

RECENTLY DISCOVERED AND NEWLY ASSIGNED FROG LARVAE (RANIDAE AND RHACOPHORIDAE) FROM BORNEO

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ABSTRACT. - The tadpoles of *Rhacophorus angulirostris* and *R. baluensis* are described for the first time. The tadpole of *Rhacophorus gauni* is redefined and a recently described, slender benthic tadpole is assigned to a species.

INTRODUCTION

Within the last four years, field work in Sabah, Borneo has resulted in the collection of many larval forms of frogs. The majority of these new samples have shed light on developmental patterns and ecological distribution of forms already known. In this paper, we describe a few that enable us to assign poorly understood larvae to parental species.

MATERIALS AND METHODS

All specimens were preserved in formalin and, with the exception of a few tadpoles collected more than 25 years ago, held in buffered formalin since collection. Specimens are in the collections of Field Museum of Natural History (FMNH), Chicago, U.S.A.; Sabah Parks (SP), Kota Kinabalu, Sabah, Malaysia; and Universiti Kebangsaan Malaysia, Sabah Kampus (UKMS), Kota Kinabalu, Sabah, Malaysia. Some specimens have not yet been integrated into these collections and are listed by field catalogue numbers indicated by the abbreviation RFI.

Tadpoles are staged according to Gosner (1960). Denticle counts follow the system devised by Altig (1970). In this scheme, rows of denticles are numbered, beginning with the anterior-most row of each lip. The row number of any divided row is shown in parentheses, and the counts for the two lips are separated by a slash mark. Thus, 3(2-3)/4(I) indicates that the upper or anterior lip has three rows of denticles of which the second and third (that is, the two rows closest to the mouth) are divided, and the lower or posterior lip has four rows of which the first (i.e., the innermost) is divided.

All measurements were made using an ocular grid at a magnification of X 12. Abbreviations used are HBL for head-body length and TTL for total length. Definitions of microhabitat types are given in Inger (1985).

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RESULTS

RANIDAE

Staurois natator (Günther, 1858)

Recently, a slender, virtually pigmentless, semifossorial stream tadpole was described from two localities in Borneo, but not assigned to a family (Inger & Wassersug, in press). We have since collected samples of this larval form at four additional localities, all in Sabah, at 200 to 600 m above sea level. These samples span stages 25 to late 41, making assignment to genus (and therefore family) possible.

In the pre-metamorphic tadpole (stage 41), the tips of the toes are expanded into large disks and full webbing reaches the disks. The tips of the fingers have large truncate disks typical of *Staurois* species. As the fingers lack webbing, *S. latopalmatus* can be eliminated as the parental species. The other two species, *S. natator* and *S. tuberilinguis*, lack webbing between the outer fingers, but differ strikingly in texture and colouration of the skin of the dorsum. Unfortunately, the skin of the stage 41 tadpole remains in the larval condition. However, adults of only *S. natator*, but no *S. tuberilinguis*, were found at five of the six localities where we collected these distinctive larvae and only *natator* is abundant below 600 m. It is on this basis that we assign this larval form to *S. natator*.

When captured, these tadpoles had pinkish bellies which changed in preservative to shiny silvery. The eyes are covered with thick skin, as previously noted (Inger & Wassersug, in press), but in stages 36 onward there is a small, clear "window" over the eyeball. The nostrils are far forward, just above the corner of the oral disk. The distance from the eye to the tip of the snout is 0.25 to 0.36 of HBL. The tail is 0.69 to 0.71 of total length (i.e., more than twice HBL) and tail depth is 0.18 to 0.21 of tail length (n=9). In stage 25 HBL varies from 5.4 to 9.8 mm (n=7) and total length from 15.4 to 30.1 mm. In stages 35 to 38, HBL is 10.1 to 10.8 mm (n=9) and total length 31.0 to 34.0 mm. The stage 41 larva has a total length of 34.5 mm and HBL 10.5 mm.

Denticle counts in the new material are 2(2)/10(1) (nine individuals), 2(2)/9(1) (five individuals), and 2(2)/8(1) (one stage 25 tadpole, HBL = 5.8 mm). This larval form, thus, has one of the most extreme, negatively imbalanced tooth row counts known (cf. Altig & Johnston, 1989).

Six of the new samples were collected in microhabitats having thick accumulations of dead leaves covering the bottom; two were in leaf drifts and four in side pools. Oxygen measured 1.6 to 7.9 mg just above the dead leaves in three of the sites. Two stage 25 larvae were taken in a riffle. We have no microhabitat data for two stage 25 tadpoles.

Material examined. - Sarawak: 7th Division, Kapit District, Nanga Tekalit (140 m) (FMNH 221024). Sabah: Ranau District, Sungai Kepungit (580 m) (FMNH 229889). Lahad Datu District, Danum Valley Field Centre (175 m) (FMNH 231452). Kota Marudu District, Marak-Parak (250 m) (RFI 41622-23). Tambunam District, Kg. Rangkam (550 m) RFI 42943). Tenom District, Sungai Purulon (350 m) (RFI 43565, 43572, 43719, 44167, 44173, 44557).

RHACOPHORIDAE

Rhacophorus

Four Bornean species of *Rhacophorus* are known to call from vegetation along stream banks: *angulirostris* (Ahl), *bimaculatus* (Peters), *everetti macroscelis* Boulenger, and *gauni* (Inger) (Inger, 1966; unpublished data). Four types of rhacophorid larvae found in Bornean streams have been described and given provisional names: *Rhacophorus bimaculatus*, *R. gauni*, *Rhacophorus* "sp. KB", and *Rhacophorus* "sp. NT" (Inger, 1985). Within the past four years, additional samples of *Rhacophorus* tadpoles have been collected at a number of localities in Sabah. The stages of development and distributional data allow us to assign "sp. KB" to *Rhacophorus angulirostris* and to clarify the relations of the larval form tentatively referred to *gauni*. The similarities of these larvae in general form, details of the oral disk, and the microhabitats used suggest close taxonomic relationships of the species *R. angulirostris*, *R. bimaculatus* and *R. gauni*.

***Rhacophorus angulirostris* Ahl, 1927**

New samples spanning stages 25 to 41 have been collected in the Crocker Range north of Tambunan (ca. 5°45'N, 116°25'E) and at Mendolong (4°55'N, 115°42'E), at elevations between 1050 and 1350 m above sea level. The pre-metamorphic tadpole has webbing of the hand and foot characteristic of adult *R. angulirostris* and like that species, has no dermal projections or flaps along the outer edges of the limbs. At that stage of development, larval *Rhacophorus* usually have dermal appendages diagnostic of their species well developed; that is the case in, for example, *R. nigropalmatus*, *pardalis* (cf. Inger, 1985), and *baluensis* (see description below). We have collected adults, including calling males, of *R. angulirostris* along the streams of Kinabalu (Sungai Silau-Silau, Sungai Liwagu) where this larval form occurs (Inger *et al.*, in press) and at Sungai Dolop, Sunsuron, one of the new localities.

Two of the new samples came from riffles. Precise microhabitat data are lacking for the other specimens, but all came from montane streams having rocky bottoms.

Description. - Head-body oval in plan view, slightly flattened above, rounded below, maximum width between eye and spiracle, width 0.65-0.75; snout rounded. Eyes dorso-lateral, not visible from below; eye diameter 0.14-0.15 of HBL; interorbital 1.5-2 times eye diameter, less than eye-snout distance. Nostrils dorsolateral, midway between eye and tip of snout; a very weak dorsal projection; internarial narrower than interorbital.

Oral disk ventral, subterminal, cup-like, without lateral emargination; slightly narrower than snout. Extra-denticular portion of anterior lip complete and as wide as corresponding part of posterior lip. Both lips with a complete fringe of very small marginal papillae; 4-6 irregular rows of low, thick inframarginal papillae occupy entire expanse of posterior lip between marginal papillae and outermost row of denticles; inframarginal papillae extend on to lateral corners of anterior lip; a low edentulous ridge peripheral to outermost row of denticles of anterior lip, continued laterally by low papillae. Denticles 4(3-4)/4-5; denticles in outermost anterior row (A1) about one-third size of those in other

anterior rows (A2-A4); denticles in fourth row of posterior lip (P4) equal to those in A1 and about one-third size of those in rows P1-P3; denticles in P5, when present, smaller than those in A1 and P4; in every row, size of denticles decreases from medial to lateral parts of row. Beaks black, coarsely serrated, 12-18 serrae on anterior beak, 25-28 on posterior; serrae of posterior beak often worn; anterior beak less than half transverse width of posterior; latter less than one-fourth width of oral disk; both beaks broadly V-shaped.

Spiracle half way between eye and end of body; midway up side; tube free of body wall. Anus median, tube attached to ventral fin.

Tail convex, maximum depth at mid-length, tapering gradually to obtusely pointed tip; tail length 0.64-0.70 of total length; tail depth 0.31-0.38 of tail length; caudal muscle deeper than fins in proximal two-thirds; origins of both fins at end of body; dorsal fin deeper than ventral.

Colour of body in preservative light brown or grey dorsally and laterally, without pigment below; tail pale, usually with bold dark spots on muscle; several dark spots on dorsal fin and usually one or two near end of ventral fin.

Head-body lengths (mm) 7.6-9.3 (stages 25-27, n=4), 8.9-9.5 (stage 28, n=3), 9.6-11.8 (stages 30-33, n=4), 12.2-13.7 (stages 35-37, n=3), 15.0 (stage 41, n=1). Total length to 44.5 (stage 41).

Material examined. - Sabah: Ranau District, Sungai Silau-Silau (1500 m) (FMNH 229886, UKMS unnumbered, Sabah Parks unnumbered); Sungai Liwagu (1400 m) (FMNH 131249-50, 229888, UKMS unnumbered); Sungai Kepungit (500 m) (FMNH 130918-20); Sungai Panataran (FMNH 229887, UKMS unnumbered). Tambunan District, Sunsuron, Sungai Dolop (1350 m) (RFI 42552); Sungai Tainapan (1350 m) (RFI 42534). Sipitang District, Mendolong (1050 m) (FMNH 235316-17).

***Rhacophorus gauni* (Inger, 1966)**

The larva previously designated *R. bimaculatus* (cf. Inger, 1985) we now believe is larval *R. gauni*. We have this form from nine localities. Adult *R. gauni* has been collected at six of them and *R. bimaculatus* at one. Webbing and digital disks in stage 40 to 42 correspond to adults of both these species. The metamorphic individuals lack any other diagnostic features of adults. To avoid confusion with the literature, we present a revised description of larval *gauni*.

Twelve of the new samples came from riffles, six from rocky open pools, one from a torrent, and one from a leaf drift. All were in rocky streams.

Description. - Head-body oval in plan view, maximum width near spiracle (stages < 38) or just in advance of spiracle (stages > 38), width 0.56-0.65 of HBL; snout rounded. Eyes dorsolateral, not visible from below; eye diameter 0.14-0.16 of HBL; interorbital about 1.5 times eye diameter, less than eye-snout distance. Nostrils dorsolateral, midway between eye and tip of snout or a little closer to latter, pointing obliquely anterolateral; no dorsal projection; internarial equal to interorbital.

Oral disk ventral, subterminal, cup-like, weakly emarginate; slightly narrower than snout. Anterior lip longer than and usually overlapping posterior lip laterally; connecting tissue between lips narrower than lips. Extra-denticular portion of anterior lip continuous, as wide as corresponding portion of posterior lip. Both lips with complete fringe of small marginal papillae; anterior lip with 1-3 rows of inframarginal papillae; posterior lip with 4-6 rows of inframarginals occupying all of extra-denticular space. Denticles 4(3-4)/3(1); denticles of first row of anterior lip (A1) about half size of those in other anterior rows; denticles of fourth row of posterior lip smaller than those in other posterior rows, but larger than those in A1; in all rows lateral denticles smaller than medial ones. Beaks heavy, black, coarsely serrated; 16-25 serrae on anterior beak and 20-28 on posterior one; anterior beak less than one-fourth width of oral disk, posterior beak narrower; both beaks V-shaped.

Spiracle midway between eye and end of head-body, low on side; spiracular tube long, free of body wall. Anal tube median, free of ventral fin.

Tail convex, maximum depth at mid-length, tapering gradually to obtusely pointed tip; tail length 0.64-0.70 of total length; tail depth 0.26-0.36 of tail length; caudal muscle deeper than fins in proximal two-thirds; origins of both fins behind end of body, that of dorsal fin farther to the rear.

Colour of head-body dorsally and laterally dark brown in preservative, almost black in life, without pigment ventrally; caudal muscle with large dark spots, anterior ones confluent; dorsal fin with 2-4 dark spots in proximal half of tail; ventral fin without pigment.

Head-body lengths (mm) 5.0-7.9 (stages 25-27, n=18), 6.5-8.3 (stages 28-29, n=7), 7.5-9.5 (stages 31-32, n=7), 8.8-11.2 (stages 34-37, n=7), 10.0-11.1 (stages 38-40, n=6), 10.1-10.4 (stages 41-42, n=4). Total length to 35.8 mm.

Material examined. - Sabah: Kota Marudu District, Marak Parak (210 m) (RFI 41545, 41548-49, 41561, 41763). Ranau District, Poring (600 m) (FMNH 130921-22, 130924, 213128, 229885, 235240-41; UKMS 2062). Lahad Datu District, Danum Valley Field Centre (150 m) (FMNH 231575-93, 235253-54). Sipitang District, Mendolong (670-750 m) (FMNH 235242-52; SP unnumbered; UKMS unnumbered; RFI 45272, 45276, 45470). Tambunan District, Kg. Rangkam, Sungai Tondulu (550 m) (RFI 42953, 42963, 42978). Tenom District, Sungai Purulon (380-410 m) (RFI 42155, 42340, 43677, 44548, 44612). Sarawak: 4th Division, Long Seniae, Sungai Akah (FMNH 83020). 7th Division, Nanga Tekalit (175 m) (FMNH 213888-96).

***Rhacophorus baluensis* Inger, 1954**

Three samples of rhacophorid tadpoles were collected from small ponds in the Crocker Range at 1300 to 1500 m above sea level. They span developmental stages 25 to 43. The metamorphic individuals have the long, pointed dermal projection at the heel, characteristic of adult *baluensis*. They also agree with adults in webbing of hands and feet and in brown dorsal colouration. At one pond, adult *baluensis* were calling as tadpoles were being collected. This particular site, near the crest of the Penampang to Tambunan highway, has since been obliterated by road maintenance work.

Description. - Head-body oval in plan view, slightly flattened above, maximum width just before spiracle, width 0.57-0.71 of HBL; snout rounded. Eyes dorsolateral, not visible from below; eye diameter 0.08-0.12 of HBL; interorbital about three times eye diameter and less than eye-snout distance. Nostril dorsolateral, slightly closer to tip of snout than to eye, open, rim not raised, internarial narrower than interorbital.

Oral disk ventral, subterminal, less than half width of body. Papillae longer than wide; in two rows restricted to corners of upper lip; in one row laterally and two to three medially on margin of lower lip without median gap. Denticles 6-7 (2 or 3-7)/3[1], commonest formula 7(3-7)/3(1). Beaks less than half black; finely serrated; upper beak curved, with weak median projection; lower beak V-shaped.

Spiracle midway between eye and end of body, about midway up side; tube fused to body wall.

Tail elongate leaf-shaped, tapering in last third to obtusely pointed tip; tail length 0.61-0.72 of total length; tail depth 0.30-0.41 of tail length; at maximum depth of tail, fins not as deep as caudal muscle; origins of both fins at end of body.

Colour in preservative medium brown without markings; belly and last half of tail paler.

Head-body lengths and total lengths are given in Table 1.

Material examined. - Sabah: Tambunan District, Sunsuron (1300-1500 m) (RFI 42355, 42502, 42514, 42557).

Table 1

Head-body lengths (HBL) and total lengths (TTL) of larval *Rhacophorus baluensis*.

Stages	n	HBL	TTL
25	9	10.0-14.6	25.0-38.7
26-28	5	10.4-17.5	22.5-46.1
30-35	6	20.3-24.3	53.3-62.3
36-37	11	20.8-23.8	56.9-69.3
38-40	5	23.3-25.8	70.0-75.0
41	9	22.0-25.8	61.2-74.2
43	1	25.5	42.5

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