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# NEW SPECIES AND NEW RECORDS OF BORNEAN FROGS (AMPHIBIA: ANURA)

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***ABSTRACT.* –** One hundred fifty four species of frogs have been recorded from Borneo and the number continues to grow. In this paper we describe two new species, *Ansonia echinata* and *Pelophryne saravacensis* (Bufonidae), and a new form of bufonid tadpole. In addition we report on a significant range extension for *Meristogenys whiteheadi* (Ranidae) and ecological differentiation of two species of the *Rana chalconota* complex (Ranidae).

***KEY WORDS.* –** Borneo, frogs, new species, geographic & ecological distribution.

## INTRODUCTION

Despite more than fifty years of rather intensive surveys of the anuran fauna of Borneo, it is clear that much remains to be learned both of the number of species that constitute the fauna and of the distributions of those species. One hundred fifty four species of anurans are currently known from the island and the number continues to grow. Here we describe two new species of the family Bufonidae and a new form of tadpole of the same family. In addition we report on a significant range extension of one of the known species (*Meristogenys whiteheadi,* Family Ranidae)and on ecological distributions of a pair of recently differentiated species (*Rana chalconota* group, Family Ranidae).

This new information results from our effort to characterize the anuran fauna of a newly developing plantation area of *Acacia mangium* in west-central Sarawak. Sixty five days spread over four years were devoted to field work in this area of exotic and natural vegetation, resulting in the finding of 45 species of anurans. These frogs were encountered in plots of *Acacia* or in the original secondary forests that are intercalated between *Acacia* plots. We also spent 27 days total in two forested sites peripheral to the plantation area, where 42 species were discovered, including 17 not found within the plantation area.

## MATERIAL AND METHODS

Specimens were caught by hand or, in the case of larvae, by use of electro-fishing in strong currents and dip nets in standing water. Specimens were preserved in 10% formalin. Liver tissue (adults) or tail clips (tadpoles) were preserved in 95% ethanol before specimens were placed in formalin. Adults were transferred to 70% ethanol after three to five months. Tadpoles remain in formalin. The following measurements of adults were made with a Mitutoyo calipers graduated to 0.01 mm: snout-vent length (SVL), tibia length (T) made with the leg flexed, head width (HW) made at the rear of the head. Four measurements on adults were made with an ocular micrometer at 12X magnification: eye diameter, tympanum diameter (TYM), snout length from the anterior border of the eye to the tip of the snout, width of the disc of the third finger (dF3). Measurements on tadpoles were also made using the ocular micrometer at 12X magnification: head-body length, head-body width, total length. Tadpoles were staged using the system of Gosner (1960). We use FMNH as the acronym for The Field Museum.

Total genomic DNA was extracted from tissues to verify association of certain tadpoles with species of adults. PureGene Animal Tissue DNA Isolation Protocol (Gentra Systems, Inc.) was used for the extraction. For two larvae of *Meristogenys* species (FMNH 272643, 272658) and three adults of *Meristogenys whiteheadi* (FMNH 272624, 272628 from Bukit Kana and FMNH 238286 from Purulon, Tenom District, Sabah) a 442–443 bp fragment of mitochondrial DNA that encodes part of the 12S rRNA gene was amplified by the polymerase chain reaction (PCR) following Shimada *et al.*, (2007). For three tadpoles of the *Rana chalconota* species group (FMNH 272647, 272678, 272682), two adult *Rana megalonesa* (FMNH 272605, 272867), and three adult *Rana raniceps* (FMNH 272602-04) a 572-576 bp fragment of mitochondrial DNA that encodes part of the 16S rRNA gene was amplified by PCR using the primers L-16SRana (5'-CCTACCGAGCTTAGAGATAGC-3')

and H-16SRanaIII (Stuart *et al.,* 2006). PCR products were electrophoresed in a 1% low melt agarose TALE gel stained with ethidium bromide and visualized under ultraviolet light. The bands containing DNA were excised and agarose was digested from bands using GELase (Epicentre Technologies). PCR products were sequenced in both directions by direct double strand cycle using Big Dye version 3 chemistry (Perkin Elmer). Cycle sequencing products were precipitated with ethanol, 3 M sodium acetate, and 1225 mM EDTA, and sequenced with a 3730 DNA Analyzer (ABI). Sequences were edited and aligned using Sequencher v. 4.1 (Genecodes). Sequences were deposited in GenBank under accession numbers (Field Museum numbers and field tags in parentheses):

GQ161200 (FMNH 272682 = RFI 52425)
GQ161201 (FMNH 272699 = RFI 52906)
GQ161202 (FMNH 272670 = RFI 52909)
GQ161203 (FMNH 272647 = RFI 53249)
GQ161204 (FMNH 272602 = RFI53366)
GQ161205 (FMNH 272605 = RFI 53367)
GQ161206 (FMNH 272603 = RFI 53385)
GQ161207 (FMNH 272604 = RFI 53387)
GQ161208 (FMNH 272867 = RFI 53389)

Sarawak localities mentioned in text:
Bukit Kana 2°39.363'N 112°54.219'E
Bukit Sarang 2°39'N 113°03'N
Matang 1°36'N 110°20'E
Nanga Tekalit 1°37'N 113°35'E
Samarakan 2°56'N 113°07'E
Sungai Mina camp 2°47'N 113°10'N
Sungai Penyilam camp 2°54'N 113°23'E
Sungai Pesu 3°07'N 113°48'E
Sungai Segaham 2°44'N 113°55'E
TamaAbu mts 3°40'N 115°20'E

## RESULTS

***Ansonia echinata*, new species (Bufonidae)**
(Figs. 1, 2)

***Holotype.* –** FMNH 272784, collected at Bukit Kana, Bintulu Division, Sarawak (2°39.363'N 112°54.219'E), on 28 Mar.2007, by Leong Tzi Ming, Freddy Julus, Patrick Francis, and Jacinta Richard. This specimen was collected at night perched on dead leaves at the edge of a small stream (3 m wide) in primary rain forest.

***Paratypes.* –** All collected at the same locality and along the same stream as the holotype. FMNH 272785 a male collected on the same night as the holotype but perched on the leaf of a shrub 1.0 m above ground; FMNH 272787 a male collected 3 Apr.2007, perched less than 1.0 m above ground on the leaf of a small herb 2.5 m from the water's edge; FMNH 272788 a male collected on 4 Apr.2007, perched on the leaf of a small herb 3.5 m from the water's edge.

***Diagnosis.* –** A small species of *Ansonia*, adult males 20.0–21.3 mm; males with black spines under mandible; first finger much shorter than second, tips of outer fingers not expanded; toes three and five with at least one phalange free of webbing; back with small and large rounded tubercles, those in dorsolateral region tipped with small black spines; chest and abdomen with rounded tubercles, ventrolateral ones larger and tipped with small black spines, tubercles on top of snout set with black spines.

***Etymology.* –** Specific name from *echinatus*, Latin for thorny, referring to the spinose tubercles on top of the snout and on the sides.

***Description.* –** Habitus moderately stocky; body wider than head in males; snout truncate in dorsal view, oblique in side view, projecting well beyond tip of mandible, snout longer than eye diameter; nostril lateral, near tip of snout; canthus sharply angular, constricted behind level of nostrils; lores vertical, not concave; eye diameter greater than eye-nostril

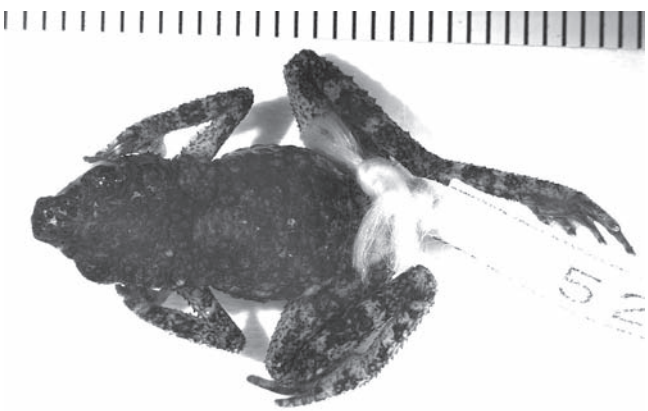

Fig. 1. *Ansonia echinata* new species. Dorsal view of holotype. Scale in mm.

Fig. 2. *Ansonia echinata* new species. Ventral view of holotype. Scale in mm.

distance; interorbital wider than upper eyelid; tympanum superficial, diameter slightly greater than half eye diameter; no crests on head.

Tips of all fingers rounded, not expanded; first finger much shorter than second, not reaching rounded tip of second; subarticular tubercles obscure; palm with low, rounded tubercles. Tips of all toes rounded; fifth toe projecting farther than third; first two toes fully webbed to tips laterally; third toe with 1–1 1/2 phalanges free of web laterally; fifth toe with two phalanges free of web medially; fourth toe with three phalanges free; subarticular tubercles obscure; sole of foot with small, low, rounded tubercles; two metatarsal tubercles, both oval and slightly raised; no tarsal fold.

Dorsal surfaces covered with small and large rounded tubercles, tubercles not arranged in distinct rows, those down center of back and along dorsolateral regions largest; tubercles along dorsolateral regions tipped with one or two small black spines; top of head with smaller rounded spinose tubercles, spines of these tubercles larger than those on back; eyelid with similar though smaller tubercles; sides and abdomen covered with low rounded tubercles, those in ventrolateral region larger (some ca. half diameter of tympanum) and tipped with small black spines; entire surfaces of limbs covered with spinose tubercles.

Colour in preservative dark brown above, raised tubercles yellowish brown; ventrally light yellowish brown without pattern; limbs with dark crossbars; no light streak below and behind eye.

Males have subgular vocal sacs with one large slit-like opening on either the right or left side in the floor of the mouth. The nuptial pad is a dense cluster of very fine dark spinules on the dorsal surface of the first finger. The ventral surface of the mandible has black spines, in two or three irregular rows beneath the symphysis and in a single row below the remainder of the jaw.

***Measurements (mm) and body proportions (holotype in parentheses).*** – Snout-vent length 20.0–21.3 (20.0); T/SVL 0.470–0.502 (0.470), HW/SVL 0.309–0.315 (0.315), TYM/SVL 0.054–0.075 (0.054), eye/snout 0.711–0.811 (0.811).

A juvenile (FMNH 272786), SVL 13.5 mm, has the spinose tubercles characteristic of this species. It was captured in water of a small stream (width 3 m) at the type locality.

***Comparisons.*** – Eleven species of *Ansonia* are known currently from Borneo. Only four of these—*albomaculata, hanitschi, minuta,* and *platysoma*—have adult males <25 mm SVL (Inger, 1960). However, the last three of these four differ from *A. echinata* (males <22 mm) in having widened, spatulate tips to the outer fingers and in lacking enlarged, spinose tubercles ventrolaterally and spinose tubercles on top of the snout. *Ansonia albomaculata* also differs from *A. echinata* in lacking enlarged, spinose tubercles ventrolaterally, spinose tubercles on top of the snout, and mandibular spines under the jaw. The light streak from below the eye that characterizes *A. albomaculata* (Inger, 1960) is absent in *A. echinata.*

The relatively short first finger and small size distinguish *Ansonia echinata* from *A. leptopus, A. longidigita,* and *A. spinulifer*, all of which have males larger than 30 mm and the first finger reaching the swollen tip of the second (Inger, 1960). *Ansonia latidisca*, *A. guibei*, *A. fuliginea*, and *A. torrentis* are larger (males >30 mm) than the new species and none has spinose tubercles dorsolaterally or on top of the snout (Dring, 1983; Inger, 1966). In contrast to *A. echinata, A. latidisca* has the tips of the outer fingers expanded while *A. guibei* males have the web reaching the swollen tips of the third and fifth toes. The nuptial pad of *A. fuliginea* consists of a cluster of 15–25 large black spines (Inger, 1966), very different from the cluster of very fine spinules in *A. echinata.*

As to the continental species, *A. ornate* Günther, *A. siamensis* (Kiew, 1984), and *A. latiffi* (Wood *et al.*, 2008) are significantly larger (males >25 mm snout-vent) than *A. echinata* and differ further in lacking spines on top of the snout. Males of *A. malayana*, *A. ornata, A. rubigina* (Pillai & Pattabiraman, 1981), *A. inthanon* (Matsui *et al.*, 1998), and *A. kraensis* (Matsui *et al.*, 2005) differ from *A. echinata* in having the third and fifth toes webbed to the swollen tips. *Ansonia penangensis* differs from *A. echinata* in having a longer first finger, which reaches the swollen tip of the second (Inger, 1960). None of these continental species has elevated, melanic spines on top of the snout. The recently described *A. jeetsukumarani* (Wood *et* al., 2008) is approximately the same size as *A. echinata* but lacks spinose tubercles on the snout and ventrolaterally, such as characterize *A. echinata,* and has the venter dotted with light spots. The Sumatran species, *A. glandulosa* (Iskandar & Mumpuni, 2004), is much larger (male 39.6 mm) than *A. echinata* and has no spines on top of the snout.

At the type locality, Bukit Kana, Sarawak, of *Ansonia echinata* we collected three kinds of *Ansonia* tadpoles, larval *A. longidigita* (as defined in Inger, 1992) plus two unassigned. Although strikingly different from one another, the last two are recognizably larval *Ansonia*—oral disc expanded and ventral, labial tooth rows 2/3, marginal papillae continuous across lower lip, upper beak divided into two separate pieces, muscular tail with relatively low fins. They differ in colouration, in size, in the degree of separation of the halves of the upper beak, in relative lengths of the upper and lower rows of labial teeth, in papillae of the lower lip, and in pattern of the coiling of the gut. One of the unnamed forms is identical to the *Ansonia* 'cruciform' tadpole described previously (Inger, 1992). Absence of tissues from *Ansonia echinata* prevented associating either of these two larval forms to that species by means of DNA sequencing.

**Tadpole *Ansonia* sp. "cruciform"** (Family Bufonidae)
(Figs. 3, 4)

***Material examined.* –** FMNH 272748-57.

***Description.* –** Headbody ovoid, widest slightly behind eyes, very slightly tapered; snout broadly rounded; nares closer to eyes than to tip of snout, eye-naris equal to diameter of eye and one-third naris-snout; eyes dorsolateral; internarial subequal to interorbital. Oral disc ventral, subequal to width of body; marginal papillae confined to lateral quarters of upper lip, continuous across margin of lower lip; no inframarginal papillae on lower lip; distance from lower beak to P3 subequal to distance from P3 to margin of lip; labial tooth rows 2/3, upper rows of labial teeth longer than lower rows but not curved around ends of lower ones; beaks slender, smooth; upper beak in separated halves; half of upper beak 0.40–0.90 (median 0.58, n = 11) of gap between halves.

Spiracle opening midway between eye and end of body, tube fused to body wall.

Gut in transverse coils.

Tail tapered slightly in distal fourth to rounded tip; caudal muscle deeper than fins except in distal third.

Colouration (in preservative) black and white (cream) at all stages 27–42; a transverse orbital dark band ca. as wide as eye diameter, beginning at ventrolateral margin and extending across body; a pair of wide dark longitudinal bands from rostrum through nostrils and narrowly separated from dark orbital band; a wide dark transverse band near end of body; mid-dorsal dark band from orbital band extending through posterior band and covering caudal muscle except for a narrow strip along dorsal margin and a wider light strip along ventral margin; fins without pigment except for narrow dark marginal strip on the dorsal fin; ventral surface of body immaculate cream-colored.

Head-body lengths (HBL) are given in Table 1. Total lengths varied from 13.5 mm (stage 36) to 16.5 mm (stage 37). HBL/total 0.38–0.43 (n = 6).

These tadpoles were collected at Bukit Kana (250 m ASL) in large (13–15 m wide), rocky, clear streams, in riffles, torrents, and, in the case of one tadpole, in an open pool.

This larval form is identical to that labelled "*Ansonia* cruciform" in Inger (1992). The tadpoles studied for that publication came from northern Sarawak (Long Seniai 3°27'/114°57'E) and western Sabah (Mendolong 4°54'N/115°42'E; Poring Station 6°03'N/116°42'E; 6 km E of Tuaran 6°11'N/116°14'E).

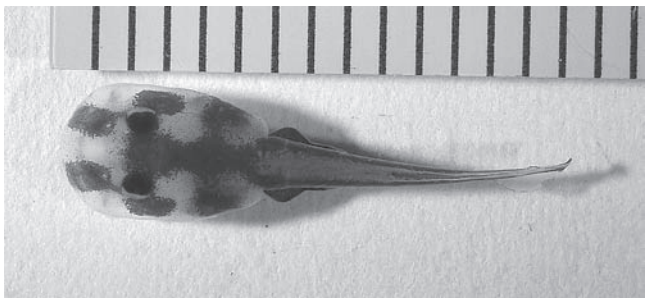

Fig. 3. *Ansonia* sp cruciform. Dorsal view of larva. Scale in mm.

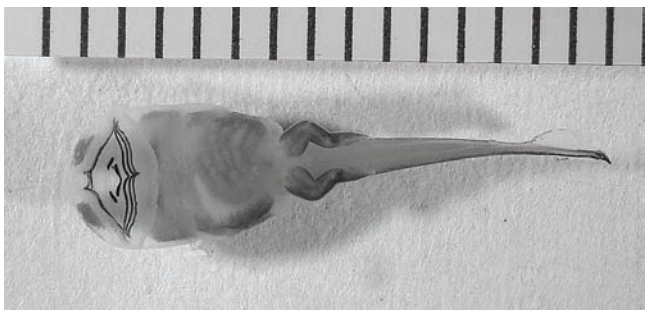

Fig. 4. *Ansonia* sp cruciform. Ventral view of larva. Scale in mm.

**Tadpole *Ansonia* sp. cruciform2** (Bufonidae)
(Figs. 5, 6)

FMNH 272705-47.
Headbody teardrop-shaped, widest at plane through nares, distinctly tapered; snout very broadly rounded; nares much closer to eyes than to tip of snout, eye-naris distance less than eye diameter and one-third naris-snout; internarial distance slightly narrower than interorbital. Oral disc ventral, slightly narrower than maximum body width; marginal papillae of upper lip confined to lateral quarters; marginal papillae continuous across lower lip; inframarginal papillae present in lateral thirds of lower lip; distance from lower beak to P3 greater than distance from P3 to margin of lip; labial tooth rows 2/3, upper rows longer, but not curling around ends of lower rows; beaks slender, upper smooth, lower feebly serrate; upper beak in separated

Fig. 5. *Ansonia* sp. cruciform2. Dorsal view of larva. Scale in mm.

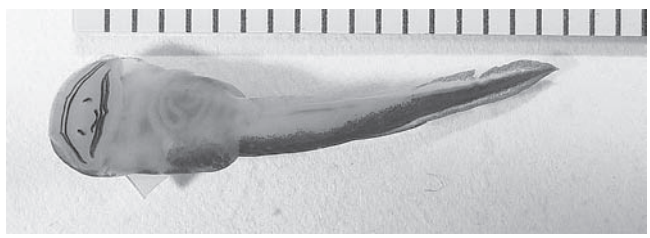

Fig. 6. *Ansonia* sp. cruciform2. Ventral view of larva. Scale in mm.

Table 1. Comparison of head-body lengths (mm) of two forms of *Ansonia* tadpoles from Borneo.

| Stage | Cruciform2 | Cruciform |
|---|---|---|
| 5 | 5.9 | |
| 26 | 5.4 | |
| 27 | 8.2 | 3.8 |
| 28 | 7.4 | |
| 29 | 7.9 | |
| 30 | 7.5 | |
| 31 | 7.6 | |
| 32 | 8.1 | 5.1 |
| 33 | 7.8 | 5.5 |
| 35 | 8.4 | 5.9 |
| 36 | 8.6 | 5.8 |
| 37 | | 6.7 |
| 40 | | 6.3 |
| 41 | 9.4 | 6.4 |
| 42 | 9.4 | 6.9 |
| n | 28 | 15 |

halves, half of upper beak 0.26–0.39 (median 0.31, n = 19) of gap between halves.

Spiracle opening low on side, midway between eye and end of body, tube fused to body wall.
Gut in circular coils.

Tail tapered slightly in distal fifth to a point; caudal muscle deeper than fins except in distal fourth.

Coloration (in preservative) dark brown or black dorsally and laterally, immaculate white (cream in life?) ventrally; slightly lighter anterior to eyes; a transverse light band, half diameter of eye, across body behind eyes, interrupted mid-dorsally; a light streak beginning ventrolaterally above corner of oral disc and extending back to postorbital light band; light ventral area curling up behind end of body; caudal muscle dark brown except for light ventral margin; fins whitish with black margins

Head-body lengths are given in Table 1. Total lengths 22.6 (stage 35) to 26.8 (stage 41).

These larvae were collected at Bukit Kana (250 m ASL) in large (width 13–15 m), clear, rocky streams. Fifteen samples (79%) were found in torrents, three (16%) in riffles, and one in an open pool. Of the 70 stations searched on these streams, 36 (51%) were torrents, 29 (41%) were riffles, and 5 were open pools or side pools. Search for tadpoles was carried out in smaller (width 3 m) streams, but no larvae of this species were found. Of the 29 stations on these small streams,16 (55%) were riffles, seven (24%) were open pools, three were leaf drifts, and three were side pools.

Larval *Ansonia longidigita* were collected from the same two large streams, 24 samples from torrents and one from a riffle. No larval *A. longidigita* were found in the small (width 3 m) streams.

Altogether 46 samples of larval *Ansonia* were collected at Bukit Kana. Five samples included tadpoles of *A. longidigita* and *A.* cruciform, one sample included larval *A.* cruciform and *A.* cruciform2, and two samples included all three larval forms.

### ***Pelophryne*** Barbour (Bufonidae)

***Remarks.*** **–** There are two general morphotypes among the Bornean species of this genus—one with the tips of the fingers expanded into truncate discs and one with the tips of the fingers rounded and not expanded. The latter group includes only three species—*P. misera* (Mocquard) known from high elevations on Mt. Kinabalu, *P. api* Dring from a wide altitudinal range in northern Sarawak, and the recently described *P. linanitensis* Das—which are easily distinguished from one another.

Both the recognition of species within the group having expanded finger tips and the association of specimens with named taxa have posed problems. There are six similar, nominal Bornean taxa in this group: *guentheri* (Boulenger), *macrotis* (Boulenger), *signata* (Boulenger), *exigua* (Boettger), *rhopophilius* Inger & Stuebing, and *murudensis* Das. In the past very small samples and lack of multi-species samples from single localities have made it difficult to decide if differences among the morphotypes represent intraspecific or interspecific variation. Roux (1906), for example, placed *exigua* in the synonymy of *guentheri*, stating that the type of *exigua* was merely a juvenile *guentheri*; however, the type of *exigua*, which we have examined, is an adult male having vocal sac openings and mandibular spinules. Inger (1966) placed both *exigua* and *signata* in the synonymy of *brevipes* (Peters), a Philippine species; examination of new material calls that decision into doubt (Inger & Tan, 1996). The recently described species, *P. rhopophilius*, was the first species based on a type series of more than two specimens. The seven frogs constituting this type series show little variation in size, secondary sex characters, coloration, and body proportions (Inger & Stuebing, 1996). Das (2008) has recently described *P. murudensis*, based on a sample of four specimens that also exhibit little intraspecific variation.

We now have five samples from Sarawak, each consisting of at least five individuals; three of these samples consist of two morphotypes. One of these morphotypes is small: males having vocal sacs, yellowish mandibular spines, and a nuptial pad of fine, light spinules measure 13.5–15.9 mm snout to vent (n = 9) and adult females 15.3–17.6 mm (n = 9). They have two consistent elements of coloration: (1) The venter is cream or yellow with small, isolated black spots; the dark pigment occupies less than one-third of the ventral surface, and the light coloration extends half-way up the side. (2) The side of the head is dark with a wide cream or yellow streak running from below the eye under

the tympanum and over the axilla where it is continuous with the light colour of the side. In coloration, size, and secondary sex characters, this morphotype agrees with the types of *P. signata* (Boulenger) (BM 1947.2.19.25–26), and *P. exigua* (Boettger) (SMF 3737); we have examined types of both nominal species. We assign this small form to *Pelophryne signata* (Boulenger) and place *Nectophryne exigua* Boettger in its synonymy. *Pelophryne signata*, as here defined, is about the same size as the Philippine species *P. brevipes* (Peters): males 16.0–17.8 (n = 5), females 16.6–17.4 (n = 3), but *P. brevipes* has brown or black pigment covering most of the belly and underside of the hind limb and lacks the uninterrupted light lateral streak present in *signata*.

The second morphotype in each of these multi-species samples is larger: adult males with nuptial pads and vocal sacs measure 17.0–24.6 mm and adult females 19.1–24.3 mm. Males do not have conical or spinose tubercles under the mandible. All have the dorsal surface set with small spinose tubercles and scattered larger tubercles that do not form a pattern. Dorsally all are brown (in preservative) with small, irregular darker markings. The side of the head is lighter with dark spots. These frogs fall into two groups. In one (*P. rhopophilius*), snout-vent length of adult males (with nuptial pads) ranges from 21.6 to 24.6 mm (mean ± SE = 22.70 ± 0.26; n = 11); the single adult female measures 24.3 mm. The abdomen in this group is mottled black and white (in preservative), with the light areas elongate and irregular in shape. The second group is slightly smaller with adult males 17.2–20.0 mm (mean ± SE = 18.98 ± 0.65; n = 4) and two adult females 19.1 and 21.6, the last having enlarged, non-pigmented ova. The abdomen is dark with many discreet, small, round, white spots. We treat this second group as a distinct species that we describe below as *Pelophryne saravacensis*.

The other large form of *Pelophryne* from Borneo, *P. guentheri* (Boulenger), is larger with females 28.3–31.1 mm (n = 4) and a mature male 29.9 mm, the last having a row of mandibular spines. We consider *P. macrotis* (Boulenger), its type examined by us, to be conspecific with *P. guentheri*.

The type series of *P. murudensis* Das from northern Sarawak consists of males measuring 21.9–25.6 mm (Das, 2008). These differ from the species described below in several respects (see below).

### ***Pelophryne saravacensis***, new species
(Figs. 7, 8)

***Holotype.–*** FMNH 223014, adult male collected at Sungai Segaham, Belaga District, Kapit Division, Sarawak (2°44'N/113°55'E), on 6 Jun.1984, by Robert F. Inger and Paul Walker.

***Paratypes*** (all from Sarawak). – FMNH 223012, 223015–17, 223019, 223021–23 from the type locality; FMNH 128131 from Tama Abu Mts., Baram District, Miri Division (3°40'N/115°20'E); FMNH 138111 from Nanga Tekalit, Kapit Division (1°37'N/113°35"E); FMNH 157119 from Sungai Pesu, Bintulu Division (3°07'N/113°48'E).

***Diagnosis. –*** Tips of fingers expanded into truncate discs, tip of third finger equal to or wider than tympanum; webbing leaving one to 1 ½ phalanges of outer fingers free; heels meet when legs folded at right angle to body axis; no continuous ventrolateral light band; abdomen dark with small, distinct white spots; males without mandibular spines; adult males 17–20 mm, adult female 22 mm.

***Description. –*** Habitus slender; head as wide as trunk. Snout truncate with median projection, vertical in profile or weakly projecting; nostril near tip of snout; canthi rounded, constricted; lores vertical; diameter of eye equal to length of snout; interorbital about 1.5 times width of eyelid; tympanum superficial, oval, rim usually visible, about 1/3 to 2/5 diameter of eye.

Tips of fingers expanded, truncate; disc of third finger equal to or wider than tympanum; fingers with fleshy web, less than one phalanx of first finger projecting, other fingers webbed at bases only; subarticular tubercles obscure. Tips of toes truncate or rounded, not expanded, smaller than tips of fingers; fifth toe longer than third; webbing fleshy; only tips of first three toes projecting from web, fifth toe webbed to distal subarticular tubercle; fourth toe webbed to middle


Fig. 7. *Pelophryne saravacensis,* new species. Dorsal view of holotype. Scale in cm.


Fig. 8. *Pelophryne saravacensis,* new species. Ventral view of holotype. Scale in cm.

tubercle; subarticular and metatarsal tubercles indistinct, but present; no tarsal ridge; when legs folded at right angles to body axis, heels meet or overlap slightly.

Back and sides with large, round tubercles, most less than half diameter of tympanum; numerous fine, colorless spinules between tubercles of back; dorsal surfaces of limbs densely covered with conical tubercles; belly coarsely granular.

Color in preservative sandy brown to pale tan dorsally; a dark interorbital triangle, apex to rear, with thin anterior projection; some individuals with a faint dark triangle or elongated trapezoid in lumbar region; side of head dark brown with irregular creamy areas, but no continuous light band from below eye to axilla; side of trunk brown with small, irregular light and dark spots; ventrally dark brown with small, discrete, white spots, dark pigment occupying more than half of surface. In life, several individuals with small red spots on larger dorsal tubercles.

Adult males 17.2–20.0 mm (n = 4); yellowish nuptial pad on mediodorsal surface of first finger; vocal sac openings slit-like; no mandibular spines. Only one adult female, 21.6 mm. Body proportions (adults only): T/SVL 0.48–0.53, HW/SVL 0.30–0.34, TYM/SVL 0.049–0.069, dF3/SVL 0.053–0.62.

***Comparisons.*** – This species is similar to *P. guentheri, P. signata, P. rhopophilius,* and *P. murudensis* in the expanded, truncate finger discs. However, it is distinctly smaller than *P. guentheri* (both sexes > 28 mm SVL), *P. rhopophilius* (males 21.6–24.6 mm), and *P. murudensis* (males 21.9–25.6 mm; Das, 2008). *Pelophryne saravacensis* has a longer leg than *P. guentheri* and *P. murudensis* (T/SVL of *P. guentheri* 0.39–0.40, n = 4; of *P. murudensis* 0.38–0.44, n = 4). Das (2008) noted that the heels of *P. murudensis* did not meet when the legs were flexed at right angles to the body axis; in *P. saravacensis* the heels meet or overlap in that position.

*Pelophryne saravacensis* differs from *P. rhopophilius* in not having a strongly projecting snout and from the latter and *P. murudensis* in coloration. In *P. rhopophilius* the abdomen is light with anastamosing, dark lines; less than half of the area is covered with dark pigment. In *P. saravacensis*, the abdomen is dark with small light spots and much more than 50% of the area is dark. In *P. murudensis* the lower side has a continuous broad band of light (buff) coloration, whereas in *P. saravacensis* that area is brown with small light and dark spots.

*Pelophryne saravacensis* is larger than *P. signata*; adult males of the latter measure 13.9–15.9 (n = 9) and adult females 15.3–17.6 (n = 9). In addition males of the smaller *P. signata* have mandibular spines, which are lacking in *P. saravacensis*. The abdomen of *P. signata* is yellow with small, scattered black spots and the sides of the head and trunk have a continuous light streak, contrasting with the coloration of *P. saravacensis* (see above).

***Meristogenys whiteheadi*** (Boulenger) (Ranidae)

***Remarks.*** – Large samples of *Meristogenys* frogs and tadpoles were collected at Bukit Kana, Bintulu Division, Sarawak. These frogs are relatively large for species of *Meristogenys*. Males measure 48.8–57.4 mm SVL (mean ± SE = 54.07 ± 0.39, n = 32); females measure 77.2–79.7 mm (n = 3) (FMNH 272607–41). The rear of the thigh in these frogs is brown with large, irregular areas of lighter color (yellow in life?). The ventral surface of the calf is dusted with scattered melanophores. All but two have round black spots on the back, usually covering most of the surface. The sides of the body are much lighter than the back and are heavily spotted in most individuals. The throat is densely dusted. Only one type of *Meristogenys* tadpole was collected at Bukit Kana (FMNH 272642–78, Gosner stages 25–40). The labial tooth formula of the upper lip is 7(4-7) (n = 22), that of the lower lip 6(1) (n = 2), 7(1) (n = 15), or 8(1) (n = 4). The upper jaw sheath is divided with 8–16 ribs in each half. The lower jaw sheath is single with 14–23 ribs. There are 0–5 glands in the ventral fin (median = 2). Two tadpoles of this sample differ from three adults in only three sites of a 442 bp fragment of 12S, verifying association of these larvae with the adult species.

Four species of *Meristogenys* have been described from Sarawak, one from the southwestern corner of the state and three from central Sarawak. *Meristogenys jerboa* (Günther, 1872) from southwestern Sarawak (type locality Matang 1°36'N 110°20'E, Kuching Division) is relatively small. Males are 32–41 mm SVL (mean 35.50 ± 0.25, n = 48), and females 61–68 mm (mean 63.66 ± 0.77, n = 9). The rear of the thigh is brown with irregular large and small light spots. The sides are darker brown than the back. The light median strip of the ventral surface of the calf is immaculate white or, less often, with a few scattered melanophores. The tympanum of the male is distinctly enlarged compared to that of the female. The tadpoles of this species have both jaw sheaths divided, three divided rows of labial teeth on the upper lip and six (rarely five) undivided rows of labial teeth on the lower lip (Inger, unpublished data).

*Meristogenys macrophthalmus* (Matsui, 1986) (type locality Sg Pesu, 3°07'N 113°48'E) from the Bintulu Division is small, the unique holotype male measures 36.7 mm. It lacks dark spots on the back. The tympanum is enlarged, TYM/SVL = 0.114. Larvae have not been assigned to this species, but three were collected at the type locality. These are small (HBL 5.2–6.7 mm) stage 25 tadpoles having the lower jaw sheath divided, each half with 6 ribs, and denticular formula 6(4–6)/5(1) (Inger, unpublished data).

*Meristogenys poecilus* and *M. phaeomerus* (Inger & Gritis, 1983) were described from the Kapit District (Nanga Tekalit, 1°37'N 113°35'E). Males of *M. poecilus*, the larger of these two species, measure 34.5–51.0 (mean 44.08), and thus are significantly smaller than the Bukit Kana males (see above). The rear of the thigh in *M. poecilus* has large light areas on a dark brown background. The area behind the tympanum and above the axilla is dark brown. About 10%

of the paratypes have dark spots dorsally. Tadpoles of *M. poecilus* have both jaw sheaths divided and have only three divided rows of labial teeth on the upper lip and only 4–5 undivided rows on the lower lip (Inger & Gritis, 1983).

Males of *M. phaeomerus* measure 33.0–43.0 mm (mean 38.25) and have the rear of the thigh brown dusted with fine light spots. The side from behind the tympanum and extending almost to the groin is dark brown. The back is marked with small dark spots. Tadpoles of this species have both jaw sheaths divided and only three undivided rows of labial teeth on the upper lip and five undivided rows on the lower lip (Inger & Gritis, 1983).

The Bukit Kana species differs from all four of the Sarawak species—*M. jerboa, macrophthalmus, phaeomerus,* and *poecilus*—in several ways. Adults are larger than all four of those. The relative size of the tympanum in males of the Bukit Kana form (median 0.079) is smaller than in males of the four Sarawak species (median TYM/SVL 0.096, 0.114, 0.100, 0.099, respectively Larvae of the Bukit Kana species differ from larvae of *jerboa, phaeomerus,* and *poecilus* and from the larvae found at the type locality of *macrophthalmus* in the denticular formula and in the lack of division of the lower jaw sheath.

The Bukit Kana species is most similar in size of adults and larval characters to *M. whiteheadi,* which is known so far only from Sabah at elevations between 200 and 990 m ASL (unpublished data). Males of *M. whiteheadi* from Sabah measure 48.7–62.4 mm (mean 53.90, n = 72) and females 77.9–86.5 mm (n = 3). Larvae of *M. whiteheadi* have the lower jaw sheath single and have four divided rows of labial teeth in the upper lip. Thus in both size of adults and these larval characters there is agreement between the Bukit Kana species and *M. whiteheadi.* There are several differences, however. Larvae of *M. whiteheadi* from Sabah usually have five undivided rows of labial teeth in the lower lip, in contrast to six in the Bukit Kana species. Adults of *M. whiteheadi* in our Sabah samples lack black spots dorsally, though some individuals have an obscure dark mottling.

***Rana chalconota*** group (Family Ranidae)

***Remarks. –*** It has recently been determined that there are two species of this group in Borneo, *Rana raniceps* (Peters) and *Rana megalonesa* Inger, Stuart & Iskandar (2009). The former species has been found so far only in swampy and low-lying coastal areas of Sarawak whereas *R. megalonesa* has been collected over a wide area of western and northern Borneo (Sarawak and Sabah) (Inger *et al*., 2009). Both species have been collected at four localities in the Bintulu Division of Sarawak. Two of those localities, Bukit Sarang and Sungai Penyilam, are swamp forests. At Bukit Sarang we found both species along the same slowly flowing streams, but *R. raniceps* more often along non-riparian trails: *raniceps* 6 non-riparian of 8 total; *megalonesa* 2 non-riparian of 11 total. At Sungai Penyilam both species were found along the banks of slowly flowing streams. We collected both species at two localities, Sungai Mina and Samarakan that have both flat and hilly terrain. At Samarakan we found *R. raniceps* in swamps and along streams, but *R. megalonesa* only along streams. At Samarakan both were found in a single night along a small stream (width 2 m) flowing through secondary forest. The lower reaches of that stream passed through a sedge marsh where the bottom was deep mud. Upstream from that segment, the stream flowed over a rocky bed with moderate gradient. On that night 15 *R. raniceps* (FMNH 272602–4, 272797–810) were caught in the marshy portion of the stream, but none in the rocky portion, whereas two *R. megalonesa* (FMNH 272604, 272867) were found in the rocky area and one in the marshy segment (FMNH 272605). At the Sungai Mina site, both species were found along stream banks, but only one (of four) *R. megalonesa* was found along a small stream (width 2 m) with four (of seven) *raniceps*. At Bukit Kana, an area of steep topography lying at 200–300 m ASL in the Bintulu Division, we found only *R. megalonesa*, all on the banks of streams 3–15 m wide.

These observations indicate that, in the region where the two species occur, *Rana megalonesa* has a wider ecological distribution than *R. raniceps*, which seems to be restricted to flat, even swampy, habitats.

Tadpoles belonging to the *Rana chalconota* group were collected at Bukit Kana and at Samarakan. The 16S gene of three tadpoles, two from Bukit Kana and one from Samarakan, differs by 0–9 of 572 bp from two adults of *Rana megalonesa* but by 60–64 bp plus six single bp gaps out of 576 bp of three adults of *Rana raniceps*. All five adults were from Samarakan. We assign the tadpoles to *R. megalonesa*. These tadpoles agree with the description of larval *R. chalconota* (Inger, 1985) which, given the

Fig. 9. Ventral view of larval *Rana megalonesa* showing post-oral patches of glands.

localities of the latter, were probably *R. megalonesa*. The single difference from those earlier described tadpoles is that in the present ones the ventral post-oral glandular patch is divided into two separate round groups (Fig. 9).

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## LITERATURE CITED

Das, I., 2008. Two new species of *Pelophryne* (Anura: Bufonidae) from Gunung Murud, Sarawak (Northwestern Borneo). *Raffles Bulletin of Zoology*, **56**(2):435–443.

Dring, J., 1983. Some new frogs from Sarawak. *Amphibia-Reptilia*, **4**:103–115.

Gosner, K. L., 1960. A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica*, **16**:183–190.

Günther, A., 1872. On the reptiles and amphibians of Borneo. *Proceeding of the Zoological Society of London*, **1872**: 586–600.

Inger, R. F., 1960. A review of the Oriental toads of the genus *Ansonia* Stoliczka. *Fieldiana: Zoology*, **39**:473–503.

Inger, R. F., 1966. The systematics and zoogeography of the Amphibia of Borneo. *Fieldiana: Zoology,* **52**:1–402.

Inger, R. F., 1985. Tadpoles of the forested regions of Borneo. Fieldiana:Zoology (n.s.) no. 26, 89 pp.

Inger, R. F. 1992. Variation of apomorpic characters in stream-dwelling tadpoles of the bufonid genus *Ansonia* (Amphibia: Anura). *Zoological Journal of the Linnean Society*, **105**: 225–237.

Inger, R. F. & P. A. Gritis, 1983. Variation in Bornean frogs of the *Amolops jerboa* species group, with description of two new species. *Fieldiana: Zoology* (n.s.) No. **19**: 1–13

Inger, R. F., B. L. Stuart & D. T. Iskandar, 2009. Systematics of a widespread south-east Asian frog, *Rana chalconota* (Amphibia: Anura: Ranidae). *Zoological Journal of the Linnean Society*, **155**: 1230–147.

Inger, R. F. & R. B. Stuebing, 1996. Two new species of frogs from southeastern Sarawak. *Raffles Bulletin Zoology*, **44**: 543–549.

Inger, R. F. & Tan F.-L., 1996. Checklist of the frogs of Borneo. *Raffles Bulletin Zoology*, **44**: 551–574.

Iskandar, D. T. & Mumpuni, 2004. A new toad of the genus *Ansonia* (Amphibia, Anura, Bufonidae) from Sumatra, Indonesia. *Hamadryad*, **28**: 59–65.

Kiew B.-H., 1984. A new species of toad, *Ansonia siamensis* (Bufonidae), from the Isthmus of Kra, Thailand. *Natural History Bulletin Siam Society*, **32**: 111–115.

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

Matsui, M., J. Nabhitabhata & S. Panha, 1998. A new *Ansonia* from northern Thailand (Anura: Bufonidae). *Herpetologica*, **54**:448–454.

Matsui, M., W. Khonsue, & J. Nabhitabhata, 2005. A new *Ansonia* from the Isthmus of Kra, Thailand (Amphibia, Anura, Bufonidae). *Zoological Science*, **22**: 809–814.

Pillai, R. S. & R. Pattabiraman, 1981. A new species of torrent toad (Genus: *Ansonia)* from Silent Valley, S. India. *Proceedings Indian Academy Sciences* (Animal Series), **90**: 203–208.

Roux, J., 1906. Synopsis of the toads of the genus Nectophryne B. & P., with special remarks on some known species and description of a new species from German East Africa. *Proceedings Zoological Society London*, **1906**: 58–65.

Stuart, B. L., R. F. Inger & H. K. Voris, 2006. High level of cryptic species diversity revealed by sympatric lineages of Southeast Asian forest frogs. *Biology Letters*, **2**: 470–474.

Wood, P. L. Jr., L. L. Grismer, N. Ahmad & J. Senawi, 2008. Two new species of torrent-dwelling toads *Ansonia* Stoliczka, 1870 (Anura: Bufonidae) from Peninsular Malaysia. *Herpetologica*, **64:** 321–340.