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Redescription of *Cyrtodactylus fumosus* (Müller, 1895) (Reptilia: Squamata: Gekkonidae), with a revised identification key to the bent-toed geckos of Sulawesi

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Abstract. The binominal *Cyrtodactylus fumosus* has frequently been used for populations of bent-toed geckos occurring on some Indonesian islands, including Java, Bali, Sulawesi, and Halmahera. Unfortunately, incorrect usage of this name for different geographic lineages has resulted in confusion about the true identity of *C. fumosus*. Examination of the type specimen and additional specimens from Rurukan and Mount Masarang, North Sulawesi Province, Indonesia, revealed that this population is distinct from other forms heretofore called '*fumosus*' by a combination of unique morphological characters. In order to stabilize the taxonomy of *C. fumosus* sensu stricto, and to prevent further confusion, we provide a comprehensive redescription of this species, whose distribution we herein restrict to North Sulawesi. *Cyrtodactylus fumosus* is one of the most distinctive species among the six bent-toed geckos recorded from Sulawesi, and it differs from Sulawesi congeners by the presence of (1) precloacofemoral scales, including three pore-bearing scales on each thigh, separated from 10 or 11 pore-bearing scales in the precloacal region by 9-11 interscales in males, (2) a precloacal groove in adult males, (3) flat dorsal tubercles in 4-7 irregularly arranged longitudinal rows at midbody, and (4) a distinct lateral fold lacking tubercles. We also provide a revised identification key to the bent-toed gecko species of Sulawesi.

Keywords. *Cyrtodactylus fumosus*, *C. marmoratus*, Lacertilia, bent-toed geckos, reptiles, North Sulawesi, Indonesia, morphology.

INTRODUCTION

The bent-toed gecko fauna of Sulawesi consists of six species, including *Cyrtodactylus batik* Iskandar et al., 2011; *C. fumosus* (Müller, 1895); *C. hitchi* Riyanto et al., 2016; *C. jellesmae* (Boulenger, 1897); *C. spinosus* Linkem et al., 2008; and *C. wallacei* Hayden et al., 2008. Two of these, *C. fumosus* and *C. jellesmae* have been reported from North Sulawesi Province, Indonesia (e.g., Boulenger, 1897; Koch et al., 2009; Iskandar et al., 2011; Koch, 2012). *Cyrtodactylus fumosus* was described by Müller (1895a) based on a single specimen (NMB-REPT 2662; adult female), collected by Paul Benedict Sarasin (1856-1929) and Karl Friedrich ("Fritz") Sarasin (1859-1942) in the

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"Boelawa Mountains" (= Huidu Matabulawa) of northern Sulawesi. Following its original description, *C. fumosus* was also reported from localities outside of Sulawesi (e.g., De Rooij, 1915; Mertens, 1929, 1934; Manthey and Grossmann, 1997; McKay, 2006; Oliver et al., 2009; Das, 2010; Koch, 2012; De Lisle et al., 2013; Riyanto et al., 2013, 2015), leading to the perception of a wide distribution and a rather inconsistent or even erroneous definition of the taxon, since the name became applied to bent-toed gecko species not representing *C. fumosus* sensu stricto (see Hartmann et al., 2016). Boulenger (1897) was the only author who provided a detailed, though not entirely correct (see Hartmann et al., 2016: footnote 1), species account for *C. fumosus* sensu stricto, based on specimens from North Sulawesi.

The recent identification of new species from the Sunda Islands masquerading under the name *C. fumosus* (Riyanto et al., 2015; Hartmann et al., 2016) and re-examination of *C. fumosus* specimens from North Sulawesi, however, show that the taxonomy of *C. fumosus* is in disarray, and this makes it necessary to properly redescribe this conspicuous taxon based on a multitude of eidonomic characters, some of which have never been provided in the literature. Whereas Hartmann et al. (2016) already published remarks on the taxonomy of *C. fumosus* and provided selected comparative morphological data for this species, a comprehensive redescription of *C. fumosus* is necessary to stabilize the taxonomy of a species that has experienced prominent use in the literature, but whose identity has regularly been misconstrued. This redescription, featured below, can serve as solid basis for the delineation and description of additional new species of bent-toed geckos currently recognized as *C. fumosus*, and allows the correction of comparative literature data.

MATERIALS AND METHODS

Our redescription of *Cyrtodactylus fumosus* is based on the examination of four specimens of that taxon, including the holotype (NMB-REPT 2662) and three additional specimens (NMB-REPT 2663; BMNH 1895.2.27.7, 1896.12.9.3). For each specimen used in the redescription, we recorded data for 31 eidonomic characters (see Table 1 for definitions and abbreviations). Of these, 14 were metric and 16 meristic. We also calculated the following ratios: AxialL/SVL, ArmL/SVL, LegL/SVL, HeadL/SVL, HeadW/HeadL, SnoutL/HeadL, SnoutL/OrbD, and MentalH/MentalW. All measurements were taken to the nearest 0.1 mm using digital calipers. Scale counts and observations of external morphology were made using a dissection microscope. Characters occurring bilaterally were measured or counted on the right side of specimens, unless stated otherwise; for femoral pores, interscales, and labial scales, we provide counts for both sides of the body (the prefixes "R" and "L" are used to distinguish characters counted on the right or left side, respectively). In our diagnosis, ranges are followed by means ± standard deviations. For descriptions of pattern and coloration we apply the terminology of Köhler (2012). Numbers in parentheses behind the respective capitalized color name refer to the coding therein. The terminology used to distinguish between different depressed precloacal areas follows Mecke et al. (2016). Drawings are based on photographs of ethanol-preserved specimens and were prepared using the program CorelDraw Graphics Suite X3. Museum abbreviations follow Sabaj Pérez (2014).

RESULTS

***Cyrtodactylus fumosus* (Müller, 1895)** (Figs 1; 2)
Gymnodactylus fumosus Müller, 1895a: 833 (holotype NMB-REPT 2662; type locality: "*Boelawa Gebirge*," Sulawesi, elevation 1200 m)
Gymnodactylus fumosus—Müller, 1895b: 865
Gymnodactylus fumosus—Boulenger, 1897: 204
Gymnodactylus fumosus (part.)—De Rooij, 1915: 16
Gymnodactylus fumosus—Brongersma, 1934: 168
Gymnodactylus fumosus—Brongersma, 1953: 172
Gymnodactylus fumosus—Kramer, 1979: 160
Cyrtodactylus fumosus (part.)—Manthey and Grossmann, 1997: 222
Cyrtodactylus fumosus (part.)—Grismer, 2005: 429
Cyrtodactylus fumosus (part.)—Grismer and Leong, 2005: 588
Cyrtodactylus fumosus (part.)—Biswas, 2007: 19
Cyrtodactylus fumosus (part.)—Hayden et al., 2008: 109
Cyrtodactylus fumosus (part.)—Rösler and Glaw, 2008: 14
Cyrtodactylus fumosus (part.)—Chan and Norhayati, 2010: 50
Cyrtodactylus fumosus (part.)—Das, 2010: 209
Cyrtodactylus fumosus (part.)—Iskandar et al., 2011: 65
Cyrtodactylus fumosus (part.)—Koch, 2012: 161
Cyrtodactylus fumosus—Hartmann et al., 2016: 556
Cyrtodactylus fumosus (part)—Riyanto et al., 2016: 69
Cyrtodactylus fumosus—Mecke et al., 2016: 356

Holotype: NMB-REPT 2662 (Fig. 1A and Table 2; Hartmann et al. 2016: Fig. 5): adult female (SVL = 77.8 mm) collected by Paul and Fritz Sarasin in 1894; terra typica: "*Boelawa Gebirge*" (= Huidu Matabulawa), corrected to "Bone Mountains" (= Pegunungan Bone, North Sulawesi Province, Indonesia) by Boulenger (1897).

Referred specimens: NMB 2663 (Fig. 1B): Mount Masarang; BMNH 1895.2.27.7 (Fig. 1C; same specimen figured in Boulenger, 1897: Plate VII, Fig. 2), 1896.12.9.3 (Fig. 1D): Rurukan.

Definition: *Cyrtodactylus fumosus* is a moderately-sized bent-toed gecko species (maximum SVL = 78 mm)

Table 1. Metric and meristic characters with abbreviations used in this study.

Character	Abbreviation	Definition
Snout-vent length	SVL	From tip of snout to cloaca
Axial length	AxialL	From axilla to groin
Tail length	TailL	From cloaca to tip of tail
Arm length	ArmL	From insertion of brachium into body wall to claw of longest finger
Leg length	LegL	From insertion of thigh into body wall to claw of longest toe
Head length	HeadL	From tip of snout to articulation of quadrate bone with lower jaw
Head width	HeadW	Measured at level of ear openings
Head height	HeadH	Measured at level of ear openings
Snout length	SnoutL	From tip of snout to anterior margin of orbit
Orbit-Ear distance	OrbEarD	From posterior margin of orbit to anterior margin of ear opening
Orbital diameter	OrbD	From anterior to posterior margin of orbit
Ear length	EarL	From anterior to posterior margin of ear opening
Mental length	MentalL	Maximum length of mental shield
Mental width	MentalW	Maximum width of mental shield
Dorsal tubercle rows	DTR	Number of longitudinal tubercle rows on dorsum at midbody, counted in one row between lateral folds
Paravertebral tubercles	PVT	Number of tubercles counted in a longitudinal row between posterior insertion of forelimb and anterior insertion of hindlimb
Ventral scales	VS	Number of ventral scales at midbody, counted in one row between lateral folds
Precloacofemoral scales	PFS	Number of enlarged precloacofemoral scales, counted along lowest, pore-bearing series
Femoral pores	FP	Number of femoral pores on enlarged scales on thigh
Interscales[a]	InterS	Number of enlarged poreless scales between series of pore-bearing precloacal scales and series of pore-bearing femoral scales on thigh
Precloacal pores	PP	Number of precloacal pores situated in precloacal groove
Postcloacal tubercles	PCT	Number of postcloacal tubercles
Subdigital lamellae under 4th toe	LT_4	Number of subdigital scales under 4th toe, counted from first enlarged scale (lamellae) on lower side of toe to scale proximal to apical scale
Supralabial scales 1	$SupraLab_1$	Number of labial scales of upper jaw, beginning with first enlarged scale bordering rostral shield, ending with last enlarged scale bordering labial angle
Supralabial scales 2	$SupraLab_2$	Number of labial scales of upper jaw, beginning with first enlarged scale bordering rostral shield, ending with enlarged scale below anterior margin of eye
Infralabial scales	InfraLab	Number of labial scales of lower jaw, beginning with first scale bordering mental shield, ending with last enlarged scale bordering labial angle
Internasal scales	InterNas	Number of scales between rostronasals, bordering rostral
Supraciliar scales	SC	Number of enlarged scales extending from anterior-ventral to posterior-dorsal edge of orbit
Interorbital scales	IOS	Number of scales counted in a row between the medial edges of orbits across head
Gular scales	GulS	Number of gular scales bordering pair of first postmentals

[a] Rösler et al. (2007); Hartmann et al. (2016); and Mecke et al. (2016) referred to interscales as "infrascales."

that can be readily distinguished from all other congeners occurring in the Greater and Lesser Sunda Islands, Sulawesi, and the Maluku Islands by the following combination of characters: (1) a single series of precloacofemoral scales, including three pore-bearing scales on each thigh, separated from 10 or 11 pore-bearing scales in the precloacal region by 9-11 interscales in males (Fig. 2A), (2) a precloacal groove in adult males (Fig. 2A), (3) posterior precloacal scales (Fig. 2A), (4) flat and smooth (unkeeled) dorsal tubercles in 4-7 irregularly arranged longitudinal rows at midbody (Fig. 2B), (5) a distinct lateral fold lacking tubercles, (6) 37-50 longitudinal rows of ventral scales at midbody, (7) 17-23 scales under 4th toe, and (8) a horizontal slit-like ear opening.

Comparisons: Characters distinguishing *Cyrtodactylus fumosus* from all other species of *Cyrtodactylus* occurring on the Sunda Islands and Sulawesi were provided by Mecke et al. (2016: Table 2). Here, our comparisons are limited to Sulawesi taxa, with characters of *C. fumosus* provided in parentheses. *Cyrtodactylus batik* can be

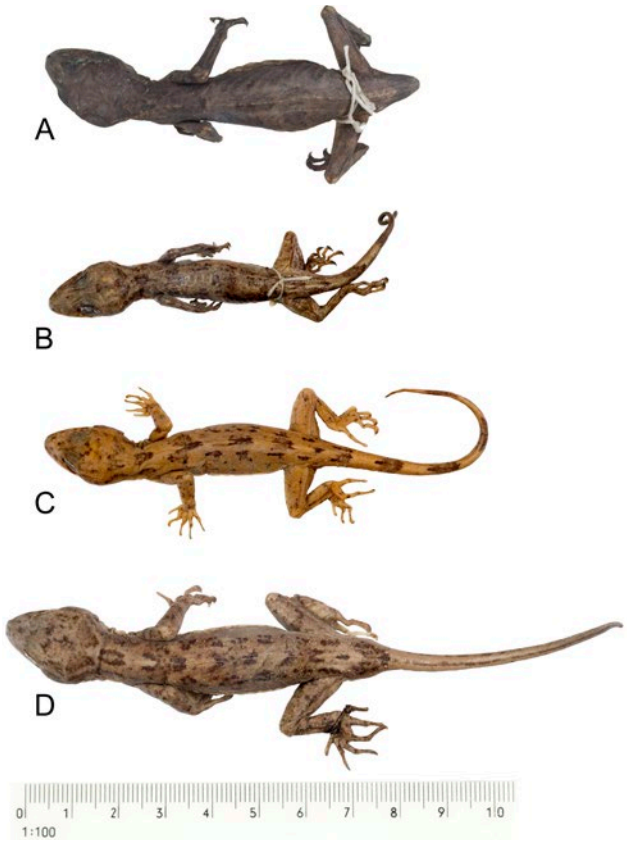

Fig. 1. Dorsal views of the known specimens of *Cyrtodactylus fumosus*: (A) NMB-REPT 2662 (holotype, adult female); (B) NMB-REPT 2663 (subadult male); (C) BMNH 1895.2.27.7 (adult female); (D) BMNH 1896.12.9.3 (adult male). Photographs by Sven Mecke. BMNH 1895.2.27.7 is also figured (in dorsal view) in Boulenger (1897: Plate VII, Fig. 2).

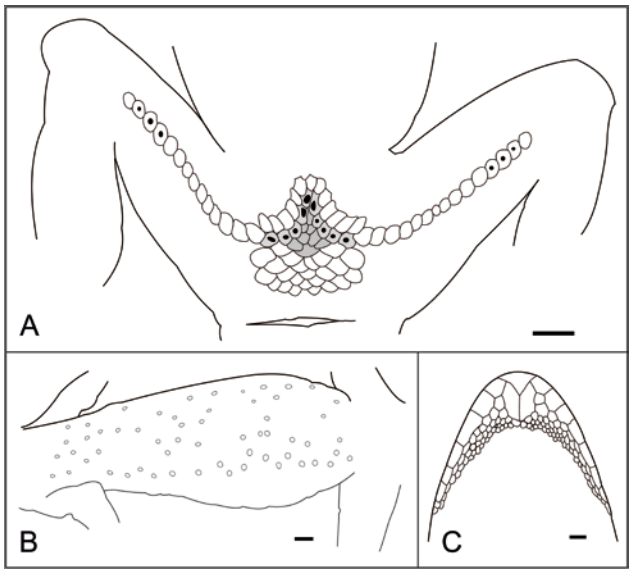

Fig. 2. Diagnostic characters of *Cyrtodactylus fumosus*. (A) Precloacofemoral region (with pore-bearing precloacal scales and groove shaded in grey) of a male specimen (BMNH 1896.12.9.3), showing precloacal and femoral pores. Scale bar equals 2 mm (B) Dorsum, showing tubercles (holotype NMB-REPT 2662). Scale bar equals 2 mm. (C) Ventral side of anterior part of head (holotype NMB-REPT 2662). Scale bar equals 1 mm. Drawings prepared by Felix Mader based on photographs by Sven Mecke.

distinguished from *C. fumosus* by a larger size of adults with a maximum SVL of 115 mm (78 mm); the absence of PFS (PFS present); the absence of PP and FP in both sexes (PP and FP present in males); the absence of a precloacal depression in both sexes (precloacal groove present in males); 23-26 slightly keeled DTR (4-7 unkeeled DTR); the presence of tubercles on the lateral skin fold (tubercles on lateral skin fold absent); 24-27 LT_4 (17-23 LT_4); and the presence of transversely enlarged subcaudal scales in a single row (enlarged, paired median subcaudals) (Iskandar et al., 2011; Riyanto et al., 2016). *Cyrtodactylus hitchi* can be distinguished from *C. fumosus* by the absence of PFS (PFS present); the absence of PP and FP in both sexes (PP and FP present in males); the absence of a precloacal depression in both sexes (precloacal groove present in males); the presence of 18-20 keeled DTR (4-7 unkeeled DTR); the presence of tubercles on the lateral skin fold (tubercles on lateral skin fold absent); and the presence of transversely enlarged subcaudal scales in a single row (enlarged paired median subcaudals) (Riyanto et al., 2016). *Cyrtodactylus jellesmae* can be distinguished from *C. fumosus* by the absence of PFS (PFS present); the absence of PP and FP in both sexes (PP and FP present in males); the absence of a precloacal depression in both sexes (precloacal groove present in males); the presence of 13-22 raised DTR (4-7 flat DTR); the presence of tubercles on the lateral skin fold (tubercles on lateral skin fold absent); and the absence of enlarged subcaudal scales (enlarged paired median subcaudals present) (Boulenger, 1897; Mecke et al., 2016, pers. obs.). *Cyrtodactylus spinosus* can be distinguished from *C. fumosus* by the absence of a continuous series of enlarged precloacal and femoral scales (PFS present); by widely spaced femoral scales (femoral scales juxtaposed); the presence of a shallow precloacal pit in males (deep precloacal groove in males); the presence of lateral and caudal spines (spines absent); and the presence of a prehensile tail (tail not prehensile) (Linkem et al., 2008; Harvey et al., 2016). *Cyrtodactylus wallacei* can be distinguished from *C. fumosus* by a larger size of adults, reaching a maximum SVL of 114 mm (78 mm); the absence of PFS (PFS present); the absence of PP and FP in both sexes (PP and FP present in males); the absence of a pre-

Table 2. Metric (in mm) and meristic data for the known specimens of *Cyrtodactylus fumosus*. Abbreviations are defined in Table 1. Characters occurring bilaterally were measured or counted on the right side of specimens, unless stated otherwise; for femoral pores, interscales, and labial scales we provide counts for both sides of the body (the prefixes "R" and "L" are used to distinguish characters counted on the right and left side, respectively). n/a = not applicable. Our metric data of BMNH 1895.2.27.7, the only known specimen with an original tail (TailL = 67.1), well agree with the measurements listed by Boulenger (1897), who also provided a drawing of a specimen (Plate VII, Fig. 2) identifiable as BMNH 1895.2.27.7.

	NMB-REPT 2662 (holotype)	NMB-REPT 2663	BMNH 1895.2.27.7	BMNH 1896.12.9.3
Sex	Female	Male	Female	Male
SVL	77.8	56.6	60.7	77.5
AxialL	35.2	22.2	28.3	31.4
ArmL	35.7	22.1	24.9	32.9
LegL	43.9	29.6	32.9	42.0
HeadL	21.3	15.7	16.8	20.4
HeadW	14.2	10.6	11.9	14.5
HeadH	9.2	7.0	6.7	9.5
SnoutL	8.8	6.9	7.7	9.4
OrbEarD	6.6	4.1	4.3	6.3
OrbD	5.2	3.6	4.0	4.1
EarL	1.2	1.2	2.0	2.3
DTR	5	7	4	6
PVT	13	16	14	18
VS	38	37	47	50
PFS	46	45	46	39
FP	0	R3 L3	0	R3 L3
InterS	n/a	R10 L9	n/a	R10 L11
PP	0	11	0	10
$LT_{4\ (proximal)}$	7	8	10	9 (L)
$LT_{4\ (distal)}$	10	11	13	12 (L)
LT_4	17	19	23	21 (L)
$SupraLab_1$	R12 L12	R13 L13	R11 L12	R11 L12
$SupraLab_2$	R6 L5	R6 L6	R6 L6	R6 L6
InfraLab	R9 L11	R10 L10	R11 L10	R8 L8
GulS	9	8	7	8

cloacal depression in both sexes (precloacal groove present in males); and the presence of 23-25 slightly keeled, trihedral DTR (4-7 unkeeled and flat DTR) (Hayden et al., 2008).

Description of the holotype. General habitus, metrics, and ratios: Adult female; SVL = 77.8 mm; AxialL = 35.2 mm; TailL (broken, only tail stump present) = 8.7 mm; ArmL = 35.7 mm; LegL = 43.9 mm; HeadL = 21.3 mm; HeadW = 14.2 mm; HeadH = 9.2 mm; SnoutL = 8.8 mm; OrbEarD = 6.6 mm; OrbD = 5.2 mm; EarL = 1.2 mm; head rather short (HeadL/SVL = 0.27) and wide (HeadW/HeadL = 0.67), clearly depressed between eyes, distinct from neck; snout rather elongate (SnoutL/HeadL = 0.41), longer than OrbD (SnoutL/OrbD = 1.69), canthus rostralis distinct; fore- and hindlimbs of moderate size (ArmL/SVL = 0.46; LegL/SVL = 0.56), without webbing between digits; relative length of fingers = IV > III > V > II > I; relative length of toes = IV > III > V > II > I; lateral skin fold distinct, lacking tubercles.

Scalation: Dorsal scales granulate, interspersed with slightly enlarged, flat, roundish and irregularly arranged dorsal tubercles (Fig. 2B), 5 DTR; 13 PVT; tubercles on occiput, neck, and hindlimbs similar in shape to those on dorsum (no tubercles present on the forelimbs).

Thirty-eight VS, distinctly larger than those on dorsum, juxtaposed; a single series of 46 poreless PFS; enlarged posterior precloacal scales present, arranged in a chevron-like shape consisting of five series of scales (from anterior to posterior: 10/ 8/ 7/ 6/ 2 scales); 2 flat PCT; number of lamellae under fingers: I 12, II 16, III 16, IV 18, V 16; number of lamellae under toes: I 13, II 15, III 17, IV 17, V 16.

Rostral shield rectangular, 2.2 times as wide as high, partly divided by a median, vertical furrow, in contact with 1st SupraLab, 2 rostro-nasals and a single InterNas; naris surrounded by rostral, 1st SupraLab, a single rostro-nasal, and three post-nasals; R12 L12 $SupraLab_1$, R6 L5 $SupraLab_2$, separated from orbit by three rows of small granular scales; R9 L11 InfraLab; cephalic scales small, rounded, granulate and juxtaposed; tubercles on occiput and neck flat and unkeeled; 40 SC; 46 IOS; mental triangular, wider than long (MentalW/MentalL = 1.7); one pair of enlarged 1st postmentals, enlarged 2nd postmentals absent (Fig. 2C); pair of 1st postmentals bordered by mental, 1st InfraLab, and 9 GulS (Fig. 2C); scales on throat minute and rounded.

Coloration: Natural color and pattern altered due to preservation. Ground color of dorsum Cinnamon-Drab (50); head darker than dorsum, Burnt Umber (48) in color, with indistinct Warm Sepia (40) stripe running from posterior border of orbits along neck, forming a collar at level of posterior margin of forelimbs; labial scales Buff (5), stippled with darker color, with stipples most concentrated at edges of some scales; dorsum with irregular, faint Dark Drab (45) blotches, not arranged in distinct pairs, most visible on vertebral region between forelimbs and on mid-dorsum; ground color of dorsal surface of limbs similar to ground color of dorsum; limbs with diffuse Dark Drab (45) markings; venter, throat and lower surface of limbs uniformly Smoke Grey (266), heavily dotted; color of dorsal and ventral surfaces of tail stump similar to dorsal and ventral ground color, respectively.

Intraspecific variation: Our assessment of the variation is based on the holotype and three additional specimens from North Sulawesi (one adult and one subadult male, one adult female) unless stated otherwise. Measurements (in mm) are listed as range followed by mean ± standard deviation provided in parentheses: SVL = 56.6-77.8 (68.2 ± 11.1); AxialL = 22.2-35.2 (29.3 ± 5.5); TailL (original tail) = 67.1 (n = 1); ArmL = 22.1-35.7 (28.9 ± 6.4); LegL = 29.6-43.9 (37.1 ± 6.9); HeadL = 15.7-21.3 (18.6 ± 2.7); HeadW = 10.6-14.5 (12.8 ± 1.9); HeadH = 6.7-9.5 (8.1 ± 1.5); SnoutL = 6.9-9.4 (8.2 ± 1.1); OrbEarD = 4.1-6.6 (5.3 ± 1.3); OrbD = 3.6-5.2 (4.2 ± 0.7); EarL = 1.2-2.3 (1.7 ± 0.6). Ratios: AxialL/SVL = 0.39-0.47 (0.43 ± 0.03); ArmL/SVL = 0.39-0.46 (0.42 ± 0.03); LegL/SVL = 0.52-0.56 (0.54 ± 0.02); HeadL/SVL = 0.27-0.28 (0.27 ± 0.01); HeadW/HeadL = 0.67-0.71 (0.69 ± 0.02); SnoutL/HeadL = 0.41-0.46 (0.44 ± 0.02); SnoutL/OrbD = 1.69-2.29 (1.96 ± 0.25); RostralW/RostralH = 1.53-2.18 (1.91 ± 0.28); MentalW/MentalL = 1.29-1.83 (1.64 ± 0.24).

Scale counts are listed as range followed by mean ± standard deviation provided in parentheses: DTR = 4-7 (5.75 ± 1.3); PVT = 13-18 (15.25 ± 2.2); VS = 37-50 (43 ± 6.5); PFS = 39-46 (44 ± 3.4), only a single series present; enlarged posterior precloacal scales consisting of 5 or 6 series; PCT = 2-3, flat in shape; LT_4 = 17-23 (19 ± 2.8); $SupraLab_1$ = 11-13 on right side of head and 12-13 on left side of head; InfraLab = 8-11 on right side of head and 8-11 on left side of head; SC = 32-40 (33.5 ± 4.4); IOS = 45-49 (47.3 ± 2.1); GulS = 7-9.

Furthermore, all specimens possess a distinct lateral skin fold lacking tubercles and a horizontal, slit-like ear opening. A distinctive row of 5 or 6 tubercles on the dorsal surface of the upper leg is present in three specimens (absent in the holotype). Specimens with unregenerated tails possess two strongly enlarged median subcaudal rows. Unlike female specimens, male specimens of *Cyrtodactylus fumosus* (n = 2) possess three pore-bearing scales on each thigh, separated from 10 or 11 pore-bearing precloacal scales by 9-11 InterS. A distinct precloacal groove is fully developed in adult males (n = 1) only. Data of measurements and scale counts for the main characters of the holotype and additional specimens used for the diagnosis are provided in Table 2.

Ground color of dorsal surface of body, head, and tail varies considerably between the specimens available to us and appears to depend on the respective preservation method. Hence, ground color of dorsal surface varies from Cinnamon (255) over Cinnamon-Drab (50) to Drab (19), with the specimens housed in NMB being darker than the ones housed in BMNH; dorsum with 4-7, sometimes indistinct, Warm Sepia (40) blotches; original tail (n = 1) with six Warm Sepia (40) blotches; regenerated tail of one specimen (BMNH 1896.12.9.3) possesses three indistinct, partially interrupted, Warm Sepia (40) lines, running from base to tip of tail; dorsal surface of limbs and head with diffuse Warm Sepia (40) or Dark Drab (45) markings; venter, lower surface of limbs, and throat uniformly Pale Buff (1) or Smoke Grey (266 and 267). See Fig. 1 for coloration and pattern of preserved specimens.

Distribution and natural history: Although the name *Cyrtodactylus fumosus* has frequently been applied to bent-toed gecko populations from Java, Bali, Halmahera, and the entire island of Sulawesi (e.g., De Rooij, 1915; Grismer, 2005; Das, 2010; De Lisle et al., 2013; Riyanto and Mumpini, 2013; Riyanto et al., 2015), *C. fumosus* sensu stricto is only known from the four specimens featured herein, all of which were collected in North Sulawesi (Müller, 1895a, b; Boulenger, 1897; see Fig. 3). The occurrence of *C. fumosus* on Lembeh Island, off the coast of northern Sulawesi (Grismer, 2005: Appendix 1, Grimser and Leong, 2005: Appendix 1), appears to be based on misidentified specimens, since the data (including key characters for diagnosis) provided by Grismser (2005: Table 2) and Grismer and Leong (2005: Table 2) do not match those of *C. fumosus* sensu stricto as reported herein. Moreover, the data provided by Grismer (2005) and Grismer and Leong (2005: Table 2) seem to be partly based on the erroneous description of *C. fumosus* provided by De Rooij (1915) (see Hartmann et al., 2016).

According to the data provided by Müller (1895a, b), specimens of *Cyrtodactylus fumosus* sensu stricto were collected at elevations 1200-1260 m, in a terrain that is, based on satellite images (Google Earth, viewed on 24 January 2016), covered with montane rainforest. Although there are only limited data available on the natural history of *C. fumosus*, we believe the species to be restricted to montane rainforest habitats in North Sulawesi. The distribution of *C. fumosus*, as currently known, overlaps with the range of *C. jellesmae*, the only other species of *Cyrtodactylus* known from North Sulawesi. Figure 3 shows the distribution of the six bent-toed geckos currently known from Sulawesi.

Remarks on the identity of Cyrtodactylus fumosus *from Java*: Hartmann et al. (2016) discussed the status of *Cyrtodactylus fumosus* populations outside of Sulawesi and came to the conclusion that these records were based on erroneous data provided in the literature (e.g., De Rooij, 1915) and/or misidentified specimens. Recently, Riyanto et al. (2015) applied the name *C. fumosus* to populations of bent-toed geckos from Java, which are unequivocally identifiable as belonging to the *C. marmoratus* (Gray, 1831) complex. These authors largely based their

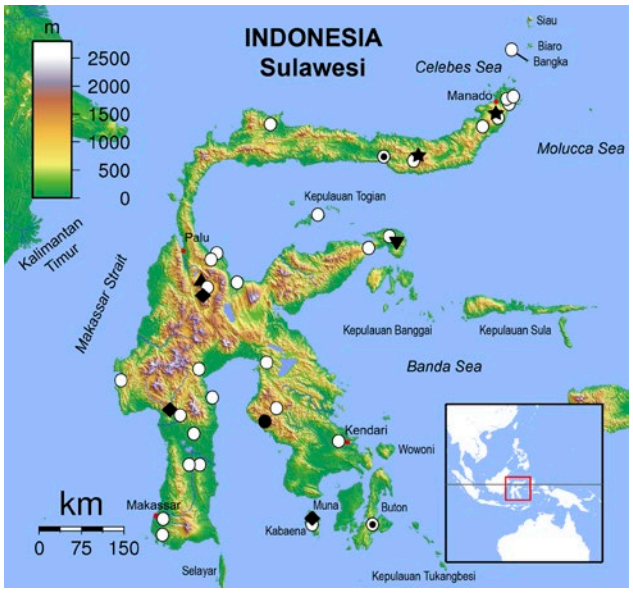

Fig. 3. Map of Sulawesi showing the distribution of the six species of *Cyrtodactylus* currently recognized from this island: *Cyrtodactylus batik* (inverted black triangle), *C. fumosus* (black star), *C. hitchi* (black circle), *C. jellesmae* (white circle), *C. spinosus* (black triangle), and *C. wallacei* (black diamond). Records are based on specimens listed in the appendices and data provided in Hayden et al. (2008), Linkem et al. (2008), Iskandar et al. (2011), Wanger et al., (2011), Koch (2012), Riyanto et al., (2016). A white circle with a black dot represents a photo-voucher for *C. jellesmae* available to us. Base map modified from Wikipedia © Sadalmelik / Wikimedia Commons / CC-BY-SA-3.0 by Max Kieckbusch.

assumption on De Rooij (1915), who mainly distinguished between *C. fumosus* and *C. marmoratus* by a continuous or discontinuous pore series, respectively. However, De Rooij (1915) largely based her definition of *C. fumosus* on Boulenger (1897), who erroneously reported this species to have a continuous pore series, and her personal examination of specimens housed in the collections of BMNH and SMF, which are conspecific with *C. halmahericus* (Mertens, 1929) (see Hartmann et al., 2016: Footnote 1). *Cyrtodactylus halmahericus*, unlike *C. fumosus*, possesses a continuous pore series in males (a redescription of *C. halmahericus* is currently underway).

Whereas the lectotype of *C. marmoratus* (RMNH. RENA 2710a.1; adult male), all other adult male paralectotypes housed in RMNH (RMNH.RENA 2710a.2-a.5, 2710.1-2), and several other adult male specimens we have examined personally, possess a continuous series of pores (precloacofemoral pores), this character may vary ontogenetically (Brongersma, 1953, pers. obs.), between sexes (Rösler et al.; 2007, Mecke et al., 2016), and between *C. marmoratus* sensu stricto and morphologically similar species masquerading under this name. *Cyrtodactylus fumosus* can be easily distinguished from *C. marmoratus* as currently defined by the following characters: (1) a discontinuous series of precloacal (10 or 11) and femoral pores (three on each thigh) in males, (2) the absence of pores in females, (3) the presence of posterior precloacal scales, (4) the presence of widely scattered, roundish, flat, and smooth dorsal tubercles in 4-7 rows at midbody (11-19 in the type series of *C. marmoratus* at RMNH), (5) 14-18 paravertebral tubercles (22-29 in in the type series of *C. marmoratus* at RMNH), and enlarged paired median subcaudals (enlarged subcaudals absent in *C. marmoratus*).

It is obvious that the male specimen (MZB.Lace 12903) identified as *Cyrtodactylus fumosus* by Riyanto et al. (2015) and depicted in their Fig. 4B is not conspecific with *C. fumosus*, because it possesses a continuous pore series and lacks posterior precloacal scales. The precloacofemoral region of that specimen rather matches that of *C. marmoratus* sensu stricto (see Hartmann et al., 2016: Fig. 3H, Mecke et al., 2016: Fig. 1A). Since Riyanto et al. (2015) failed to properly identify *C. fumosus* and *C. marmoratus*, their comparative Table 3 should not be used for the identification of these taxa. The example well demonstrates the importance of examining relevant type specimens before taxonomic decisions are made.

DISCUSSION

The phylogenetic affinities of *Cyrtodactylus fumosus* remain unclear. The presence of pores, a precloacal depression in males, and posterior precloacal scales are shared with other species of *Cyrtodactylus* from the region, e.g., *C. halmahericus* (Halmahera) and *C. klakahensis* Hartmann et al., 2016 (eastern Java), with which it may be closely allied[1]. By contrast, *C. fumosus* might represent an offshoot of an exclusive clade containing Sulawesi bent-toed geckos only.

Results of studies on Sulawesi amphibians and reptiles suggest that this island is herpetogeographically complex, supporting taxa of both Sundaic and Australopapuan affinities (Koch, 2011, 2012), including endemics (e.g., How and Kitchener, 1997; Whitten et al., 2001; Koch, 2011, 2012).

The restriction of *Cyrtodactylus fumosus* to Sulawesi underscores that this island holds a significant amount

[1] *Cyrtodactylus petani* Riyanto et al., 2015 also shares with *C. fumosus* the presence of pores and posterior precloacal scales. Riyanto et al. (2015) provided inconsistent data on whether a precloacal groove is present in male specimens of *C. petani*. However, male *C. petani* lack a precloacal groove or pit (Awal Riyanto, in litt.; Mecke et al., 2016).

of endemism. The species is apparently only found in the mountains of North Sulawesi Province, and such a limited range exemplifies that isolated geographic features in this region (e.g., mountain ranges) may be the key locales for such endemism. According to Koch (2012: Table 11) more than 20 amphibians and reptiles (including candidate species) are endemic to northern Sulawesi. Most of these appear to be endemic to offshore islands, but we hypothesize that the North Sulawesi mountain ranges may harbor a higher number of endemic herpetofaunal taxa than generally assumed as well.

We disagree with Iskandar et al. (2011), who considered that the Sulawesi herpetofauna is impoverished compared to other regions in Southeast Asia, largely due to natural factors alone. The high rate at which new amphibian and reptile species are being discovered on Sulawesi contradicts this hypothesis, and the relatively low diversity may simply reflect the limited amount of fieldwork conducted there to date. Since 2000, 16 reptile species have been described from Sulawesi (e.g., *Tropidophorus baconi* Hikida et al., 2003; *Calamaria butonensis* Howard and Gillespie, 2007; *Rabdion grovesi* Amarasinghe et al., 2015), a number that equals ~15% of the reptiles known from this island. The number of described species of *Cyrtodactylus* in Sulawesi alone increased by 200% during the last decade. Preliminary examination of preserved bent-toed geckos from Sulawesi in museum collections suggests that at least one undescribed species of bent-toed gecko is present on the island. Photographic images of specimens in life available to us indicate that a further three species of *Cyrtodactylus* from Sulawesi are yet to be described. Therefore we agree with e.g., Linkem et al. (2008), and Koch (2011, 2012), who considered the herpetological diversity of Sulawesi to be underestimated.

KEY TO THE SPECIES OF THE GENUS *CYRTODACTYLUS* OF SULAWESI

This key is applicable to identify adult bent-toed geckos based on non-sexually dimorphic characteristics, although characters present in males only may accompany a choice.

1a Long spines on lateral fold and lateral portion of tail present; tail prehensile ***C. spinosus***
1b Long spines on lateral fold and lateral portion of tail absent; tail not prehensile **2**
2a Enlarged precloacofemoral scales present in both sexes, bearing a total number of 16 or 17 pores in males, 10 or 11 of which are precloacal pores and 3 of which are femoral pores; pore-bearing scales separated by 9-11 enlarged interscales; precloacal groove present in males; no tubercles on lateral fold ***C. fumosus***
2b Enlarged precloacofemoral scales; pores; precloacal groove; and tubercles on lateral fold absent **3**
3a Enlarged median subcaudals absent ***C. jellesmae***
3b Enlarged median subcaudals present **4**
4a Enlarged subcaudals in multiple rows ***C. wallacei***
4b Enlarged subcaudals in a single row for most of the tail's length **5**
5a 24-27 lamellae under 4th toe; SVL in adults 103-113 mm ***C. batik***
5b 18-21 lamellae under 4th toe; SVL in adults 62-79 mm ***C. hitchi***

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APPENDIX

Specimens examined for diagnosis and comparison

Cyrtodactylus fumosus.—**Indonesia**: *North Sulawesi Province*: Bone Mountains (Pegunungan Bone, 1200 m a.s.l.): NMB 2662 (holotype); Mount Masarang: NMB 2663; Rurukan: BMNH 1895.2.27.7, 1896.12.9.3.

Cyrtodactylus halmahericus.—**Indonesia**: *North Maluku Province*: North Halmahera: MCZ Herp R-19279, SMF 8230 (paratype); Central Halmahera: Oba (Payahe): SMF 8232 (paratype); Soah Konorah (Soakonora): SMF 8233 (holotype).

Cyrtodactylus jellesmae.—**Indonesia**: *Central Sulawesi Province*: Malakosa, Kuala Navusu: AMNH R142969-73; Tolai, Sungai River: AMNH R142974; *North Sulawesi Province*: Kema: NMB-REPT 2659 (paralectotype); Buol: NMB-REPT 2660 (lectotype); Mount Masarang: NMB-REPT 2661 (paralectotype); Pulau Biaro: MCZ 171466; *South Sulawesi Province*: Lowah (Muara Loa): MCZ 25337.

Cyrtodactylus klakahensis.—**Indonesia**: *Jawa Timur Province*: Lumajang, Klakah: SMF 22476 (holotype); SMF 22477-79 (paratypes).

Cyrtodactylus marmoratus.—**Indonesia**: Java: RMNH.RENA 2710.1-8 (paralectotypes), RMNH.RENA 2710a.1 (lectotype), RMNH.RENA 2710a.2-6 (paralectotypes), MTKD 8903-05, SMF 8218; West Java: RMNH.RENA 9847, ZMA.RENA 15387 (three specimens); *Jawa Barat Province*: Garoet (Garut Regency): RMNH.RENA 9846 (three specimens), RMNH.RENA 10114 (two specimens), Kamodjang (Kawah Kamojang): RMNH.RENA 9849; *Jawa Tengah Province*: "Goewa Djatidjadjar Jdjoe Bagelen" (= Gua Jatijajar, Kebumen); Karangpucung: SMF 92361; *Jawa Timur Province*: Malang: RMNH.RENA 9848 (two specimens).

Cyrtodactylus petani.—**Indonesia**: *Jawa Timur Province*: Toelong Agoeng (Tulungagung Regency): ZMA.RENA 11353.