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A new bent-toed gecko of the genus *Cyrtodactylus* Gray, 1827 (Reptilia, Gekkonidae) from Mount Tompotika, eastern peninsula of Sulawesi, Indonesia

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Abstract

Cyrtodactylus batik is a new species described on the basis of seven specimens collected from Mount Tompotika, in the Balantak Mountains, eastern peninsula of Central Sulawesi, Indonesia. This large *Cyrtodactylus* (up to 115 mm snout–vent length), differs from all other congeners by the combination of striking velvety black dorsal coloration with four irregular dark bands and yellow markings, enlarged tubercles not differently colored from other parts of the dorsum except on the flanks, and the absence of precloacal and femoral pores. The new species, together with *C. wallacei* and *C. jellesmae* appear to form an exclusive lineage in Sulawesi.

Key words: morphology, systematics, new species, evolution, biogeography, Balantak Mountains, Wallacea

Introduction

The genus *Cyrtodactylus*, which comprises more than 130 species, is the fastest growing genus in the family Gekkonidae with more than 80 species being added just during the last two decades (see Uetz & Hallerman 2010 and references therein). In 2010 alone, several new species have been described from all over Southeast Asia (Bauer *et al.*, 2010; Chan & Ahmad 2010; Grismer *et al.* 2010; Lei & Hui 2010; Nasarov *et al.* 2010; Ngo & Chan 2010; Ngo & Grismer 2010; Nguyen *et al.* 2010; Shi & Zhao 2010; Siler *et al.* 2010; Sumontha *et al.* 2010; Welton *et al.* 2010; Ziegler *et al.* 2010).

At present, four described species are known to occur in Sulawesi, *C. fumosus* (Müller, 1895), recorded from Northern Sulawesi, Sangihe Island, and Java; *C. jellesmae* (Boulenger, 1897), a widespread species from all over Sulawesi; *C. spinosus* (Linkem *et al*., 2008) from Central Sulawesi and *C. wallacei* (Hayden *et al*., 2008) also from Central Sulawesi and Kabaena Island. The current low number of species in Sulawesi is certainly an underestimate based on the diversity of this genus elsewhere, as in addition to the discovery of new species, *C. jellesmae* is found to be composed of several sibling species (Linkem *et al*. 2008; this study).

In 2009, we obtained a series of two forms of *Cyrtodactylus* from Mount Tompotika, the highest point in the Balantak Mountains, eastern peninsula of Sulawesi, which consisted of a small and a large species. The small form was compared with a large sample of specimens from the island considered morphologically very similar to the widespread and variable *C. jellesmae* complex. The large form is morphologically similar to *C. wallacei*, but very distinctive in its size, coloration, and other details of squamation. Comparison of this large form with samples from all over the island indicated that it represents an undescribed species and easily distinguished from *C. wallacei*.

Material and methods

We consider as new species, morphologically distinguishable forms, based on the interpretation that morphologically distinct populations are unlikely to be sharing genes with other *Cyrtodactylus* species and are thus independent lineages, conformed with the general lineage species concept of de Queiroz (1998, 1999) or evolutionary species concept (Wiley 1978).

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The following measurements were made to the nearest 0.1 mm using digital calipers following Bauer (2002): snout–vent length measured from the tip of the snout to cloacal opening (SVL), trunk length (TrL, the distance between limb insertions), crus length (CrL, from base of heel to knee), tail length, (TL, from cloaca to tip of tail), tail width (TW, at base of tail), head length (HL, from the retroarticular process of the jaw to tip of snout), head width (HW, measured at widest part of head), head height (HH, from occiput to underside of jaw), ear length (EaL, along longest dimension of ear opening), forearm length (FaL, from base of palm to elbow), orbital diameter (OD, from greatest diameter of orbit), naris to eye distance (NE, from anteriormost part of eye to nares), snout to eye distance (SL, from anteriormost part of eye to tip of snout), eye to ear distance (EaEy, from anterior edge of ear opening to posterior edge of eye), internarial distance (IN, distance between nares), and interorbital distance (IOa, IOp, distance between left and right superciliary scale rows measured at the anterior and posterior end). Examined meristic characters follow Grismer (2005): precloacal pores (PP), enlarged precloacal scales (EPS), infrascales, if present, referring to imperforated scales between precloacal and femoral pores; enlarged femoral scales (EFS), scale counts for postmentals (PM) and degree of medial contact (PMm), supralabials (SuL, to midpoint of orbit), infralabials (InL, including largest discernable scale up to rictus), number of infralabials bordering post mentals (InL~PM) scales bordering nostrils, supranasal (SuN), postnasal (PoN), internasal (InN), longitudinal rows of tubercles on dorsum beginning at right lateral fold and ending at left (DT), paravertebral tubercles between midpoint of forelimb insertion and midpoint of hind limb insertion (PVT), ventral scales between dorsolateral folds (V), and number of subdigital lamellae on fingers and toes, counted to the phalange–metacarpal/metatarsal articulation (FLa and TLa). Scale counts were made using a binocular microscope. Description of the species follows the format of Hayden *et al.* (2008). Field methodology consisted of intensive day and night visual encounter surveys in which reptiles and amphibians were collected by hand or with the aid of a blowpipe. Sampling strategies included long-term, extensive sampling undertaken at a single locality over the course of several days. For each specimen the following ecological data were recorded: forest type (secondary forest, primary forest); vertical height and distance from stream at which the animal was first observed and stream width; as well as the substrate upon which the animal was first observed (tree trunk, leaf litter, branch, rock, etc.). Animals were euthanized via oral application of lidocaine using a cotton bud. Following euthanization, liver tissue was removed for subsequent molecular work and specimens were injected with a 10% formalin and allowed to soak in this solution for several days before being transferred to 70% ethanol for permanent storage. Sex was determined by the presence of hemipenes which were everted while injecting the specimen with formalin or from the presence of eggs in the oviduct. Mass was determined using a digital balance. SVL and TL were measured to the nearest mm prior to fixation (fresh) and also after being preserved. At present the whole series is kept in the Institut Teknologi Bandung (ITB) reference collection, Bandung, Indonesia upon acceptance of the manuscript. The holotype and a part of the paratypes will be housed later in the Museum Zoologicum Bogoriense (MZB), Indonesian Institute of Sciences, Cibinong, Bogor, Indonesia.

Species account

Cyrtodactylus batik sp. nov.

(cicak batik; batik bent-toed gecko)
(Figs. 1A, B; 2; 3A; 4A)

Holotype. ITB.DTI 2805, an adult female with original tail from Longkoga Stream, Bualemo, Mount Tompotika, Balantak Mountains (between 00°40'05.1"–00°40'12.7"S; 123°06'41.7"–123°06'39.2"E; alt: 951–1002 m asl), Desa Trans Tanah Merah, Kecamatan Bualemo, Kabupaten Banggai, Propinsi Sulawesi Tengah, Sulawesi Island, Indonesia collected by A. Rachmansah and Umilaela on 20 May 2009.

Paratypes. DTI 2784, DTI 2801, DTI 2804, DTI 2785, DTI 2803, DTI 2802, same data as for the holotype, collected 19–20 May 2009.

Diagnosis. A large form of *Cyrtodactylus* with SVL reaching 115 mm in adult females, males slightly smaller, up to 110 mm, tail 108–120% of SVL; body robust, limbs medium length; digits long; single pair of postmentals in contact posteriorly, isolating triangular mental from chin shields; dorsum with 23–26 transverse rows of slightly keeled trihedral tubercles, slightly larger than adjacent dorsal scales giving a generally smooth appearance; 48–57 smooth, round, juxtaposed ventral scales between distinct ventrolateral folds; no precloacal groove, no precloacal

or femoral pores, no enlarged femoral scales; distinctly enlarged precloacal scale patch; 7–10 transversely expanded lamellae proximal to basal inflection of 4th toe, 10–16 narrow lamellae distal to inflection. Underside of the hemipenal bulge of tail base bearing approximately 30 rows of small postcloacal scales, followed by approximately five rows of slightly enlarged, rectangular subcaudals followed by transversely expanded subcaudals.

FIGURE 1. A. *Cyrtodactylus batik* (DTI 2805, holotype) climbing on a liana trunk, photographed at night. B. A paratype of *Cyrtodactylus batik* (DTI 2804) with regenerating tail, photographed at daylight showing the greenish pupil. Photos by Umilaela.

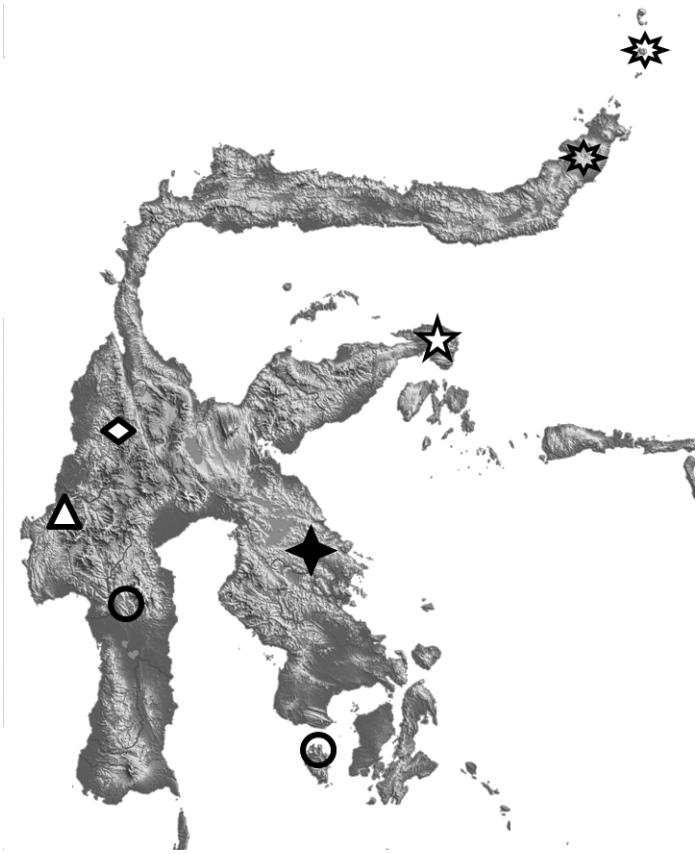

FIGURE 2. Distribution pattern of Sulawesian *Cyrtodactylus* with restricted range. Star, *C. batik*: circle, *C. wallacei*; diamond, *C. spinosus*; four sided star, *C.* cf. *jellesmae* (large); triangle, *Cyrtodactylus* sp.; spinous circle, *C. fumosus*; distribution of the widespread species, *C. jellesmae* complex is not shown. Map modified from Wikipedia.

Etymology. The specific epithet is used as a noun in apposition, originating from the specific Indonesian pattern of traditional "batik" cloth that is especially well known on Java. The dorsal pattern of the new species is similar to that of traditional batik cloth.

Holotype description. An adult female, SVL 103.2 mm (104.8 mm measured prior to fixation after being euthanized), TL 115.1 mm (fresh 118.2 mm, TL/SVL ratio 1.08–1.20). Head moderately long (HL/SVL ratio 0.29), wide (HW/HL ratio 0.60), moderately depressed (HH/HL ratio 0.34), distinct from neck. A raised, rounded supraorbital ridge continuous with canthus rostralis. Distinct frontoparietal depressions posterior to each supraorbital prominence. Lores weakly convex anteriorly, mildly depressed posteriorly; separated from anterior palpebrals and orbits by deep lacrimal grooves. Dorsal surface of snout anteriorly swollen above nostrils. Lacrimal groove met orthogonally by midpalpebral depression continuing around orbit. Small, raised extension of skin comprised of superciliaries and distalmost rows of palpebrals extending to the circumference of the orbit. Supraorbital scales uniform, lacking small tubercles. Superciliaries large, composed of two rows of overlapping scales. These scales are relative long, uniform, height ranged from 0.9 mm at the sides to 1.2 mm above the center of eye; forming a crenulated, erect rim around eye, rounded and smooth, without distinct keel, 16–21 rows of interorbital tubercles across narrowest point of frontal bone. Snout relatively short (SL/HL ratio 0.40); longer than eye diameter (OD/SL ratio 0.59). Scales of snout round, granular, uniform in size, rostrum scales smooth, without tubercles; tiny tubercles present on medial palpebral and interorbital regions. Head tubercles pointed, symmetrical, larger posteriorly, attaining maximum size at occiput. Scales of rostrum granular, regular in size (as in snout region). Eyes moderate (OD/HL ratio 0.23). Auricular openings erect, egg shaped, narrower dorsally and rounded ventrally; openings large (EaL/HL ratio 0.14); eye to ear distance slightly greater than diameter of eye (EaEy/OD ratio 1.1). Rostral 50% deeper (2.1 mm) than wide (4.2 mm) at narrowest point, 69 % as deep (2.9 mm) as wide (4.6 mm) at longest point; incompletely divided by dorsal Y– shaped rostral groove; two supranasals, anteriormost pair separated by pair of median postinternasals and two internasal scales; rostral in contact with first supralabial, anteriormost supranasal,

median postinternasal and internasal. Nares oval, oriented laterally, in contact with two supranasals, first supralabial; 3/3 postnasals, about the same size of head or body granular scales; Mental triangular in shape, nearly twice as wide as deep; single pair of postmentals contacting posteriorly about half their length. Postmentals bordered laterally by first infralabials, the anterior tips extend to the suture between mental and first sublabials; posteriorly by two slightly enlarged chin shields (adjacent to second infralabial), 2 intermediate sized and seven small irregularly shaped, granular gular scales. Throat covered with uniform granular scales. Nine supralabials to midpoint of orbit (13 to angle of jaw). Eight infralabials to midpoint of orbit (12 on the left and 11 on the right to angle of jaw). Body slender (TrL/SVL ratio 0.49); indistinct ventrolateral folds with about a dozen rounded, white tubercles. Dorsum between forelimb insertion and caudal region characterized by small granular scales interspersed with irregularly spaced, keeled unicarinate tubercles. Anterior side of tubercles rounded, rising gradually, defined by a single pronounced median, rounded keel; posterior sides convex, steeply sloping. From forelimb insertion to frontal region, tubercles progressively decrease in size, becoming round, non-keeled on head. A total of 36 paravertebral tubercles between forelimb and hind limb insertions are present. Ventral scales smooth, juxtaposed, regular in size; ventrals larger in diameter than both dorsal granular scales and some dorsal tubercles; gulars small, granular, uniform; 49 scales between dorsolateral folds across midsection of body. No precloacal pores or precloacal groove. No femoral pores or enlarged femoral scales, but enlarged precloacal scales present. Scales adjacent the precloacal area and on the lower parts of the femur become abruptly smaller compared to those at the precloacal region. Limbs medium in length, moderately robust; forearms shorter than hind limbs; forearm short (FaL/SVL ratio 0.17); tibia short (CrL/SVL ratio 0.18); suprabrachials and prebrachials larger than scales of adjacent dorsum, granular, tuberculate, much smaller in postbrachial region proximal to elbow; infrabrachials small, granular, about equal to gulars; postantebrachials granular at elbow; numerous tuberculation present on tibial surfaces, except infratibial surfaces; supraantetibials regular, granular proximally, becoming large, continuous, unchanged in size with supracarpals and supradigital lamellae; infraantebrachial squamation similar to supraantebrachials, though tubercles not present; suprafemorals and prefemorals similar to supratibials, scales regular, smooth, tubercles numerous, well differentiated compared to neighboring granules; infrafemorals small, similar to granules on adjacent body; no enlarged infrafemoral or postfemoral scale series, squamation similar to adjacent interfemorals; ventrals, supratibials and pretibials small, granular, as in ventral femoral regions; unlike supracarpal squamation, supratarsals consistently small, granular, met abruptly by enlarged supradigital lamellae; infratarsals similar in size proximally, but becoming enlarged, subimbricate distally. Digits long, strongly inflected at basal interphalangeal joints. Claws large (maximum length of 1.9 mm), surrounded by elongate, deeply notched distal-most subdigital lamella, one enlarged supradigital scale, and a smaller (about half size) lateral scale. Subdigital lamellae elongate, narrow distal to first interphalangeal joint. Subdigital lamellae proximal to first interphalangeal joint wider than long, swollen, padlike, especially at interphalangeal joint. Counts of subdigital lamellae on manus I: 15/15; II: 18/19; III: 20/20; IV: 21/22; V: 19/19, on pes I: 15/14; II: 19/19; III: 23/23; IV: 24/26; V: 23/24; webbing absent. Relative lengths of digits on manus: IV > III > II > I > V, on pes: IV > V > III > II > I. Tail relatively long, (TL/SVL ratio 1.11); portion of tail subrectangular at base with regularly–spaced strongly trihedral, keeled tubercles more sparsely distributed than tubercles of dorsum; three prominent, enlarged post–cloacal spurs on each side of vent; subcaudals arranged in several rows of small, narrow rectangular scales followed by enlarged median subcaudal plates variable in size, largest 3.9 mm wide, 1.2 mm long; most approximately half this size.

Holotype coloration. Overall dorsal appearance uniform velvety black, tubercles have the same color as background hence not visible on photographs except on the flanks. Four pairs of overlapping "><" shaped irregular yellow transverse bands between nape and base of tail and 10 similar marks on the tail, the first three "><" shaped marks on the tail are more or less similar to the dorsal pattern, the remainder less distinct in form with yellow spots and crosses. The areas within the overlapping "><" shaped marks are lighter compared to the dorsum. A yellow line borders the posterior margin of the head. Limbs with irregular yellow bands or spots at various angles; distinct yellow bars at the finger-carpal joint; head coloration slightly lighter than dorsum, faintly marbled with yellow spots which are variable in size, a yellow line running along superciliaries to occiput enclosing parietal region of head and posterior part of canthus rostralis; upper labials scales generally lighter with some yellow spots along the upper border; rostral as dark as body coloration; nape dark; eyes essentially black, iris greenish metallic during daylight (see Fig 1B); lateral surfaces similar to dorsum but with yellow tubercles, sparsely arranged on the flanks, strongly contrasted with velvety black base color; venter and undersides of limbs uniformly blackish, ventral scales with numerous fine purple flecks covering otherwise pale scales.

TABLE 1. Morphometric characters of the type series of *Cyrtodactylus batik*.

Specimen Number	DTI 2804	DTI 2805 holotype	DTI 2784	DTI 2803	DTI 2801	DTI 2785	DTI 2802
Collecting date	20-v-09	20-v-09	19-v-09	20-v-09	20-v-09	19-v-09	20-v-09
Sex	female	female	male	female	juvenile female	juvenile female	juvenile female
Weight (gm, fresh)	28	20	23	22	3.4	5.4	2.6
SVL	112.8	103.2	108.6	108.1	57.85	67.1	53.2
SVL (fresh)	114.6	104.8	109.7	111.1	61.4	69.8	56.1
TrL	55.3	50.5	52.1	50.1	28.1	30.9	20.9
CrL	21.3	18.9	20.7	20.9	10.1	11.6	9.2
TL (reg)	(104.6)	115.1	(112.8)	(65.5)	64.5	80.7	57.2
TL fresh	(101.5)	118.2	(115.7)	(68.7)	65.8	81.9	57.2
TW	9.2	7.6	9.2	9.0	4.3	5.1	3.4
HL	32.5	29.9	31.2	32.5	18.8	21.6	17.0
HW	20.8	17.85	20.2	19.65	10.4	12.05	10
HH	10.9	10.3	10.4	10.2	5.1	6.0	4.65
EaL	4.3	4.2	3.7	4.5	2.3	2.9	2.1
FaL	18.9	17.1	18.1	18.6	9.0	10.7	8.8
OD	7.5	7	7.6	7.3	4.5	5.4	4.3
NE	10.1	9.5	10.7	10.3	5.5	6.8	5.3
SL	12.9	11.9	13.5	12.9	7.0	8.3	6.1
EaEy	9.6	7.5	8.4	8.8	5	5.5	4.6
IN	3.5	3.0	3.1	3.0	2.1	2.5	1.9
IOa	12.2	10.2	11.1	10.9	6.7	6.7	6.4
IOp	8.5	8.2	8.5	7.9	5.5	5.4	4.6
PP	absent	absent	absent	absent	absent	absent	absent
EPS	present	present	present	present	present	present	present
EFS	absent	absent	absent	absent	absent	absent	absent
V	57	49	54	52	49	56	48
SuL	12/14	13/13	15/14	14/13	13/14	15/14	12/12
SuL to Orbit	9/9	10/9	10/9	10/9	10/10	10/10	9/9
InL	11/11	12/11	11/11	11/10	12/10	13/11	13/12
InN	3	2	2	3	2	3	3
a scale at mid rostral	yes	yes	yes	yes	yes	yes	yes
Rostral groove	Y	Y	Y	inverted Y and Y	Y	Y	Y
HL/SVL	0.29	0.29	0.29	0.30	0.32	0.32	0,32
HW/HL	0.64	0.60	0.65	0.60	0.55	0.56	0.59
HH/HL	0.34	0.34	0.33	0.31	0.27	0.28	0.27
TL/SVL	(0.93)	1.11	(1.04)	(0.61)	1.11	1.20	1.08
TL/SVL (fresh)	(0.89)	1.13	(1.05)	(0.62)	1.07	1.17	1.17
TrL/SVL	0.49	0.49	0.48	0.46	0.49	0.46	0.39
CrL/SVL	0.19	0.18	0.19	0.19	0.17	0.17	0.17

Variation in the paratypes. The head varies slightly in length (HL/SVL ratio 0.29–0.32), width (HW/HL ratio 0.59–0.65), and moderately depressed (HH/HL ratio 0.27–0.34); interorbital tubercles across narrowest point of frontal bone varies between16–21 rows. Snout relatively short (SL/HL ratio 0.39–0.43); longer than eye diameter (OD/SL ratio 0.56–0.58). Eyes moderate (OD/HL ratio 0.22–0.25). Auricular openings is large (EaL/HL ratio 0.12–0.14); eye to ear distance slightly greater than diameter of eye (EaEy /OD ratio 1.1–1.3). Rostral varies from 43–53% deeper (1.8–2.1 mm) than wide (4.2–4.6 mm) at narrowest point, 67–88 % as deep (2.9–3.7 mm) as wide (4.6–5.6 mm) at longest point. Anteriormost pair of SuN separated by a pair of median post InNs and two to three InNs. PM bordered laterally by first and/or second InLs, the anterior tips extend to the suture between mental and first InLs; posteriorly by two slightly enlarged chin shields (adjacent to second InL) and two to eight intermediate sized and up to seven small irregularly shaped, granular gular scales. Supralabials varies from nine or ten to mid-point of orbit (13–15 to angle of jaw). Body slender (TrL/SVL ratio 0.39–0.49). A total of 33–40 PVTs between forelimb and hind limb insertions are present. Ventrals ranges from 48–57 scales between dorsolateral folds across midsection of body. The limbs are medium in length, forearm short (FaL/SVL ratio 0.15–0.17); tibia short (CrL/SVL ratio 0.17–0.19); Variations of subdigital lamellae on manus I: 13–16; II: 18–20; III: 20–23; IV: 21–23; V: 18-22, on pes I: 14–16; II: 19–21; III: 23–25; IV: 24– 27; V: 20–24; webbing absent. Tail relatively long, (tail length/SVL ratio 1.08–1.20). For other detailed measurements and detailed count of the whole type series see Table 1.

Regenerated tail completely round; caudals of re–grown tail extremely reduced, tubercles absent; subcaudals of regenerated part of tail in proportion to original subcaudals, but reduced in size and shorter. Scales of regrown tail similar in shape, lightly colored, mottled, lacking tubercles and the "><" shaped marks (see Fig 1B).

Secondary sex characteristics. From specimens on hand, the male attains a size nearly as large as females, and can be distinguished by the presence of bulging hemipenes at the base of the tail, whereas females have a slender tail base. Both sexes lack precloacal and femoral pores, and hence these are not useful for determining sex of this species.

Ecological notes. All specimens were found on vegetation in undisturbed primary forest, from 1.5 to 3 meters above ground and more than 50 meters from the closest stream (Longkoga) in primary forest. The trees format the collecting sites were lianas and small trees with trunks less than 40 cm in diameter. The smaller species, *C. jellesmae* was not found in the same site, but at other camp sites it occurred approximately 1–2 meters above the ground on tree trunks and smaller vegetation.

Comparison between species. *Cyrtodactylus batik* and *C. wallacei* have a similar coloration pattern (Fig 2A, B), but the basic coloration of *C. batik* is black with yellow (cream) transverse stripes, sharply demarcated with tubercles having the same coloration as the background except on the flanks. In *C. wallacei*, the dorsal ground coloration is reddish brown with weakly defined lighter stripes made up by light colored tubercles on the dark background. The scales and tubercles of *C. batik* are smaller compared to those of *C. wallacei*. Consequently, every detail in number of scales, head scales, tubercles as well as number of lamellae under finger and toes are higher in *C. batik*, except for the number of first and second toe lamellae, which are higher in *C. wallacei* (see Table 2). Despite similarity in size, the banding pattern, velvety black dorsum, differences in number of tubercles, and number of ventral scales distinguish it from the very similar and geographically close *C. wallacei*. The smaller size and light brown dorsal coloration with sharply defined blotching pattern distinguish *C. jellesmae* from *C. batik*. These three Sulawesi species are similar in lacking precloacal and femoral pores. Based on examination of gravid females, *C. jellesmae* is a species complex with at least two different body size groups (Table 2). The smaller form is widely distributed, has fragmented subcaudals and shares the presence of tubercles along the ventrolateral fold with *C. spinosus* and *C. batik*. The larger form is restricted to southeast Sulawesi and is characterized by the absence of enlarged tubercles along the ventrolateral fold, but has broad transverse subcaudals as in *C. batik*. Otherwise both forms currently identified as *C. jellesmae* have similar dorsal coloration (aside for other small forms with different dorsal blotching pattern and not included in the analysis).

Cyrtodactylus batik is distinguishable from all but eight congeneric species by the absence of a precloacal groove, and precloacal and femoral pores. The first two (three if the large form identified as *C. jellesmae* is counted as a separate species) occur in Sulawesi and have been discussed previously. The six remaining congeners may be distinguished from *C. batik* by the following characteristics: tiny dorsal conical tubercles, a black dorsal coloration and large size (maximum SVL 113 mm) distinguish *C. batik* from *C. laevigatus* (Darevsky, 1964; presence of an enlarged femoral scale row forming a distinct boundary and separating smaller posterior femorals distinguish *C. paradoxus* (Darevsky & Szczerbak, 1997); presence of enlarged femoral scales, smaller SVL and dark bands or

blotches contrasting with a light gray background distinguish *C. semenanjungensis* (Grismer & Leong, 2005); presence of a quadrangular rostral bordered by fewer scales and with a single median cleft, smaller size, and heavy yellow spotting on arms, dorsum and, most distinctively, along ventrolateral folds and labial regions distinguish *C. sermowaiensis* (de Rooij, 1915); presence of an extremely enlarged femoral and precloacal scale series, slightly smaller size and distinct reddish-orange and black bandings distinguish *C. thirakhupti* (Pauwels et al.). *Cyrtodactylus malayanus* (de Rooij, 1915) and *C. consobrinus* (Peters, 1871) are two species from Borneo, about equal in size, that differ dramatically from the Sulawesi forms by their banded color pattern and in having enlarged femoral scales. Precloacal and femoral pores may be present in some individuals, but these, in combination with different dorsal coloration, set them apart from all Sulawesi forms. *Cyrtodactylus spinosus* and *Cyrtodactylus* sp. from Sulawesi Barat (see Appendix 1) both have precloacal pores, while *C. fumosus* has both precloacal and femoral pores in a continuous series. The lack of spines along the ventrolateral flanks and head, as well as size and blotching pattern distinguish *C. batik* from *C. spinosus*.

TABLE 2. Comparison of selected mensural and meristic characters among the four most distinctive *Cyrtodactylus* of Sulawesi. *) Data on *C. wallacei* and *C. spinosus* were extracted from the original description. n.a = data not available.

SPECIES	*Cyrtodactylus batik*	*Cyrtodactylus wallacei*	*Cyrtodactylus spinosus*	*Cyrtodactylus jellesmae*	*Cyrtodactylus* cf. *jellesmae* (large)
	n=7	*)	*)	n=28	n=13
SVL	104.8–114.6	92.0–113.6	70.0–83.2	57.6–70.0	73.1–92.6
HL/SVL	0.30 ± 0.02	0.28	0.30 ± 0.01	0.29 ± 0.01	0.28 ± 0.01
HW/SVL	0.18 ± 0.04	0.21	0.20 ± 0.01	0.19 ± 0.01	0.19 ± 0.01
HH/HL	0.31 ± 0.03	0.42	0.40 ± 0.02	0.37 ± 0.02	0.37 ± 0.02
SuL	12-15	10	8–11	10–14	9–11
InL	11-13	9–11	7–11	9–11	9–11
SuN	2/2	1	1	1–2	1 ± 0
PoN	3–4	3	3	3–4	3.2 ± 0.6
InN	2–3	3	2	1–3	2.4 ± 1.0
V	48–57	46–48	38–44	41–46	32–55
subcaudal	wide	wide	wide	fragmented	wide
Ventrolateral fold	with tubercles	with tubercles	spinose scales	with tubercles	smooth
DT	23–26	n.a.	25–30	20–23	18–25
PvT	33–40	29–31	n.a.	50–61	40–53
FLa1	13–16	12	15	9–13	11–14
FLa2	18–20	17	20	13–16	14–16
FLa3	20–23	19	23	16–18	15–21
FLa4	21–23	18	21	15–19	14–20
FLa5	18–22	n.a.	19	13–17	14–18
TLa1	14–16	20	n.a.	11–15	11–15
TLa2	19–22	23	n.a.	15–17	15–19
TLa3	23–25	21	n.a.	15–22	17–22
TLa4	24–27	24–25	19–21	19–22	21–24
TLa5	20–25	13	n.a.	17-22	17–24

In the Lesser Sunda Islands three other species have been described: *C. darmandvillei* (Weber, 1890), *C. gordongekkoi* (Das, 1993) and *C. wetariensis* (Dunn, 1927). Each has precloacal and femoral pores, hence they are easily distinguished from *C. batik*. From Maluku, three species have been recognized, *C. halmahericus* (Mertens, 1929) from Halmahera and Seram; *C. deveti* (Brongersma, 1948) from Morotai Island and *C. nuaulu* (Oliver *et al*.,

2009) from Seram Island. As all three species have precloacal and femoral pores, they are easily distinguished from *C. batik*. Regarding coloration differences, *C. deveti* has bold bars on the dorsum and *C. nuaulu* is ornamented with elongated bands along paravertebral area, hence these are easily distinguishable from *C. batik*. *Cyrtodactylus halmahericus* has a number of poorly defined bands and hence is also easily distinguishable from *C. batik.*

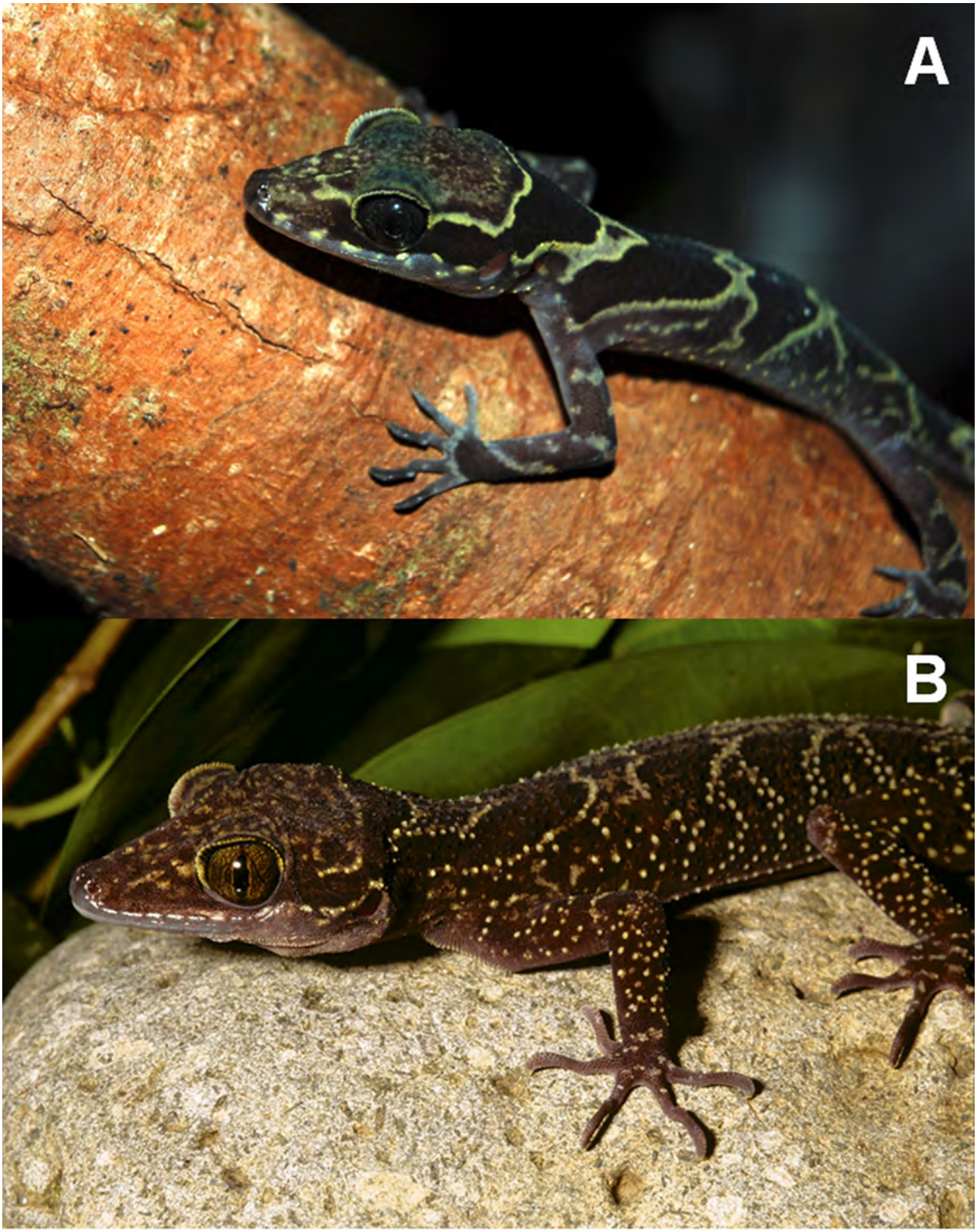

FIGURE 3. Comparison of anterior part between *Cyrtodactylus batik* (A) and *C. wallacei* (B) to show the distinctive tubercle coloration and dorsal bands. Photos by Umilaela (A) and R. M. Brown (B).

It is interesting that among the eight poreless species mentioned above, four occur in the Wallacean region, three are present in Southeast Asia and one in New Guinea. The absence of precloacal pores, femoral pores and an enlarged femoral scale series in *C. batik, C. wallacei, C. jellesmae* complex, *C. laevigatus* and *C. sermowaiensis* suggests these species may be closely related. Three species are Sulawesi endemics. In contrast, *C. laevigatus* is endemic to Lesser Sunda Islands while *C. sermowaiensis* is restricted to the north coast of New Guinea. Nothing is known about the evolutionary process towards pore loss or other frequently-used diagnostic morphological characters in *Cyrtodactylus*. Change in body size and the wide transverse subcaudal scales are plausible paths of evolutionary change. Several other species without precloacal and femoral pores have been found in Sumatra, but these forms comprise individuals with completely different coloration (Iskandar *et al*., in prep.). We suspect that the Sulawesi species can be distinguished in a phylogenetic framework, as half of the Sulawesi species lack pores at the precloacal and femoral region. We have no basis to suggest that the Papuan *C. sermowaiensis* and *C. laevigatus* from the Lesser Sunda islands represent a single phylogenetic entity together with those from Sulawesi as both have a completely different coloration compared to the Sulawesi species and are of the same general small size and coloration as the Sunda shelf forms. We therefore hypothesize that *Cyrtodactylus batik, C. wallacei* and *C. jellesmae* complex form a monophyletic group marked by evolutionary shifts in body size and modification of subcaudal scales. Although *C. jellesmae* has distinct body coloration; its coloration pattern reflects the same basic structure as those of *C. wallacei* and *C. batik*. The light dorsal patterns are much wider and with poorly defined margins in *C. jellesmae* as compared to *C. batik*, in which they are very narrow and straightly demarcated (Fig. 4). The body coloration pattern of *C. wallacei* can be considered the most extreme case. It is very similar to that of *C. batik*, but the light parts are chiefly confined around enlarged dorsal tubercles (Fig, 3).

FIGURE 4. Side by side comparison between *Cyrtodactylus batik* (A) and *C. jellesmae* (B) of the same size to show the same basic colouration pattern Photo by D. T. Iskandar.

Remarks. Sulawesi has been isolated for at least 25 million yr and has also undergone a complex suite of geological processes which occurred throughout the Tertiary (Hall 1996, 1998, 2001). Paleogeographic studies indicate that Sulawesi's current topography is the result of a complex suite of geological processes that resulted in at least seven oceanic islands that were initially isolated but later joined together as a single more or less continuous tract of land (Moss & Wilson 1998; Hall 2002, 2008). The herpetofauna of Sulawesi is depauperate in terms of number genera and highly endemic in species compared to the adjacent regions of Sundaland (Whitten & Whitten 1992; Whitten *et al.* 2000; How & Kitchener 1997; Iskandar & Tjan 1996; Iskandar & Colijn 2000, 2001; Inger &

Voris 2001; McGuire *et al.* 2007). Similar levels of faunal impoverishment and high species endemism are documented for mammals (Musser 1987; Shekelle *et al.* 2008) and invertebrates (Gressit 1961; Vane-Wright 1991; Whitten *et al*. 1987), indicating the pattern observed in reptiles and amphibians is likely real and not merely an artifact of the limited attention biologists have paid to Sulawesi's herpetofauna in comparison to other regions in Southeast Asia. Wallacean and Australian *Cyrtodactylus* are likely of western origin as the bulk of the species diversity in the genus is Sundaic, with more than 90% of described species occuring west of Wallace's line. While hypotheses regarding the interspecific relationships of Sulawesi *Cyrtodactylus* are currently under study, the discovery of *C. batik* is biogeographically significant as it is the second large *Cyrtodactylus* to be found on Sulawesi after *C. wallacei.* The present study reveals that the large *C. jellesmae* could well be a new form distinguished by its size and by differences in the nature of subcaudal scales and other characters (Table 2). Judging from the general distribution pattern of most vertebrates and the high external similarities between *C. batik* and *C. wallacei*, we suspect that the Kabaena population might well represent a distinct form as it does not match the microcontinental geological history of Sulawesi (Hayden *et al*. 2008; Evans *et al*. 2003a, b; McGuire *et al*. 2007). Disjunct distribution is also known in *Eutropis grandis* (Howard *et al*., 2007). Being practically isolated, Mount Tompotika is also the type locality of several endemic species such as *Luperosaurus iskandari* (Brown *et al*., 2000), an undescribed *Occidozyga* as well as an *Oreophryne* (Iskandar *et al*., in press.). In the neighboring area, several *Calamaria* have been described (Inger & Marx, 1965; Koch *et al*., 2009). The finding of this new species is thus expected and provides further evidence of the high conservation significance of the Balantak Mountains.

Key to species of *Cyrtodactylus* of Sulawesi

This key is mainly based on morphological characteristics of adult males.

1a. Precloacal groove and pores present in males 2
1b. Precloacal groove absent in males and females 4
2a. A medium sized species, 42–56 precloacal-femoral pores, sometimes a number of infrascales present in males (North Sulawesi) . . . . . *C. fumosus*
2b. Medium to large species, femoral pores lacking, males with precloacal pores 3
3a. Precloacal pores 12–14 in males, spines along ventrolateral body fold and ventrolateral margin of tail (Lore Lindu, Central Sulawesi) . . . . . *C. spinosus*
3b. Precloacal pores 9–12 in males, no spines along ventrolateral body fold and ventrolateral margin of tail (West Sulawesi) . . . . . *Cyrtodactylus* sp.
4a. No precloacal or femoral pores; SVL less than 93 mm 5
4b. No precloacal or femoral pores; SVL greater than 92 mm 6
5a. SVL 73–93 mm, subcaudals composed of transverse widened scales (Southeast Sulawesi) . . . . . *C. jellesmae* large
5b. SVL 58–70 mm, subcaudals scales fragmented (widespread allover Sulawesi) . . . . . *C. jellesmae* small
6a. Dorsum brownish purple with distinct light colored tubercles and four overlapping "><" shaped marks composed of light colored tubercles (West Sulawesi and Kabaena) . . . . . *C. wallacei*
6b. Dorsum velvety black with four overlapping "><" shaped marks of yellow stripes (Eastern Peninsula of Sulawesi) . . . *C. batik*

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APPENDIX 1. Material examined.

Museum abbreviations follow Leviton *et al.* (1985) and are as follows: BPBM, Bernice P. Bishop Museum, Hawaii; FMNH, The Field Museum of Natural History, Chicago, Illinois; LSUMZ, Louisiana State University, Museum of Natural Science, Baton Rouge; MVZ, Museum of Vertebrate Zoology, University of California, Berkeley; MZB, Museum Zoologicum Bogoriense, Bogor, Indonesia; Field Numbers: B, BAB, BS, BSI, CUS, CYR, DG, DTI, GAG, JAM, MK, RMBR and S refer to recently collected specimens from many collectors and organizations and have not yet been formally catalogued. At present, these specimens are deposited in the ITB reference collection.

Cyrtodactylus cf. *agamensis*: RMBR 321–2, 324–5, 342–4 from Bukit Kaba, Bengkulu; RMBR 142, 282, 521 from Air Putih, Bengkulu; JAM 11172–11174 from Banyak Island, Sumatra Utara; MK 281 from Air Purin, 1º49'20"S; 104º05'28"E), Desa Batu Batumbuk, Kecamatan Gunung Talang, Kabupaten Solok, Sumatra Barat; MK 312, 314, 316 from Air Sira (1º49'20"S; 104º05'28"E), RMBR 142, 228, 282 from Air Tik Tua, Air Putih, Lebong, Bengkulu, Sumatra; RMBR 529, from Batu laying, Bengkulu; Cyrt 033, 040 from Anai Nature Reserve, Padang Panjang, Sumatra Barat; B60 from Tanah Masa Island, Sumatra Barat; JAM 09099, JAM 09380, JAM 09383–5, 09396, JAM 09408–9, JAM 09492, JAM 09495 from Mt. Marapi, Sumatra Barat; JAM 09547, JAM 09583 from Mt. Singgalang, Sumatra Barat; DG 141–5 from Baba cave, Indarung, Padang, Sumatra Barat; DG 035–051 from Tanjung Lolo, Sijunjung, Sumatra Barat; DG 152–9 from Ngalau Seribu, Harau Valley, Payakumbuh, Sumatra Barat.

Cyrtodactylus baluensis: FMNH 230179–81 from Borneo.

Cyrtodactylus cavernicolus: FMNH 109956–7, 119902, 119904, 119915, 128392 (holotype and paratypes) from Borneo.

Cyrtodactylus consobrinus: MZB 4355 from Borneo; MZB 4356 from Bukit Lawang, Bohorok, Sumatra Utara; DG 154–5 from Tanjung Lolo, Sawahlunto Sijunjung, Sumatra Barat; JAM. 9442, 9635–6, 9873–4, from Rimbo Panti, Sumatra Barat; BPBM 8128, FMNH 239544, 239550, 239552–3, 239564, 239647, 239652 from Borneo.

Cyrtodactylus darmandvillei: MZB 1401, 2005 from Komodo; MZB 2140–2, 5297, FMNH 154845 from Flores.

Cyrtodactylus gordongekkoi: LSUMZ 81732 (JAM 3176); MZB 3490–2 from Lombok.

Cyrtodactylus ingeri: FMNH 248968; 248972 from Borneo.

Cyrtodactylus cf. jellesmae (large): JAM 7423, 7427, 7429, 7431–2, 7434–7438, 7468, 7471–2, 7476–7478, 7482, 7914–5 from the surrounding east of Matanno-Towuti Lake areas, Sulawesi Tenggara.

Cyrtodactylus jellesmae complex (small): JAM 155, 179 from Mt. Klabat, Sulawesi Utara; JAM 193–5 from Kali Village, Minahasa, Sulawesi Utara; JAM 313–6; 318–20; 322–6; 330–6 from Tangkoko-Batuangus National Park, Sulawesi Utara; JAM 636–7 from Bogani Nani Wartabone National Park, Sulawesi Utara-Gorontalo; JAM 5628, 5631 from Anabanua, Sulawesi Selatan; JAM 5643 from Harapan, Sulawesi Selatan; JAM 5670–1, 5677–8 from Takalasi, Sulawesi Selatan; JAM 5680–8, 5704 from Maroangin, Sulawesi Selatan; JAM 5705, 5747, 5749, 5768–73 from Enrekang, Sulawesi Selatan; JAM 5783, 5784 from Tapung, Sulawesi Selatan; JAM 5850–52 from Pecinong, Sulawesi Selatan; JAM 5892–900 from Mariorilau, Sulawesi Selatan; JAM 6338–47 from Kabiraan, Sulawesi Barat; LSUMZ 8400–1, 8403 from Kabupaten Donggala, Sulawesi Tengah; LSUMZ 8402 from Kabupaten Poso, Sulawesi Tengah: LSUMZ 8404–6 from Kabupaten Luwuk, Sulawesi Tengah; DTI 2717–9, 2738, 2774, 2800, 2802, 2808–9, 2826–7, 2836, 2852, 2887 from Gunung Tompotika, Sulawesi Tengah; JAM 8289, 8291, 8818, 8894 from Matanno-Towuti Area, Sulawesi Tenggara.

Cyrtodactylus laevigatus: MZB 979 (paratype) 1 ex., from Komodo Island.

Cyrtodactylus lateralis: MZB. 1498, 1979, 5353 from Ketambe, Leuser National Park, ITB S 396, 402 from Sauraya, Nanggroe Aceh Darussalam.

Cyrtodactylus malayanus: MZB 2927–9 from Betung Kerihun, National Park, Kalimantan Barat, ITB RMBR 718–9, 790, 866, 867, 914, 970, 972 Bukit Baka, Kalimantan Barat: MZB 3920 from Kapuas River; ITB CYR 0052, MK 021, 058, 665–7, 762–4, 780, 807, 829, 895, 996, 110, 1064, ITB CUS 016 from Kapuas Hulu, Kalimantan Barat; ITB BS 01–10, BAB 024, from Maruwai, Kalimantan Tengah; ITB RMBR 719, 723, 790–2, 914, 970, 1145, 1202, 1205, 1214, 2029 from Bukit Baka-Bukit Raya National Park, Kalimantan Tengah.

Cyrtodactylus matsuii: FMNH 239606, 239616, 239625, 239645–6, (paratypes) from Borneo.

Cyrtodactylus pubisulcus: FMNH 248499–500, 248502-4 (paratypes); ITB MK 996, 1010, 1064 from Peni Stream, head of Kapuas River, Dangkan II, Silat Hulu, Kalimantan Barat.

Cyrtodactylus quadrivirgatus: BPBM 7222–3, 7282–3 from Malaysian Peninsula.

Cyrtodactylus sermowaiensis: ITB GAG 173, 194 from Gag Island.

Cyrtodactylus spinosus: MZB 7024 (holotype), 7025–9 (paratypes) from Sulawesi Tengah.

Cyrtodactylus sworderi: BPBM 7251, 7908–13 from Malaysian Peninsula.

Cyrtodactylus wallacei: BSI 2574 (holotype), 2575 (paratype) from Sulawesi Selatan; MZB 3845, 4264 (paratypes) from Kabaena Island, Sulawesi Tenggara.

Cyrtodactylus yoshii: FMNH 63625, 230097, 230101, 230107 (paratypes), from Borneo.

Cyrtodactylus sp.: JAM 6444, 6450–2, 6620–1 from Takandaeng, Sulawesi Barat, JAM 6572–7 from road between Tasiu and Tibo, Sulawesi Barat.