than eye diameter; postnasal region constricted medially, concave; scales of rostrum weakly keeled, raised, slightly larger than those on occiput; low, rounded, supraorbital ridges; shallow frontorostral sulcus; canthus rostralis nearly absent, smoothly rounded; eye large (ED/HL 0.22); extra-brillar fringe scales largest anteriorly; pupil round; ear opening oval, taller than wide; eye to ear distance greater than diameter of eye; rostral scale concave, dorsal 75% divided by deep, longitudinal groove; rostral bordered posteriorly by two large supranasals and posterolaterally by one small, lower postnasal and first supralabial; supralabials 10 (R and L), decreasing in size posteriorly; seven (R and L) infralabials, decreasing in size posteriorly, first, second, and third infralabials nearly same size; nostrils elliptical, oriented dorsoposteriorly; three small, granular, postnasal scales (R and L) undifferentiated from lateral scales of rostrum; mental large, triangular, deeper than wide, concave medially, bordered posteriorly by three postmentals; lateral postmentals largest; postmentals bordered posteriorly by five smaller, rounded scales, laterealmost scales largest; enlarged sublabials absent; gular scales granular, slightly raised; throat scales smooth, imbricate.

Body slender, elongate; dorsal scales equal in size throughout body; dorsal tubercles more or less randomly distributed from occiput to base of tail; dorsal tubercles large with multiple keels; pectoral and abdominal scales smooth, flat, slightly elongate, imbricate, equal in size throughout; ventral scales slightly larger than dorsal scales; eight precloacal pores arranged in a chevron, not separated medially by intervening scales lacking pores; precloacal depression absent; femoral pores absent.

Forelimbs moderately long, slender; dorsal scales of brachium flat, weakly keeled; scales of forearm same size as brachials, imbricate, those on anterior margin weakly keeled; ventral scales of brachium smooth, rounded, sharply juxtaposed; scales beneath forearm, smooth, flat; palmar scales smooth, juxtaposed, slightly raised; digits long with an inflected joint; claws slightly recurved; subdigital lamellae unnotched; lamellae beneath first phalanges widened; slight interdigital webbing; fingers increase in length from first to fourth with fifth slightly shorter than fourth; hind limbs slightly longer and thicker than forelimbs; dorsal scales of thigh keeled, slightly raised, juxtaposed to subimbricate; scales of anterior margin of thigh keeled; ventral scales of thigh flat, imbricate; subtibial scales keeled, flat, imbricate, with no enlarged anterior row; plantar scales smooth, juxtaposed, raised; no enlarged submetatarsal scales beneath first metatarsal; digits elongate with an inflected joint; claws slightly recurved; subdigital lamellae unnotched; lamellae beneath first phalanx widened; interdigital webbing weak; toes increase in length from first to fourth with fourth and fifth shorter than fourth; 29 subdigital lamellae on fourth toe (R, L).

Tail 1.37 times SVL, swollen at base; caudal scales arranged in segmented whorls, first segment at base of tail eight scales wide middorsally; anteriorly caudal scales raised, juxtaposed, weakly keeled becoming flatter, imbricate, and keeled posteriorly; shallow middorsal furrow; deeper, single lateral furrow; single median row of enlarged subcaudal scales; subcaudal scales smooth; a paravertebral and dorsolateral row of large, flattened tubercles on either side of midline; transverse tubercle rows do not completely encircle tail; two (R and L) enlarged postcloacal tubercles on lateral surface of hemipenal swellings at base of tail.

Coloration (in life; Fig. 2). The holotype has a dorsal ground color of dull yellow which is overlain by five yellow, butterfly-shaped vertebral blotches extending from the shoulder region to the base of the tail. Small, faint yellow blotches occur on the flanks and limbs and tend to form caudal bands. The rostrum is grayish with faint, light markings highlighting the bright yellow, anterior, extrabrillar fringe. The interorbital region is yellow and two distinct, white, immaculate, well defined occipital ocelli are present. The ocelli are accentuated by a wide, black occipital band that forms the anterior border of a series of closely spaced, large, white to yellow spots that form a nuchal band extending from the posterior margin of one eye to the posterior margin of the other eye. Posterior to this, is a small, black shoulder patch enclosing a single white to yellow ocellus. The shoulder patches do not meet middorsally. The venter is beige and immaculate with the exception

of faint, subcaudal mottling. In alcohol, the overall ground color dulls to gray but the essentials of the color pattern remain visible.

Variation. The male paratypes closely resemble the holotype in overall coloration and pattern (Fig. 3). The white, nuchal band in ZRC 2.6698 is more continuous than that of the holotype and the black occipital band is wider. The nuchal band in ZRC 2.6697 is more a series of closely spaced spots than a continuous band. The entire tail of ZRC 2.6695 is regenerated and uniform yellow. ZRC 2.6697 and 2.6698 have broken tails. This species has a marked sexual dimorphism with respect to coloration and pattern. The adult females (ZRC 2.6694 and 2.6696) have a base color of light brown and lack the black occipital and shoulder markings seen in the males (Fig. 2). Faint, straw colored ocelli, however, are present which are homologous to those in males. A series of poorly defined, straw colored, butterfly-shaped, vertebral markings extend from the nape to the base of the tail and tend to form poorly defined caudal bands. Small, irregularly shaped, faint spots occur on the flanks and limbs. The venter is beige and immaculate with the exception of faint, subcaudal mottling. A patch of skin is missing from the dorsum between the hind limb insertions and on the base of the tail in ZRC 2.6694. Morphometric variation and variation in scalation are presented in Table 2.

TABLE 2. Descriptive measurements and characteristics of the type series of *Cnemaspis biocellata*. All measurements in milimeters. PT = number of paravertebral tubercles; PP = number of precloacal pores; PS = number of postcloacal tubercles; and 4th toe = number of subdigital lamellae on 4th toe.

	THNHM 8895 paratype	ZRC 2.6693 holotype	ZRC 2.6694 paratype	ZRC 2.6695 paratype	ZRC 2.6696 paratype	ZRC 2.6697 paratype	ZRC 2.9998 paratype
Sex	M	m	f	m	f	m	m
Supralabials	9	10	8	8	8	8	7
Infralabials	8	7	6	6	7	7	6
PT	25	24	/	26	/	27	22
PP	7	8	/	12	/	8	8
PS	1	2	1	0	0	1	0
4^{th} toe	30	29	34	35	37	32	33
SVL	39.5	36.8	37.4	38.5	38	38.2	40.2
TL	55.1	50.5	53.7	47.8	28.8	21.6	8.7
TW	2.9	3.2	3	3.1	2.9	3.5	3.2
FL	2.3	6.2	6.4	6.3	6.3	6.8	6.2
TBL	7.9	8.1	8.1	8.1	7.5	8.6	8.4
AG	16.4	16.1	17.3	16.7	16	17.2	16.8
HL	9.3	9.5	9.3	10.3	10.6	10.5	9.5
HW	5.8	7.4	7.5	6.8	6.5	6.8	6.6
HD	4.2	3.7	3.8	4.2	4.4	4.2	4.2
ED	2.3	2.1	2.2	2.2	2.4	2.2	2.3
EE	2.5	2.7	2.8	2.9	3.2	3.0	2.8
ES	5.1	4.6	4.8	4.8	4.9	5.0	4.0
EN	4.0	4.5	4.0	3.7	3.7	4.0	3.8
IO	2.6	4.5	3.2	3.0	3.2	3.1	3.3
EL	1.0	0.8	0.6	0.7	0.6	0.5	0.6
IN	0.7	1.0	1.0	0.9	1.1	0.9	0.9

Distribution. *Cnemaspis biocellata* extends at least 40 km through the isolated karst mountain range of the Banjaran Nakawan from Thale Ban National Park, Satun Province, Thailand (Manthey and Grossmann 1997) southward to Gua Kelam, Tasik Meranti, and finally Kuala Perlis in the state of Perlis, northern Peninsular Malaysia (Fig. 3). Given this species proclivities for existing on a karst substrate it is expected to range more widely in the nearby karst formations in both Malaysia and Thailand.

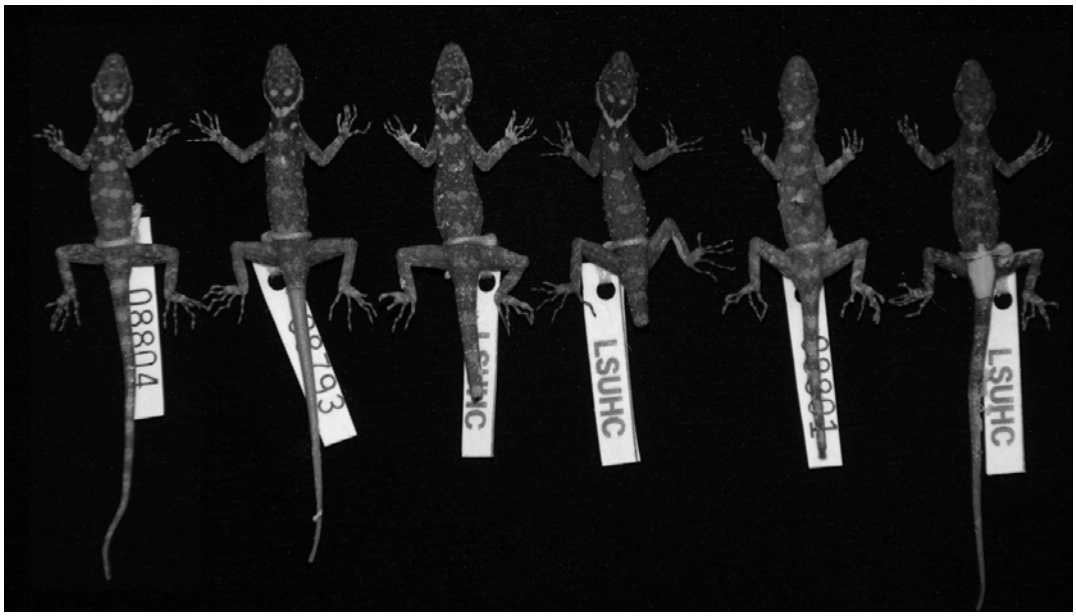

FIGURE 3. Type series of *Cnemaspis biocellata*. Left to right Holotype ZRC 2.6693. Paratypes ZRC 2.6695, 2.6697–98, 2.6696, 2.6694.

FIGURE 4. Karst formations near Tasik Meranti where *Cnemaspis biocellata* were observed.

Natural history. All specimens of *Cnemaspis biocellata* were found on a karst substrate (Fig. 4) or in one case on a tree trunk growing within a karst formation. In Gua Kelam, the habitat was highly disturbed and continually frequented by visitors to the park yet *C. biocellata* were abundant. At Tasik Meranti, lizards were

observed on large rocks in primary lowland dipterocarp forest. In Kuala Perlis, lizards were abundant on karst formations in an area with no immediate native vegetation in the vicinity of a housing community on the edge of a parking lot. These observations suggest the most important environmental parameter for the presence of this species is the karst substrate and the microhabitats it offers, regardless if the forest is disturbed or natural. *Cnemaspis biocellata* were observed abroad during the day on the shaded sides of karst rocks and boulders as well as within crevice microhabitats and beneath small rocks in piles on the ground. During the day, lizards were very wary and difficult to approach and retreated into nearby crevice shelters at our slightest advance. At night, lizards moved out further away from their retreats and were much easier to approach. This small species is amazingly quick and agile and effortlessly moves from one inclined surface to another. Upon capture, large sections of their skin are easily torn off in much the same manner as *Gehyra mutilata*.

Etymology. The specific epithet *biocellata* is derived from the Latin prefix *bi-* meaning "two" and the Latin *ocellus* meaning "a little eye" and refers to the two small occipital eyespots.

Comparisons to other species. *Cnemaspis biocellata* differs from *C. affinis, C. argus, C. aurantiacopes, C. baueri, C. boulengeri, C. caudanivea, C. dringi, C. flavigaster, C. flavolineatus, C. kendallii, C. kumpoli, C. limi, C. nigridia, C. nuicamensis, C. pemanggilensis,* and *C. perhentianensis, C. tucdupensis* in having a maximum SVL of less than 44.0 mm. It differs from *C. dezwaani, C. jacobseni, C. modiglianii, C. phuketensis,* and *C. siamensis* in being larger, having a maximun SVL greater than 39.7 mm. *Cnemaspis biocellata* differs from *C. argus, C. baueri, C. dringi, C. flavigaster, C. limi,* and *C. nigridius* in having less than 11 supralabials. *Cnemaspis biocellata* has less than eight infralabials which differentiates it from *C. affinis, C. argus, C. aurantiacopes, C. baueri, C. caudanivea, C. chantaburiensis, C. dringi, C. flavigaster, C. flavolineatus, C. kendallii, C. kumpoli, C. limi, C. nigridius, C. pemanggilensis, C. siamensis,* and *C. tucdupensis* but resembles all other species of *Cnemaspis* except *C. affinis, C. argus, C. baueri, C. boulengeri, C. dringi, C. nigridius, C. pemanggilensis,* and *C. siamensis* in having keeled scales on the forearm. All species of Southeast Asian *Cnemaspis* lack femoral pores except *C. dezwaani,* and *C. modiglianii.* Preanal pores occur in male *C. affinis, C. argus, C. biocellata, C. flavigaster, C. nuicamensis,* and *C. perhentianensis* but are lacking in male *C. baueri, C. boulengeri, C. jacobseni, C. kendallii, C. limi, C. pemanggilensis, C. phuketensis, C. whittenorum, C. aurantiacopes,* and *C. tucdupensis. Cnemaspis biocellata* is differentiated from *C. affinis, C. caudanivea, C. dringi, C. modiglianii, C. flavolineatus,* and *C. nuicamensis* in having more than six preanal pores. It is differentiated from *C. nigridia* in having less than 16 preanal pores. *Cnemaspis biocellata* is differentiated from *C. boulengeri, C. aurantiacopes,* and *C. tucdupensis* in that the ventralmost row of body tubercles are linearly arranged. All Southeast Asian species of *Cnemaspis* have caudal tubercles and only *C. biocellata, C. boulengeri, C. nuicamensis,* and *C. tucdupensis* lack a lateral row (this condition is unknown for *C. dezwaani, C. jacobseni,* and *C. whittenorum*) and only *C. biocellata, C. boulengeri, C. chanthaburiensis, C. kumpoli, C. modiglianii, C. caudanivea,* and *C. tucdupensis* lack a ventrolateral row (this condition is unknown for *C. dezwaani, C. dringi, C. jacobseni, C. siamensis,* and *C. whittenorum*). Only in *C. boulengeri* and *C. tucdupensis* are the caudal tubercles restricted to a single paravertebral row on either side of the midline. *Cnemaspis biocellata* is like all other Southeast Asia *Cnemaspis* except *C. baueri, C. flavigaster, C. boulengeri, C. chanthaburiensis, C. kumpoli, C. limi, C. nigridius, C. phuketensis, C. whittenorum, C. caudanivea, C. aurantiacopes, C. nuicamensis,* and *C. tucdupensis* in lacking, as opposed to having, keeled subcaudals although it lacks a single, median row of keeled subcaudals unlike *C. dezwaani, C. jacobseni, C. kendallii, C. pemanggilensis, C. phuketensis, C. aurantiacopes, C. nuicamensis,* and *C. tucdupensis* where this row is present (the condition in *C. dringi* is unknown). *Cnemaspis biocellata* is differentiated from all other Southeast Asian species except *C. baueri, C. flavolineata, C. kendallii, C. pemanggilensis,* and *C. phuketensis* in that the caudal tubercles do not encircle the tail. As in *C. boulengeri, C. dezwaani, C. jacobseni, C. kendallii, C. limi, C. modiglianii, C. nigridius, C. pemanggilensis, C. phuketensis, C. siamensis, C. whittenorum, C. aurantiacopes, C. nuicamensis,* and *C. tucdupensis, C. biocellata* has an enlarged, median subcaudal row of scales. *Cnemaspis biocellata* differs from *C. dringi* and *C. whittenorum* in having enlarged

postcloacal tubercles and differs from all other *Cnemaspis* except *C. affinis, C. baueri, C. boulengeri, C. chanthaburiensis, C. dezwaani, C. flavolineata, C. jacobseni, C. kendallii, C. limi, C. modiglianii, C. nigridius, C. pemanggilensis, C. phuketensis, C. caudanivea, C. aurantiacopes,* and *C. nuicamensis* in having less than three postcloacal tubercles. *Cnemaspis biocellata* differs from *C. boulengeri* and *C. caudanivea* in lacking shield-like subtibial scales. *Cnemaspis biocellata* lacks keeled subtibial scales like *C. argus, C. boulengeri, C. chanthaburiensis, C. modiglianii, C. pemanggilensis, C. caudanivea, C. nuicamensis, C. siamensis,* and *C. tucdupensis* which have smooth subtibial scales (the condition in *C. nigridia* and *C. whittenorum* is unknown). *Cnemaspis biocellata* differs from *C. boulengeri, C. dringi, C. caudanivea, C. aurantiacopes,* and *C. tucdupensis* in lacking enlarged submetatarsal scales on the first toe. *Cnemaspis biocellata* differs from all other Southeast Asian *Cnemaspis* except *C. flavigaster, C. flavolineatus, C. kumpoli, C. pemanggilensis, C. caudanivea, C. aurantiacopes, C. nuicamensis,* and *C. tucdupensis* in having more than 27 subdigital lamellae on the fourth toe. *Cnemaspis biocellata* is similar to all other Southeast Asian species of *Cnemaspis* except *C. boulengeri* and *C. baueri* in lacking, as opposed to having, distinct, large, dark, markings on the neck. *Cnemaspis biocellata* differs from *C. affinis, C. baueri, C. boulengeri, C. kendallii, C. limi, C. nigridius, C. phuketensis, C. aurantiacopes,* and *C. nuicamensis* in lacking, as opposed to having, black bands on the tail. *Cnemaspis biocellata* differs from *C. caudanivea* in lacking a white tail tip. These character states are summarized in Table 1.

Aside from the differences in SVL and scalation between *Cnemaspis siamensis* and *C. biocellata* (Table 1), these two species also differ in various aspects of adult male color pattern (Fig. 2). *Cnemaspis biocellata* has a pair of white occipital ocelli, a white to yellow nuchal band, and a black shoulder patch whereas *C. siamensis* lacks these characters but has a series of white vertebral spots and a tripartite, dark, occipital marking which are absent in *C. biocellata*.

Discussion. The need for a phylogeny of Southeast Asian *Cnemaspis* can not be understated. With the presence of at least 16 species of this genus on the Malay Peninsula and its associated islands and a total of at least 23 in Southeast Asia (Grismer *et al*. in prep.), *Cnemaspis* comprises a significant portion of the lizard fauna of the Indo-Malayan Region and until these relationships are resolved, little else can be said about the evolutionary biology of this large, widespread group. An interesting feature occurring in *C. biocellata* and *C. kumpoli* which are sympatric, but not in *C. siamensis* with which the former two species are likely sympatric (Taylor 1963), is the presence of black shoulder patches enclosing a yellow ocelli, a condition further exaggerated in *C. biocellata* on the nape and occiput (Fig. 2). Whether or not this character indicates a close phylogenetic relationship between these species or is the result of independent, parallel evolution stemming from similar selection pressures will have to await the acquisition of a phylogeny (Bauer *et al*. in prep.).

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Appendix

The following list of specimens examined is updated and expanded from that of Grismer and Ngo (2007) from which the data in Table 1 were generated.

Cnemaspis affinis (Stoliczka, 1870): ZSI 5964 (holotype), ZRC 2.1098, Penang (= Pulau Pinang, West Malaysia); ZMA 11987, Pinang, West Malaysia; ZRC 2.4858, Moon Gate, Pulau Pinang, West Malaysia; LSUHC 6695, 6758–59, 6773–74, 6787–88 Pulau Penang, West Malaysia.

Cnemaspis baueri Das and Grismer, 2003: ZRC 2.5291 (holotype), ZRC 2.5292–99, LSUHC 3921–24, 4700–01, 4717–29, 4744, 4808, 7272–74, 7301–03, 7319, Pulau Aur, Johor, West Malaysia.

Cnemaspis biocellata sp. nov**.** ZRC 2.6693–98, Kulau Perlis, Perlis Malaysia; MS 30, Khao Tohphayawang, Muang Satun, Satun Province, Thailand.

Cnemaspis boulengeri Strauch, 1887: CAS 73745, MCZ 39014-23, Pulo Condore (= Con Dao), Vietnam.

Cnemaspis chanthaburiensis Bauer and Das, 1998: FMNH 215979 (holotype) and FMNH 191479 (paratype), Khao Soi Daouw (Dao) Wildlife Sanctuary, Pongnomron (Pong Nam Ron), Chantaburi (Chanthaburi) Province, Thailand (approximately 13° 00’ N, 102° 05’ E)”; BMNH 1917.5.14.4 (paratype), Chantaburi (Chanthaburi Province), Siam (Thailand); FMNH 215978 (paratype), Khao Khiew (Khieo) Wildlife Sanctuary, Chon Buri Province, Thailand (approximately 13° 14’ N, 101° 08’ E); FMNH 215980 (paratype), Amphoe Muang, Suan Kaset, Chantaburi (Chanthaburi) Province, Thailand (approximately 123°6’ N, 102° 09’ E); LSUHC 7882, Phnom Samkos, Pursat Province, Cardamom Mountains, Cambodia (12º08.817’N, 103º08.067’E);

Cnemaspis dezwaani Das, 2005: ZMA 11988.1 (holotype), ZMA 11988.2 (paratype) Lelewoea, Pulau Nias, Indonesia.

Cnemaspis dringi Das and Bauer, 1998: FMNH 148588 (holotype), Labang Camp (03º 20’ N; 113º 29’ E), Bintulu District, Fourth Division, Sarawak, East Malaysia, Borneo; FMNH 221478 (paratype), Sungai Segaham (02º 44’ N; 113º 53’ E), Belaga District, Seventh Division, Sarawak, East Malaysia.

Cnemaspis flavigaster Chan and Grismer, 2008 HC 0082–87 (type series) Forest Research Institute Malaysia, Kepong, Selangor; BM 1898.9.22.216, Batu Caves, Selangor, Peninsular Malaysia.

Cnemaspis flavolineata (Nichols, 1949): LSUHC 8079, Fraser’s Hill, West Malaysia.

Cnemaspis jacobsoni Das, 2005: ZMA 11990 (holotype), ZMA 11989 (paratype), Laboean Badjan, Pulau Simeulue, Indonesia.

Cnemaspis kandiana (Kelaart, 1852): BMNH 60.3.17.1066, 80.2.2.119, 53.4.1.1 (three syntypes), Kandian hills, Ceylon (= hills of Kandy [or Mahanuwara], 07º 15’ N; 80º 40’ E, Central Province, Sri Lanka); MCZ 162896, 162899, Madras; MCZ 4138, 26719, Ceylon (= Sri Lanka); ZSI 5971 (holotype of *Gymnodactylus humei* Theobald, 1876), Kandy (see above); MSNG 8764 (four specimens), Ceylon.

Cnemaspis kendallii (Gray, 1845): BMNH XXII.92a (lectotype, designated by Dring, 1979), Borneo; FMNH 223201, MCZ 157158-59, Bako National Park, Sarawak, East Malaysia (Borneo); FMNH 223201; MCZ 157158-59, Bidi, Sarawak, East Malaysia (Borneo); FMNH 184424, Bukit Lanjan, Selangor, West Malaysia; BMNH 1902.12.12.12, Bidi, Sarawak, East Malaysia (Borneo); Bau, Sarawak, East Malaysia (Borneo); BMNH 1911.1.20.7–9, Bau, Sarawak, East Malaysia (Borneo); BPBM 7494, Alag Sungei Ayer, Pulau Tioman, Pahang, West Malaysia; ZRC 2.1101, Jerantut, Pahang, West Malaysia; ZRC 2.1102, Gunung Rokan, Pulau Tioman, Pahang, West Malaysia; ZRC 2.1103, Sedagong, Pulau Tioman, Pahang, West Malaysia; ZRC 2.3014, Bukit Timah, Singapore; ZRC 2.3015, Gunung Ladang, Melaka, West Malaysia; LSUHC 3773–75, 3797, 3811, 3820, 3841, 3878–88, 4659, 4666, 6213–15, 6218, 6224, Pulau Tioman, Pahang, West Malaysia; LSUHC 3894, 5056–58, Pulau Tulai, Pahang, West Malaysia; LSUHC 4707, 4756–57, 4765–67 Pulau Tinggi, Johor, West Malaysia; LSUHC 4954, 4958 Sungai Lembing, Pahang, West Malaysia; LSUHC 5184–87, 5198, 5211 Pulau Seribuat, Johor, West Malaysia; LSUHC 5244 Pulau Sembilan, Johor, West Malaysia; LSUHC 5523–24, 5731–34 Pulau Babi Besar, Johor, West Malaysia; LSUHC 5532 Pulau Sibu,

Johor, West Malaysia; LSUHC 5703, 5711 Pulau Aceh, Pahang, West Malaysia; LSUHC 5749–52 Pulau Babi Hunjung, Johor, West Malaysia; LSUHC 6380–83 Pulau Ibol, Johor, West Malaysia; LSUHC 6562 Kepong, Selangor, West Malaysia; LSUHC 7691, 8122, 8126, 8191, 8210, Endau-Rompin, Johor, West Malaysia.

Cnemaspis kumpoli Taylor 1963: LSUHC 8846–49, 8990–95 Wang Kelian, Perlis

Cnemaspis nigridia (Smith, 1925): BMNH 1946.8.22.90 (formerly BMNH 1925.9.1.8; holotype), MCZ 39024 and ZRC 2.1114-115, Mt. Gadin (= Gunung Gading, 01º 44' N; 109º 50' E, Sarawak, East Malaysia; Borneo); MCZ 15250, Lundu, Sarawak, East Malaysia; BMNH 1925.9.1.9–10, Mt. Pueh, Sarawak, East Malaysia.

Cnemaspis limi Das and Grismer, 2003: ZRC 2.5289 (holotype), ZRC 2.3504–06, 2.5290 (paratypes), LSUHC 3801–02, 3859, 3902, 3904, 4410, 4425, 4480–83, 4485–88, 4563–64, 4596, 4604, 4616, 4629, 4655, 5053, 5424, 5441, 5510, 5515, 5518, 5521, 6203, 6206–07, 6210, 6212, 6267 Pula Tioman, Pahang, West Malaysia.

Cnemaspis modiglianii Das, 2005: MSNG 31289.8 (holotype), MSNG 31289.3–7, 31289.9, 31289.1–2 (paratypes), Pulau Enggano, Indonesia.

Cnemaspis pemanggilensis Grismer and Das, 2006: ZRC 2.6043 (holotype), ZRC 2.6044–51 (paratypes), LSUHC 4457–58, 4460, 4464, 4470–76, 4495–96, 8011–16, Pulau Pemanggil, Johor, West Malaysia.

Cnemaspis siamensis (Smith, 1925): MCZ 39025, Maprit, Patiyu, peninsular Thailand; MCZ 39694, Klong Bang Lai, peninsular Thailand.

Cnemaspis whittenorum Das, 2005: BMNH 1979.225 (holotype), BMNH 1979.226 (paratype), Pulau Siberut, Mentawai Archipelago, Indonesia.