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A New Species of *Meristogenys* (Amphibia, Anura, Ranidae) from Sabah, Borneo

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We describe a new species of torrent-dwelling ranid frog of the genus *Meristogenys* from the Crocker Range, western Sabah, northern Borneo. The new species, *Meristogenys maryatiae*, differs from congeners by the combination of: small body, males 31–37 mm and females 65–66 mm in snout-vent length; head narrower than long; eyes moderate, diameter subequal to snout; iris unicolored; legs long; ventral surface of tibia without heavy pigmentation; rear of thigh blotched dark brown and cream; toes fully webbed; outer metatarsal tubercle present; larval dental formula 7(4-7)/6(1).

Key words: *Meristogenys*, new species, Southeast Asia, tadpole, taxonomy, zoogeography

INTRODUCTION

Meristogenys Yang, 1991 was split from *Amolops* Cope, 1865, a group of Oriental frogs characterized by peculiar larvae that inhabit mountain torrents using a huge abdominal, suctorial disk (Inger, 1966). Monophyly and the distinct generic status of *Meristogenys* have recently been confirmed through phylogenetic analyses using mitochondrial DNA sequences (Matsui et al., 2006), and the genus as now understood is endemic to Borneo Island and encompasses eight named species (Inger, 1966; Inger and Gritis, 1983; Matsui, 1986; Frost, 2009). However, several larval forms could not be assigned to known metamorphs (Inger and Gritis, 1983), and recent intensive work in the state of Sabah, Malaysia, suggested that additinoal, undescribed species exist on the island (Shimada et al., 2007a, b, 2008). During a joint expedition of the UMS (University Malaysia Sabah) and JICA (Japan International Cooperation Agency) to the Crocker Range National Park, Sabah (Kueh et al., 2004), and in subsequent faunal surveys of the state between 2002 and 2006, we collected larval and adult specimens of an apparently undescribed species of this genus from the Crocker Mountain Range, and below describe this material as a new species.

MATERIALS AND METHODS

Field excursions were made in Sabah between September 2002 and August 2006. After collecting specimens, we took tissues for later biochemical analysis and fixed them as vouchers. Metamorphosed specimens were fixed in 10% formalin and later preserved in 70% ethanol. Larvae were fixed and preserved in 5% formalin. Assignment of metamorphs to larvae for the new species as well as for congeners was based upon analyses of mtDNA sequences (Shimada et al., 2008).

For preserved metamorphosed specimens, we took the following 18 body measurements (Table 1), mainly following Matsui (1984), to the nearest 0.1 mm with dial calipers under a binocular dissecting microscope: (1) snout-vent length (SVL); (2) head length (HL), from tip of snout to hind border of angle of jaw (not measured parallel with the median line); (3) snout length (SL); (4) eye length (EL); (5) tympanum diameter (TD); (6) head width (HW); (7) internarial distance (IND); (8) interorbital distance (IOD); (9) upper eyelid width (UEW); (10) lower arm length (LAL); (11) forelimb length (FLL); (12) hindlimb length (HLL); (13) tibia length (TL); (14) foot

Table 1. Measurements for 18 characters of *Meristogenys maryatiae*. SVL (Mean±1SD, in millimeters) and medians of ratios (R) of other characters to SVL, followed by ranges in parentheses. See text for character abbreviations.

Sex	SVL	RHL	RSL	REL	RTD	RHW
Males	33.5±1.44	40.2	16.4	17.0	11.8	34.0
(N=24)	(31.3–37.1)	(37.8–41.3)	(15.6–17.8)	(15.5–18.2)	(10.4–13.2)	(32.7–36.3)
Females	65.3	37.8	16.2	13.8	7.6	34.6
(N=2)	(65.1–65.5)	(37.7–37.9)	(16.0–16.4)	(13.4–14.1)	(7.3–7.8)	(34.1–35.1)
Sex	RIND	RIOD	RUEW	RLAL	RFLL	RHLL
Males	10.8	9.1	10.5	52.0	65.6	208.5
(N=24)	(9.8–12.9)	(8.0–10.9)	(9.8–11.4)	(50.5–54.4)	(60.3–69.7)	(195.6–225.6)
Females	9.1	8.6	9.2	49.6	64.4	203.7
(N=2)	(9.0–9.2)	(8.6–8.6)	(9.2–9.2)	(49.3–49.9)	(62.4–66.4)	(203.5–203.8)
Sex	RTL	RFL	RIMTL	R1TL	R3FDW	R4TDW
Males	70.7	55.3	4.5	14.5	4.0	3.9
(N=24)	(66.8–77.5)	(52.0–60.0)	(4.0–5.4)	(12.6–15.1)	(3.5–4.6)	(3.6–4.4)
Females	68.5	54.2	5.1	14.4	3.5	3.3
(N=2)	(67.9–69.0)	(53.4–55.0)	(4.6–5.5)	(14.1–14.7)	(3.4–3.5)	(3.3–3.3)

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length (FL); (15) inner metatarsal tubercle length (IMTL); (16) first toe length (1TL), from distal end of inner metatarsal tubercle to tip of first toe; (17) third finger disk diameter (3FDW); and (18) fourth toe disk diameter (4TDW). Of these, measurements for FLL and HLL were taken by forcing the limbs into an extended straight position as shown in Matsui (1984).

For larvae, the following 13 measurements were taken to the nearest 0.01 mm by using a binocular dissecting microscope equipped with a micrometer: (1) total length (TOTL); (2) head-body length (HBL); (3) maximum head-body width (HBW); (4) body depth; (5) eye-snout distance; (6) eyeball diameter; (7) IND; (8) IOD; (9) oral disk width; (10) abdominal disk length; (11) abdominal disk width; (12) tail length; and(13) maximum tail depth. Measurements were made mainly following Inger (1985), and staging followed Gosner's (1960) table. We followed the terminology of Altig and McDiarmid (1999) for the oral apparatus, and of Shimada et al. (2007a, b, 2008) for other characters.

For comparisons, we used data for metamorphic individuals of all named species and larvae of most named and many unnamed species (cf., Shimada et al., 2007a, 2008).

SYSTEMATICS

Meristogenys maryatiae sp. nov.
(Fig. 1)

Diagnosis

A small form of the *M. jerboa* species group; males 31.3–37.1 mm SVL (snout-vent length), females 65.1–65.5 mm; head narrow, width relative to SVL 32.7–36.3%; eyes moderate, length relative to SVL 15.5–18.2% in males, diameter subequal to snout; iris unicolored, upper and lower halves golden; legs long, length of tibia relative to SVL 66.8–77.5%; ventral surface of tibia without heavy pigmentation; rear of thigh blotched dark brown and cream; web well developed, broad web reaching disk on all toes; ova pigmented: larvae with the denticle formula 7(4-7)/6(1).

Etymology

The specific name is dedicated to Prof. Datin Mohamed Maryati of the Institute for Tropical Biology and Conservation, University Malaysia Sabah, Kota Kinabalu, an eminent entomologist, who always greatly helped us during herpetological surveys in the state of Sabah.

Holotype

Institute for Tropical Biology and Conservation, University Malaysia Sabah (BORNEENSIS) 08132, an adult male from Base Camp of UMS-JICA 2002 expedition to the Crocker Range, Ulu Kimanis, Papar, on the western slope of the Crocker Range, western Sabah, east Malaysia (05°32'N, 116°00'E, 155 m a.s.l.), collected on 26 August 2002 by A. Sudin.

Paratypes

BORNEENSIS 08060, 08133 (two males) coll. 26 August 2002 by A. Sudin, B.-H. Kueh, and M. Matsui; BORNEENSIS 08770 (an adult male) coll. 11 September 2002 by M. Matsui; BORNEENSIS 22361–22377 and Graduate School of Human and Environmental Studies, Kyoto University (KUHE) 42968–42970 (former BORNEENSIS 22358–22360) (20 males) coll. 21 August 2004 by M. Matsui, K. Nishikawa, and T. Shimada; Sabah Parks (SP) 21630, 21631 (two females) coll. July 2006 by T. Shimada, all from the type locality.

Referred specimens

KUHE unnumbered (three tadpoles) from 6 km upstream from the type locality, Ulu Kimanis, Papar, coll. 1 September 2002 by M. Matsui; KUHE unnumbered (eight tadpoles) from Sg. (Sungai=River) Dalit, near the type locality, Ulu Kimanis, Papar, coll. 2 September 2002 by M. Matsui; KUHE unnumbered (two tadpoles) from the type locality, coll. 21 August 2004 by M. Matsui, K. Nishikawa, and T. Shimada; SP 03737, 03740, 03742 (17 tadpoles) from Kimanis, Papar; SP 20550–20554 (five males) from Sg. Terian, 900–1000 m a.s.l., Penampang, coll. by M. B. Lakim; SP 03096 (tadpoles) from Sg. Penataran, <500 m a.s.l., Kota Belud; SP 01643, 1645 (two males), SP 03548, 03551, 03559, 03562, 03658 (tadpoles) from Sg. Tinuman, near Kg. (Kampong=Village) Sayap, 650 m a.s.l., Kota Belud; SP 03564 (tadpoles) from Sg. Wario, Sayap Sub-Station, 900–950 m a.s.l., Kota Belud; SP 03225, 03235, 03243–03245 (tadpoles) from Sayap Sub-Station, 980 m a.s.l., Kota Belud; SP 03095 (tadpoles) from Marak-Parak (incorrectly spelled as Masak Pasak), around 250 m a.s.l., Kota Marudu; SP 03093 (tadpoles) from Kg. Nalumad, 550 m a.s.l., Ranau, all in Sabah.

Description of holotype (measurements in millimeters)

Body moderately slender (Fig. 1), SVL 37.1; head triangular, longer (15.1) than wide (12.4); snout moderately short (6.0) shorter than eye (6.4), pointed at tip in dorsal view, projecting in profile, projecting beyond lower jaw; canthus sharp, constricted; lores slightly oblique, concave; nostrils lateral, below canthus, distinctly closer to tip of snout than to eye; internarial distance (4.0) wider than interorbital (3.2), latter narrower than upper eyelid (3.8); eye elevated, diameter much larger than eye-nostril; pupil horizontal; tympanum distinct, length (4.3) two-thirds eye diameter and separated from eye by one-sixth of tympanum diameter (0.7); pineal spot visible, on line connecting anterior corners of orbits; vomerine teeth in short, slightly oblique groups, three to four teeth per group, separated by one-third length of one group from each other and by about same length of one group from choana, groups on line connecting rear rims of choanae; tongue deeply notched, without papilla; paired subgular vocal sacs form gular pouches at corners of throat; vocal openings just inside comissures of jaw.

Fingers slender, first finger slightly longer than second, length of first (6.7, measured from distal edge of inner palmar tubercle) subequal to diameter of eye; fourth finger much longer than second; tips of fingers expanded into disks having circummarginal grooves; disc of second finger (1.1) larger than that of first finger (0.9), discs of third (1.4) and fourth (1.5) fingers largest, one-third diameter of tympanum; no webs between fingers; no fringes of skin along fingers; subarticular tubercles oval and distinct; distinct inner and two indistinct, elongate outer palmar tubercles; no supernumerary metacarpal tubercles.

Hindlimb long (77.8) more than three times length of forelimb (23.8); tibia long (26.2), heels overlapping when limbs are held at right angles to body; tibiotarsal articulation of adpressed limb reaching to far beyond tip of snout; foot (19.8) shorter than tibia; toe disks similar to those of fingers in shape and size (disk diameter of fourth toe 1.4); webbing between toes full, extending to disks of all toes; narrow

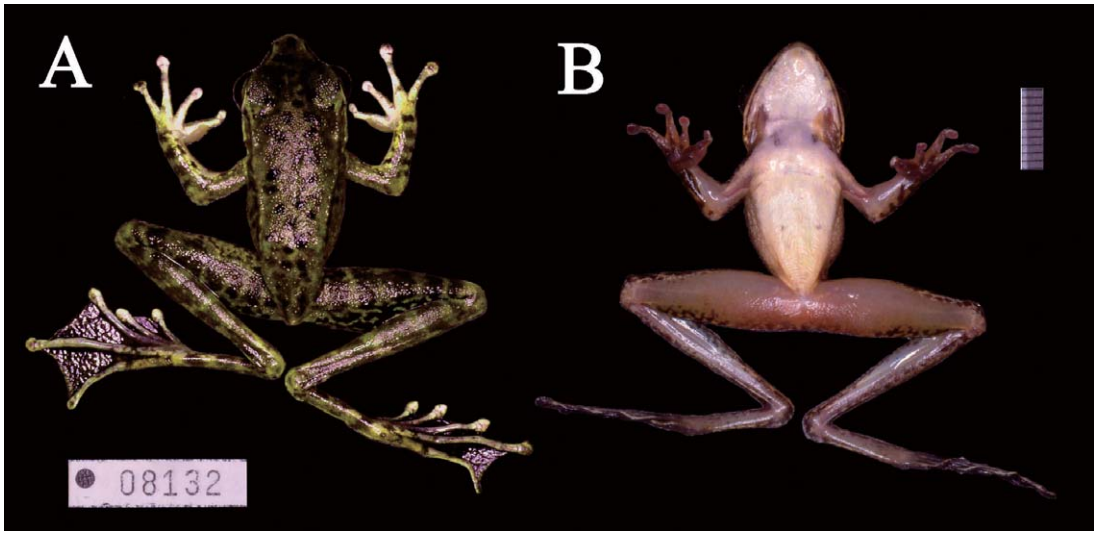

Fig. 1. **(A)** Dorsal and **(B)** ventral views of the male holotype of *Meristogenys maryatiae* (BORNEENSIS 08132). Scale bar, 10 mm.

fringes of skin along medial edge of first toe and outer edge of fifth toe from distal subarticular tubercle to base of disk; subarticular tubercles oval and distinct; an oval inner metatarsal tubercle, length (1.9) about two-fifths length of first toe (4.9) and slightly longer than distance between it and subarticular tubercle of first toe; a small, rounded outer metatarsal tubercle.

Dorsum shagreened; a low, indistinct dorsolateral fold; side of trunk coarsely granular; a weak fold above tympanum from eye; no rictal and axillary glands; no dermal ridge on tarsus; chest and abdomen smooth.

Cream-colored asperities forming a distinct nuptial pad covering dorsal and medial surfaces of the first finger from its base to subarticular tubercle, and dorsally to the base of disk.

Color

In life dorsum olive brown with dark spots (Fig. 1A); lores with indistinct dark marking below canthus; upper lip light brown with few darker spots; iris unicolored, golden (Fig. 3A); a blackish brown band around tympanum; tympanum dark brown with lighter center; limbs marked dorsally with alternating light and dark brown cross bars, the darker ones wider; rear of thigh dark brown mottled with irregular light spots (Fig. 3B); lower lips indistinctly barred with light brown; throat, chest, and abdomen whitish except for vocal sac, which is light brown (Fig. 1B); ventral surfaces of legs slightly darker, without dots of melanophores on legs; webs blackish brown. In preservative, the dorsal coloration has slightly faded, but otherwise no obvious change in color or pattern has occurred.

Fig. 2. **(A)** Dorsal, **(B)** lateral, and **(C)** ventral views of larval *Meristogenys maryatiae* (Stage 31, total length=32.9 mm). Scale bar, 10 mm.

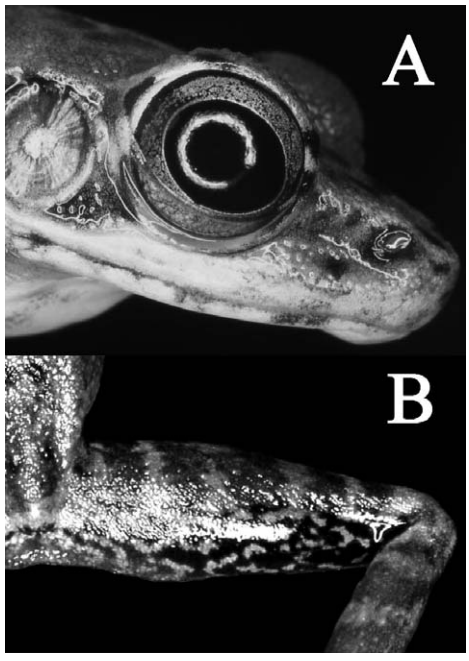

Fig. 3. **(A)** Anterolateral view of head and **(B)** posterior view of thigh of the male holotype of *Meristogenys maryatiae* (BORNEENSIS 08132).

Variation

Individual variation in size and body proportions is given in Table 1. Two females (SVL=65.1 and 65.5 mm) are larger than males (31.3–37.1 mm, mean±1SD=33.5±1.4 mm). Only two female samples limited statistical comparisons, but some dimensions relative to SVL seem to be sexually dimorphic. Males have larger values relative to SVL than females in eye length (15.5–18.2% vs. 13.4–14.1%), tympanum length (10.4–13.2% vs. 7.3–7.8%), internarial distance (9.8–12.9% vs. 9.0–9.2%), upper eyelid width (9.8–11.4% vs. 9.2%), lower arm length (50.5–54.4% vs. 49.3–49.9%), and fourth toe disk diameter (3.6–4.4% vs. 3.3%). Length of eye is subequal to snout in males, but is shorter than snout in females. Other than metachrosis, individuals are fairly uniform in coloration and pattern of markings, but the number and size of black spots on dorsum vary individually.

Eggs

The diameter of 19 ovarian eggs from two females ranged from 0.94–1.19 (mean±1SD=1.07±0.09) mm. The animal pole is black and the vegetal pole is pale yellow brown in color.

Larvae

Seventeen tadpoles of stages (Gosner, 1960) 28 (N=1, TOTL=28.5 mm, HBL=11.7 mm) to 40 (N=2, 42.8–43.4 mm, 17.9–18.0 mm) from near the type locality were examined in detail. Head-body oval, broadly rounded at snout, flat below, HBW maximum at level of spiracle, 70.0–92.6 (median=73.1%) of HBL; depth 30.5–46.3 (median=33.7%) of HBW; eyes dorsolateral, not visible from below, pointing outward, eyeball 12.1–16.9 (median=13.7%) of HBL; interorbital 166.7–229.2% (median=207.3%) of eye diameter; eye-snout distance 29.1–34.4% (median=30.2%) of HBL; nostril open, rim not raised, closer to eye than to tip of snout; internarial 60.0–72.7% (median=72.3%) of interorbital.

Oral disk ventral, width 56.0–63.8% (median=60.1%) of HBW; upper lip separated from snout by a groove; upper lip with a single row of papillae except for middle third, with a second, shorter inner row of larger papillae at corners of oral disk; lower lip with a single row of papillae across entire margin; denticles 7(4-7)/6(1) in older larvae stages (≥Stage 28), 6(3-6)/6(1) in younger stages (≤Stage 25, measurements not taken); both jaw sheaths (beaks) heavy, divided, and strongly ribbed; sheaths completely black though outer margins of upper covered with skin; margin coarsely serrate, 3–8 (median=6) serrae on each half of upper sheaths; 4–7 (median=5) serrae on each half of lower sheaths; base of upper sheaths M-shaped, lower V-shaped; a large suctorial abdominal disk following oral disk; transverse band of horny tissue present behind oral disk; length 59.4–65.4% (median=61.0%) of HBL; width 90.8–97.1% (median=95.4%) of HBW.

Spiracle sinistral; tube moderately long, length subequal to length of eyeball, pointing upward and backward, free of body wall for one-third of its length; anal tube median, free of tail; tail heavily muscled, dorsal margin strongly convex, deepest at middle, tapering to pointed tip; tail length 117.6–194.1 (median=140.8)% of HBL, maximum depth 23.5–34.2 (median=30.1)% of length; caudal muscle deeper than fins in basal half; dorsal fin origin behind body, fin deeper than ventral fin except in final fifth; ventral fin origin at end of proximal half of tail; head-body with four pairs of glandular clusters; an infraorbital cluster with 2–6 (median=4) glands, ventrolaterally below eye; a prespiracular cluster with 1–10 (median=5) glands, ventrolaterally at rear of head: a postorbital cluster with 3–8 (median=4) glands, laterally behind eye; a posterior midlateral cluster with 2–12 (median=6) glands, laterally at end of body; no ventral cluster; tail without dorsal fin cluster, but with ventral fin cluster with a row of 1–18 (median=8) glands at base of ventral fin just beyond its origin; head-body covered dorsally with minute keratinized spinules (surface projections); skin of head-body smooth in younger stages (≤Stage 25), but the area is occupied by spinules whose density increases posteriorly with stage of development; lateral line pores indistinct.

Color (in life) greenish yellow on head-body and tail, with black spots on body and caudal muscle; both fins without marking except for a fine, dark network (Fig. 2). Color (in alcohol) of head-body brown dorsally and laterally, sometimes scattered with small, black spots dorsally; caudal muscle lighter with dark mottling.

Comparisons

Of adults of eight species of *Meristogenys* hitherto described (Matsui, 1986), *M. kinabaluensis* (Inger, 1966), with a large body size (SVL=58.1–68.2 mm in males and 74.7–92.8 mm in females) and normally without an outer metatarsal tubercle, is easily differentiated from all the other species including the new species. These latter species form the *M. jerboa* group (Matsui, 1986, as the *Amolops jerboa* group), and are so similar in adult morphology that their identification is usually very difficult.

Other members of the *M. jerboa* group differ from *M. maryatiae* in the following characteristics. (1) *Meristogenys amoropalamus* (Matsui, 1986) has a broad web not extending beyond outermost tubercle of fourth toe, and a bicolored iris whose lower half is reddish brown (broad web reaching disk of fourth toe and iris unicolored golden in *M. maryatiae*). (2) *Meristogenys poecilus* (Inger and Gritis, 1983) and *M. whiteheadi* (Boulenger, 1887) have a large body, SVL usually greater than 41 mm in males and 66 mm in females (body small, SVL usually less than 38 mm in males and 66 mm in females in *M. maryatiae*). *Meristogenys whiteheadi* also has a short leg, tibia length relative to SVL usually less than 0.70 (long leg, relative tibia length usually greater than 0.70 in *M. maryatiae*). (3) *Meristogenys orphnocnemis* (Matsui, 1986) has the ventral surface of tibia with pigmentation and the web more poorly developed; excision between fourth and fifth toes usually proximal to distal edge of middle tubercle (ventral surface of tibia without pigmentation and web very well developed; excision between fourth and fifth toes distal to distal edge of middle tubercle in *M. maryatiae*). (4) In *M. phaeomerus* (Inger and Gritis, 1983) and *M. whiteheadi*, rear of thigh is dark brown, dusted with small light spots (rear of thigh pied dark brown and cream in *M. maryatiae*). (5) *Meristogenys macrophthalmus* (Matsui, 1986) has a wide head, width relative to SVL 0.37, and very large eye whose diameter far exceeds snout length (*M. maryatiae* has a narrow head, width relative to SVL less than 0.36, and normal eye whose diameter only slightly larger than snout length). (6) *Meristogenys jerboa* (Günther, 1872) resembles the new species in body size and shape,

but iris is bicolored, with the lower half reddish brown (iris unicolored, upper and lower halves golden in *M. maryatiae*). Dorsal dark spots in *M. maryatiae* seem a distinct feature, although some *M. orphnocnemis* and *M. amoropalamus* may have similar markings.

In larvae, *M. maryatiae* with four divided rows of upper labial teeth differs from *M. orphnocnemis*, *M. phaeomerus*, *M. poecilus*, and *M. jerboa*, all with three divided rows. From *M. whiteheadi* with undivided lower jaw sheath, *M. maryatiae* differs by having a narrowly divided jaw sheath. *Meristogenys amoropalamus* consists of cryptic species (Shimada et al., 2007a,b, 2008), and the one (*M*. cf. *amoropalamus* in Shimada et al., 2007b; morphotype 1 in Shimada et al., 2008) has four divided rows of upper labial teeth like *M. maryatiae*, but lacks dermal projections and possesses upper fin glands, unlike *M. maryatiae*. Another form of *M. amoropalamus* (morphotype 3-a in Shimada et al., 2008) has dermal projections and lacks upper fin glands like *M. maryatiae*, but has three divided rows of upper labial teeth in contrast to four rows in *M. maryatiae*.

Range

The new species is so far known from western Sabah, northern Borneo (Fig. 4): Ulu Kimanis (the type locality), Papar; Sg. Terian, Penampang; Sg. Penataran, Sg. Tinuman, near Kg. Sayap, Sg. Wario, and Sayap Sub-Station, Kota Belud; Marak-Parak, Kota Marudu; Kg. Nalumad, Ranau. The species ranges in altitude from 155 to 1000 m (median=625 m) a.s.l.

Natural history

The breeding season seems to include August, because two females collected in late July had nearly mature eggs in their ovaries. In late August, several calls were heard along a wide stream (width>10 m) at night, but we failed to record them. The call was similar to that of the other species including *M. jerboa* (as *Amolops*: Matsui et al., 1993). On another occasion, many males were found at night among stones and grass on riverbeds and on rocks in streams, but females were rarely seen. Tadpoles were seen clinging to bare rock in a shallow portion (depth<20 cm) of a swift stream. Associated anuran species observed include *Bufo juxtasper* Inger, 1964; *Limnonectes kuhlii* (Tschudi, 1838); and *Staurois latopalmatus* (Boulenger, 1887).

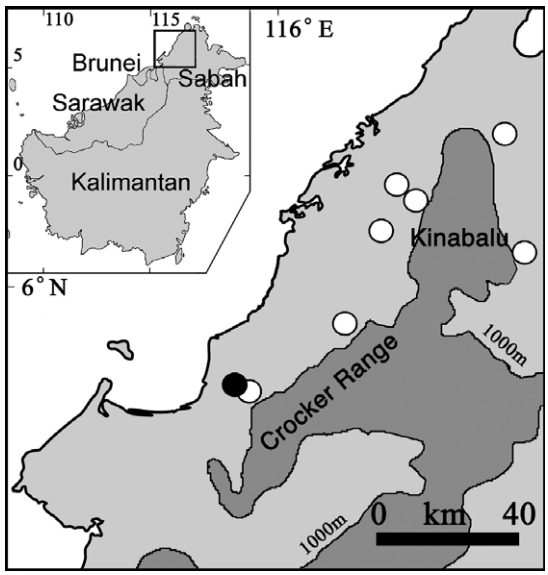

Fig. 4. Map of Sabah showing the type locality (closed circle) and known localities (open circles) of *Meristogenys maryatiae*. Darkly stippled area>1000 m a.s.l.

DISCUSSION

More than 40 years have elapsed since Inger (1966) first suggested the presence of many unnamed species of *Meristogenys* (as *Amolops*) in Borneo. Eight species were named by 20 years ago (Matsui, 1986), and Yang (1991) established the distinct generic status of this group. No new taxa, however, have been added to *Meristogenys* for two decades. This situation strongly contrasts with the cases of some other frog lineages from Borneo Island, e.g., *Leptolalax* (Malkmus, 1992; Matsui, 1997; Inger et al., 1997); *Leptobrachella* (Inger and Stuebing, 1991); *Megophrys* (Inger, 1989; Malkmus and Matsui, 1997); *Philautus* (Dring, 1987; Inger, 1989; Inger et al., 1995; Malkmus and Riede, 1996; Inger and Stuebing, 1996).

The lack of discovery of new taxa does not reflect a lack of taxonomic studies in the genus *Meristogenys*. What hinders most the taxonomy of this genus is simply the difficulty in identifying adults whose morphology is very similar. However, recent intensive surveys using molecular techniques have greatly promoted the elucidation of species diversity in *Meristogenys*, and taxonomic problems in this genus have steadily been clarified. The existence of some cryptic species is now becoming clear, and some species now treated as monotypic will be separated into several distinct forms (Shimada et al., 2007a, 2008).

The discovery of *M. maryatiae*, however, was made first through traditional morphological analysis, and then confirmed by molecular analysis. In 963-bp sequences of the mitochondrial 12S rRNA and Cyt b genes, and 1313-bp sequences of the nuclear POMC, Rag-1, and rhodopsin genes, *M. maryatiae* (*M*. sp. lineage 7 in Shimada et al., 2008) was distant from *M. jerboa*, but closer to *M. whiteheadi*, *M. orphnocnemis*, and *M. amoropalamus*, although a sister-group relationship was not supported (Shimada et al., 2008). However, because *M. maryatiae* largely resembles *M. jerboa* in adult morphology, it would be easily misidentified as the latter species.

Meristogenys maryatiae has a distributional range slightly overlapping that of *M. orphnocnemis*, but the known localities tend to be lower (155 to 1000 m, median=625 m a.s.l.) than for *M. orphnocnemis* (120 to 1300 m, median= 787 m a.s.l.; Matsui and Shimada, unpublished data), and therefore the streams it inhabits are larger. *Meristogenys jerboa* similarly inhabits the lowlands of Sarawak and might represent an ecological equivalent of *M. maryatiae* from Sabah, although DNA analyses do not support a sister-group relationship between the two, as stated above (Shimada et al., 2008).

Finally, after the discovery of *M. maryatiae*, the area of Ulu Kimanis, including the type locality of this species, has been developed for the construction of a road across the Crocker Range. Although the larvae of this species inhabit

mainly wide rivers and would not be seriously damaged, except by occasional water pollution, logging undertaken nearby for the road construction must be having adverse effects on the terrestrial life of metamorphs. Since several more endemic species in this area await description, immediate attention from the viewpoint of biodiversity conservation is required.

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REFERENCES

Altig R, McDiarmid W (1999) Body plan: development and morphology. In "Tadpoles: The Biology of Anuran Larvae" Ed by W McDiarmid, R Altig, University of Chicago Press, Chicago, pp 24–51

Dring JCM (1987) Bornean treefrogs of the genus *Philautus* (Rhacophoridae). Amphibia-Reptilia 8: 19–47

Frost DR (2009) Amphibian species of the world: an online reference. Version 5.3 (12 February, 2009). American Museum of Natural History, New York, electronic database accessible at http://research.amnh.org/herpetology/amphibia/index.html

Gosner KL (1960) A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 16: 183–190

Inger RF (1966) The systematics and zoogeography of the Amphibia of Borneo. Fieldiana Zool 52: 1–402

Inger RF (1985) Tadpoles of the forested regions of Borneo. Fieldiana Zool N S 26: i-v+1–89

Inger RF (1989) Four new species of frogs from Borneo. Malay Nat J 42: 229–243

Inger RF, Gritis PA (1983) Variation in Bornean frogs of the *Amolops jerboa* species group, with description of two new species. Fieldiana Zool N S 19: 1–13

Inger RF, Stuebing RB (1991) A new species of frog of the genus *Leptobrachella* Smith (Anura: Pelobatidae), with a key to the species from Borneo. Raffles Bull Zool 39: 99–103

Inger RF, Stuebing RB (1996) Two new species of frogs from southeastern Sarawak. Raffles Bull Zool 44: 543–549

Inger RF, Stuebing RB, Tan FL (1995) New species and new records of anurans from Borneo. Raffles Bull Zool 43: 115–131

Inger RF, Lakim M, Biun A, Yambun P (1997) A new species of *Leptolalax* (Anura: Megophryidae) from Borneo. Asiatic Herpetol Res 7: 48–50

Kueh BH, Sudin A, Matsui M, Maryati M (2004) Notes on the anurans of Crocker Range Park. In "Crocker Range Scientific Expedition 2002" Ed by M Maryati, Z Hamzah, T Tachi, N Jamili, Universiti Malaysia Sabah, Kota Kinabalu, pp 103–112

Malkmus R (1992) *Leptolalax pictus* sp. n. (Anura: Pelobatidae) vom Mount Kinabalu/Nord-Borneo. Sauria 14: 3–6

Malkmus R, Matsui M (1997) *Megophrys kobayashii*, ein neuer pelobatider Frosch vom Mount Kinabalu. Sauria 19: 31–37

Malkmus R, Riede K (1996) Die Baumfrösche der Gattung *Philautus* vom Mount Kinabalu-Teil I: Überblick und die *aurifasciatus*-gruppe mit der Beschreibung einer neuen Art (*Philautus saueri* n. sp.). Sauria 18: 27–37

Matsui M (1984) Morphometric variation analyses and revision of the Japanese toads (Genus *Bufo*, Bufonidae). Contrib Biol Lab Kyoto Univ 26: 209–428

Matsui M (1986) Three new species of *Amolops* from Borneo (Amphibia, Anura, Ranidae). Copeia 1986: 623–630

Matsui M (1997) Call characteristics of Malaysian *Leptolalax* with a description of two new species (Anura: Pelobatidae). Copeia 1997: 158–165

Matsui M, Wu GF, Yong HS (1993) Acoustic characteristics of three species of the genus *Amolops* (Amphibia, Anura, Ranidae). Zool Sci 10: 691–695

Matsui M, Shimada T, Liu WZ, Maryati M, Khonsue W, Orlov N (2006) Phylogenetic relationships of Oriental torrent frogs in the genus *Amolops* and its allies (Amphibia, Anura, Ranidae). Mol Phylogenet Evol 38: 659–666

Shimada T, Matsui M, Sudin A, Maryati M (2007a) Identity of larval *Meristogenys* from a single stream in Sabah, Malaysia (Amphibia: Ranidae). Zool J Linn Soc 151: 173–189

Shimada T, Matsui M, Sudin A, Maryati M (2007b) Ontogenetic changes in some larval characters of a species tentatively identified to *Meristogenys amoropalamus* (Anura, Ranidae). Cur Herpetol 26: 59–63

Shimada T, Matsui M, Yambun P, Lakim M, Maryati M (2008) Detection of two cryptic taxa in *Meristogenys amoropalamus* (Amphibia, Ranidae) through nuclear and mitochondrial DNA analyses). Zootaxa 1843: 24–34

Yang DT (1991) Phylogenetic systematics of the *Amolops* group of ranid frogs of Southeastern Asia and the Greater Sunda Islands. Fieldiana Zool N S 63: 1–42

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