

NEW SPECIES AND NEW RECORDS OF ANURANS FROM BORNEO

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ABSTRACT. - Samples of frogs from various localities in Sarawak and Sabah contain two new species, which we describe here as *Megophrys dringi* and *Philautus bunitus*. These samples also include a specimen of *Theloderma*, the first record of the genus from Borneo. We present the first description of *Leptolalax dringi* Dubois, a name based on an abbreviated diagnosis, and descriptions but no names of two apparently distinct forms of *Leptolalax*. Bornean populations previously referred to *Leptobrachium hasseltii* are shown to represent two distinct species, one in lowlands and one restricted to montane forests.

INTRODUCTION

During the last five years, we have sampled the amphibian fauna at a number of sites in the Malaysian states of Sabah and Sarawak in Borneo. These sites range in elevation from 175 m to 1540 m ASL and lie in lowland, submontane, and montane rain forest. In the process of identifying these collections, we have discovered undescribed species of adult frogs and one new generic record for Borneo. We have also been privileged to examine and describe a new species of *Megophrys* collected by Mr. Julian Dring in Sarawak. As we attempted to identify our samples of *Leptolalax*, we discovered that Dubois (1987) had not provided a genuine description of the species he had described as *Leptolalax dringi*; we provide one in this paper.

MATERIALS AND METHODS

We have examined specimens from four institutions: British Museum (Natural History) (BMNH), Field Museum of Natural History (FMNH), Sabah Parks (SP), and International Tropical Timber Organization (ITTO). Measurements made with dial calipers to 0.1 mm include snout-vent length (SVL), tibia length (T), head width (HW), head length (HL).

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Genus *Megophrys*

Dring (in Anderson, Jermy, and Cranbrook, 1982) collected a sample of *Megophrys* on Mt. Mulu, Sarawak, he knew to represent at least a new record for Borneo, if not a new species. These have been registered in the collections of BMNH as 1978.14-20, 1978.1532-1534. We believe these frogs constitute a new species that we designate as:

Megophrys dringi, new species

Material examined. - Holotype – adult male (BMNH 1978.20), 1650 m, Gunong Mulu National Park, Fourth Division, Sarawak, coll. J. Dring, 27.Aug.1977.

Paratypes - 9 ex. (all from same locality as holotype) (BMNH 1978.14-19, 1978.1532-34), coll. J. Dring, 9-27 Aug.1978.

Diagnosis. - A small, moderately slender form of *Megophrys*, adult males <50 mm, adult females <65 mm. No vomerine teeth. Head width about 2/3 length of tibia. Tympanum mostly obscured by skin. A small, narrow, marginal projection from eyelid; no dermal projection on snout. Tibia half of SVL, heels overlapping when legs are flexed.

Description. - Habitus moderately slender, head not wider than trunk, about as wide as long; snout projecting beyond lower jaw, oblique in profile; snout as long as eye, without dermal projection; nostril below canthus, midway between eye and tip of snout; canthi sharp, constricted; lores vertical; interorbital slightly wider than upper eyelid; eyelid with a single, short, narrow-based, projecting marginal horn; eyelid with several weaker tubercles; tympanum partially obscured, separated from eye by distance subequal to eye diameter; temporal region vertical; no vomerine teeth. Vocal sac openings round, puckered.

Limbs slender, hand and foot long. Relative lengths of fingers $2 < 1 < 4 < 3$; of toes $1 < 2 < 5 < 3 < 4$. Foot without any web or fringes. Subarticular and metacarpal and metatarsal tubercles scarcely visible. Tibia about half of SVL; foot measured from tibiotarsal joint to tip of fourth toe 0.72-0.76 of SVL.

A horizontal fold behind eye, sharply bent downward behind tympanum to axilla; a weak (but usually distinct) dorsolateral fold beginning at angle of supratympanic fold, more or less continuous to groin; a short pair of converging folds beginning on occiput and ending post-scapular. Sides with oval or round tubercles, mostly below dorsolateral folds.

Color in preservative: Obscure dark triangle between eyes, apex on occiput; temporal area dark, but without distinct pattern; dark vertical bar below center of eye; no clear pattern on side of snout; throat dusky, with obscure longitudinal median streak; chest and anterior third of abdomen dark; rear of abdomen yellowish; rear of thigh with dark horizontal streak; dorsal surfaces of limbs with dark cross bars.

The males have vocal sacs, but no nuptial pads. The single female (BMNH 1978.1534) has enlarged, non-pigmented ova.

SVL males 43-47 mm (holotype 45.5), female 55; T/SVL 0.51-0.55 (holotype 0.52); HW/SVL 0.34-0.36 (holotype 0.35) (Table 1).

Habitat. - The entire sample came from montane forest along a small, steep, rocky stream. Males were calling from leaf litter and twigs (Dring, field notes).

Comparisons. - Dring thought the Mt. Mulu form was closely related to *M. longipes*, and in habitus it is similar to the latter. However, *M. longipes*, which is known only from the Malay Peninsula, has longer legs (Table 1), a distinct tympanum (obscured in *M. dringi*), distinct though rudimentary webbing (absent in *M. dringi*), and vomerine teeth (absent in *M. dringi*).

Megophrys dringi is similar to *M. aceras* (from the Malay Peninsula) and *M. baluensis* (montane northern Borneo) in its small orbital horn and in the absence of a rostral horn. However, *M. dringi* differs from them in lacking vomerine teeth and in having a narrower head and longer legs (Table 1). Also the tympanum of *M. dringi* is less conspicuous than that of *M. aceras*.

Megophrys nasuta and *M. edwardinae*, the other known Bornean species, are larger than *M. dringi*, have wider heads and shorter legs (Table 1), and have distinctly triangular orbital projections. In addition, *M. nasuta* has two long dermal folds on the back (one in *M. dringi*) and vomerine teeth (absent in *M. dringi*). *Megophrys edwardinae* also differs from *M. dringi* in lacking any dorsolateral folds and in having tall, conical tubercles on the eyelid.

Etymology. - This species is named in honor of Mr. Julian Dring in recognition of his contributions to the knowledge of the amphibians of Borneo.

Table 1. Comparison of size and body proportions of *Megophrys dringi* with other species from the Malay Peninsula and Borneo¹.

	<i>dringi</i>	<i>aceras</i>	<i>longipes</i>	<i>baluensis</i>	<i>edwardinae</i>	<i>nasuta</i>
Snout-vent length (males)						
Range	43-47	48-55	42-45	41-45	39-42	72-104
Mean	45.1	52.0	43.4	43.0	41.0	91.7
N	9	5	3	3	4	33
Snout-vent length (females)						
Range	55.0	67-86	49-65	54-70	69-82	89-123
Mean		77.4	55.3	62.2	73.7	111.9
N	1	10	10	9	6	18
Tibia length/SVL						
Range	0.51-.55	0.41-.47	0.54-.65	0.36-.45	0.44-.50	0.34-.46
Median	0.530	0.439	0.598	0.400	0.458	0.375
N	8	8	13	9	10	28
Head width/SVL						
Range	0.34-.36	0.41-.46	0.33-.39	0.41-49	0.44-.48	0.43-.50
Median	0.356	0.436	0.367	0.434	0.466	0.455
N	8	8	13	11	10	31

¹ Data on *aceras* from Grandison (1972) and Dring (personal communication).

Genus *Leptolalax*

In 1872, Günther described *Leptobrachium gracile*, now known as *Leptolalax gracilis*, from Matang, Sarawak, in Borneo. No other form of the genus *Leptolalax* was reported from Borneo until Dubois (1987) named the species *L. dringi* from high elevation (1800 m) on Mt. Mulu, Sarawak. Unfortunately, Dubois provided only a diagnosis, not a complete description of *L. dringi*, and did not compare the new form with *L. gracilis*. By failing to make that comparison, Dubois ignored the main question concerning *L. dringi*, which is whether it is distinguishable from *L. gracilis*.

We have observed hundreds of individuals of *Leptolalax* in Sabah and Sarawak. At Nanga Tekalit, Sarawak, we found two morphotypes of *Leptolalax*. At a site in montane forest (1350 m ASL) in Sabah, we heard two call types associated with *Leptolalax*. Those observations led us to re-examine the specimens we have collected, as well as the holotype of *L. gracilis* and the type series of *L. dringi*. Our aims were to determine how many forms were represented, to identify which, if any, was referable to *L. gracilis*, and to determine the validity and relations of *L. dringi*. While we were engaged in this process, Dr. M. Matsui told us he had recorded four call types and was also studying this complex.

At Nanga Tekalit, the two forms differed in ventral and dorsal coloration and in SVL. One form has heavy dark spotting on the chest and belly, a dark brown blotch at the groin, and a distinctly bicolored forelimb, with the upper arm and elbow pale gray or tan without dark markings and the lower arm dark brown with darker crossbars or spots (fig. 1, top). These frogs are conspecific with the holotype of *L. gracilis* (female, SVL 42.8) which has a spotted venter and a bicolored forelimb. Additional specimens of *L. gracilis* were collected at two other sites in Sarawak. The second form at Nanga Tekalit has an immaculate white venter, the entire forelimb brown with dark markings (fig. 1, center), and lacks a dark blotch in the groin. These two forms differ significantly in SVL (Table 2) (for females $t = 5.297$; $P < 0.01$; ranges of the males do not overlap) and in tibia length relative to SVL, but not in relative head width (Table 3).

The four frogs in the type series of *L. dringi* represent a third Sarawak form. They have dark ventral spots as in *L. gracilis*, but do not have a bicolored forelimb and are smaller than *L. gracilis* (Table 2).

At the site in western Sabah where we heard two call types, we collected two morphotypes, one with ventral spotting, a rough skin, and very obscure dark markings on a dark brown dorsum (in preservative). Their ventral spots are not as bold as in Sarawak frogs and are sometimes evident merely as clusters of contracted melanophores. In life these frogs had a strong carmine flush inguinally on the trunk and adjacent part of the thigh and at the axilla. The second form lacks ventral spots and has smooth skin dorsally, conspicuous dark markings dorsally on a sandy ground color (fig. 1, bottom), and very bold dark spots on the side of the head. In life it lacked carmine at the groin or axilla. We found both forms at six other localities in the western portion of Sabah. The two Sabah forms differ in body proportions (Table 3) but not in size (Table 2).

The ventrally spotted form from Sabah is very similar to *L. dringi* and differs from *L. gracilis* in the same ways as *L. dringi*: Males are smaller than those of *L. gracilis* (see Table 2) and the forelimb is not bicolored. The Sabah frogs have longer legs and slightly wider heads than *L. gracilis* (see Table 3). We assign the ventrally spotted Sabah form to *L. dringi*, which we think is specifically distinct from *L. gracilis*.

Table 2. Snout-vent lengths of *Leptolalax* from Borneo. "Spotted" and "unspotted" refer to markings on the venter (see text). Assignment of specific names (see footnotes) explained in text.

Form	N	Males		N	Females	
		Range	Mean±SE		Range	Mean±SE
Sarawak						
Spotted ¹	11	31.3-38.9	35.72±0.62	9	40.5-48.3	43.81±0.96
Spotted ²	3	30.0-31.3	30.63	1	38.8	
Unspotted	7	28.7-31.3	29.63±0.33	20	36.1-42.8	39.55±0.32
Sabah						
Spotted ³	86	29.8-35.3	32.09±0.16	36	37.2-47.5	42.47±0.46
Unspotted	29	30.8-36.1	33.27±0.25	11	39.3-46.8	42.38±0.66

¹*Leptolalax gracilis*.²*Leptolalax dringi* type series.³*Leptolalax dringi* non-typic material.

The frogs with immaculate venters represent at least one additional species. Besides the unmarked venters, these frogs differ from *L. gracilis* and *L. dringi* in having slightly longer legs and narrower heads (Table 3), smooth rather than rugose, tubercular dorsal skin, and more sharply defined dorsal markings including a distinct, dark tympanic "mask" (figs. 1, center and bottom). They also differ from *L. gracilis* in lacking both contrasting coloration of the upper and lower arm and a dark blotch in the groin. There are minor differences between Sabah and Sarawak frogs with unmarked venters. Some of the Sarawak frogs, but none of those from Sabah, have small, round tubercles on the top of the snout or in the sacral region. The dark spots on the side of the head are more sharply contrasting with the ground color in the individuals from Sabah. The Sarawak frogs are slightly smaller (Table 2), and the Sabah frogs have slightly longer legs (see T/SVL in Table 3). Although we believe these frogs with unmarked venters are not conspecific with *L. gracilis* or *L. dringi*, we refrain from formal recognition pending Dr. Matsui's analysis of call types, which will help determine the number of species involved. We provide the first complete description of *L. dringi* and descriptive notes on *L. gracilis* and the ventrally immaculate forms.

Leptolalax dringi Dubois

Leptolalax dringi Dubois, 1987: 13 (type locality Sarawak: Gunung Mulu, Camp 4, 1800 m; holotype - BMNH 1978.3).

Localities of material examined. - Sarawak: Fourth Division, Mt. Mulu, camp 4, 1800 m (holotype and paratypes, BMNH). Sabah: Kota Marudu District, Marak Parak (Mt. Kinabalu Park), 200 m (FMNH, SP); Lahad Datu District, Danum Valley Field Centre, 150 m (FMNH); Ranau District, Poring (Mt. Kinabalu Park), 600 m (FMNH, SP), "Kinabalu," 1800 m (BMNH); Sandakan District, Maliau River, 450 m (FMNH); Sipitang District, Mendolong, 600-1350 m (FMNH); Tambunan District, Sungai Rangkam, 6 km NW of Tambunan, 500 m (FMNH), Sungai Sunsuron, 13 km N of Tambunan, 1230-1455 m (FMNH), Trus Madi, 1560 m (FMNH); Tawau District, Tawau Hills Park, 270m (FMNH, SP); Tenom District, Kampung Bahru Jumpah, S of Tenom (BMNH), Sungai Malutut, 340m (FMNH), Sungai Purulon, 350 m (FMNH).

Table 3. Body proportions of *Leptolalax* from Borneo. "Spotted" and "unspotted" refer to markings on the venter (see text). Assignment of specific names (see footnotes) explained in text. T/SVL, tibia length over snout-vent length. HW/SVL, head width over snout-vent length. "Analysis" gives P values resulting from Mann-Whitney U tests of indicated comparisons.

Sex	Form	N	T/SVL		N	HW/SVL	
			Range	Median		Range	Median
Sabah frogs							
Males	Spotted ¹	30	.50-.56	0.535	16	.31-.38	0.350
	Unspotted	23	.53-.58	0.561	22	.30-.35	0.320
Females	Spotted ¹	24	.47-.58	0.529	16	.31-.36	0.330
	Unspotted	11	.50-.61	0.537	11	.30-.36	0.322
Sarawak frogs							
Males	Spotted ²	10	.48-.55	0.508	7	.30-.34	0.330
	Unspotted	4	.51-.55	0.531	2	.31-.34	
Females	Spotted ²	9	.46-.52	0.499	5	.31-.33	0.319
	Unspotted	15	.48-.58	0.522	8	.29-.34	0.317
Analysis							
<i>Males X females</i>							
Sarawak	Spotted		>0.10			>0.10	
	Unspotted		>0.10			>0.10	
Sabah	Spotted		>0.10			0.02	
	Unspotted		>0.10			>0.10	
<i>Spotted X Unspotted</i>							
Sarawak			<0.02			>0.10	
			<0.001			<0.01	
<i>Sarawak X Sabah</i>							
Spotted	Males		<0.02			<0.02	
	Females		<0.01			0.04	
Unspotted	Males		<0.02			>0.10	
	Females		<0.02			>0.10	

¹*Leptolalax dringi*.

²*Leptolalax gracilis*.

Description. - (based on examination of holotype and 3 paratypes) Habitus moderately stocky, head not wider than trunk behind arms, tapering slightly at waist; snout obtusely pointed or rounded, rounded in profile, not projecting beyond lower jaw; nostril closer to tip of snout than to eye; canthus distinct, rounded; lores concave; eye diameter greater than eye-snout distance; interorbital wider than internarial; tympanum distinct, about half eye diameter.

Finger tips rounded; finger lengths $3>4=2=1$; subarticular and palmar tubercles indistinct. Tips of toes like those of fingers; third toe longer than fifth; subarticular tubercles obscure, but elongate; oval inner but no outer metatarsal tubercle; no discernible webbing. Heels overlapping when legs flexed and held perpendicular to body.

Skin dorsally and laterally with round tubercles, especially dense on top of snout; sides with larger rounded tubercles; ventrally smooth.

Coloration in preservative brown dorsally and laterally, with obscure darker markings on trunk and head; side with light-centered dark spots; chest and belly with dark spots. Forelimb brown, with dark crossbars on lower arm, no distinction between segments of arm in ground color. Hind limb brown, with dark crossbars, those of thigh crossing anterior and dorsal surfaces; anterior face of thigh without dark spots between ends of crossbars. No dark blotch in groin.

SVL males 30.0-31.3 mm, N=3; female 38.8 mm, N=1. T/SVL 0.49-0.51, HW/SVL 0.32-0.34.

Variation. - The large number of specimens from Sabah we assign to *L. dringi* extend the size range: males 29.8-35.3 mm, females 37.2-47.5 mm (Table 2). Variation in T/SVL and HW/SVL is given in Table 3 (as "spotted" frogs from Sabah). More than half of the frogs had a dark brown blotch at the groin. In some preserved individuals, the ventral spotting is not bold, but is evident as clusters of contracted melanophores. At one locality, fresh specimens had a carmine flush at the axilla and groin.

***Leptolalax gracilis* (Günther)**
(Fig. 1, top)

Leptobrachium gracilis Günther, 1872: 598 (type locality: Sarawak: Matang; holotype - BMNH)

Localities of material examined. - Sarawak: First Division, Matang (holotype, BMNH); Fourth Division, Mt. Mulu, camp 2, 500 m (BMNH), Sungai Pesu Camp (FMNH); Seventh Division: Kapit District, Nanga Tekalit, 100-230 m (FMNH), Belaga District, Segaham River, 135-290 m (FMNH).

Descriptive notes. - (based on examination of holotype and specimens from Sarawak at localities below 500 m) Habitus moderately stocky, head shape as in *L. dringi*; tympanum distinct, less than half eye diameter. Finger tips rounded; subarticular tubercles replaced by elongate, low callosities; large inner and small outer palmar tubercles. Tips of toes like those of fingers; subarticular tubercles like those of fingers; low, oval inner but no outer metatarsal tubercle; web at base of toes only.

Skin dorsally and laterally rough, with low round pustules and short, low ridges; sides with larger round tubercles; ventrally smooth.

Coloration in life dark brown dorsally and laterally, with obscure darker markings dorsally and on side of head; sides with light and dark spots, usually dark spots with light centers. Forelimb distinctly bicolored, with upper arm and elbow pale tan or cream and without markings, distal two-thirds of lower arm dark brown or tan with dark crossbars. In preservative throat, chest and belly heavily marked with dark brown or black; thigh with two or three dark crossbars on anterior and dorsal surfaces; anterior face of thigh with dark spots between ends of crossbars, proximal dark spot continuous with large, dark inguinal blotch; crossbars of calf interrupted dorsally; ventral surface of calf boldly marked with dark and light areas.

SVL males 31-39 mm, females 40-48 (Table 2). T/SVL 0.46-0.55; HW/SVL 0.30-0.34 (Table 3).

***Leptolalax* sp.**
(morphotype from Sarawak with non-spotted venter)
(Fig. 1, center)

Localities of material examined. - Sarawak: Second Division, headwaters of Sungai Sekerang (ITTO); Seventh Division, Kapit District, Nanga Tekalit, 100-230 m (FMNH).

Description. - Habitus, form of head and limbs as in *L. gracilis* and *L. dringi*, except interorbital and internarial subequal; ventral surfaces of fingers and toes as in *L. gracilis*, web at base of toes.

Skin smooth dorsally or with very small, round tubercles; sides with larger tubercles; ventrally smooth.

Color in life medium brown above with conspicuous, light edged, blackish spots dorsally and laterally; middorsal spots largest; spots on sides often white-centered; tympanum with a dark mask; ventrally head and trunk white or cream, without spots. Upper and lower segments of arm not contrasting, with same light brown ground color; upper arm usually with dark spots and lower arm with dark crossbars. In preservative ground color of back, top and side of snout dark brown; dark markings on side of snout not always sharply defined; dark spot covering most of tympanum; sides with light-centered dark spots; ventrally head and trunk immaculate white or cream. Forelimb with upper and lower segments tan with dark crossbars and spots; no distinction between upper and lower arm. Hindlimb brown with dark crossbars or spots dorsally; anterior face of thigh dusky but without distinct spots or bars; crossbars of calf widely interrupted; ventral surfaces of thigh and calf uniformly dusky. Groin with or without dark spot, but spot never extends on to thigh.

SVL: males 29-31 mm, females 37-41 mm, (Table 2). T/SVL 0.48-0.58, HW/SVL 0.29-0.36 (Table 3).

***Leptolalax* sp.**
(morphotype from Sabah with non-spotted venter)
(Fig. 1, bottom)

Localities of material examined. - Sabah: Ranau District, Poring, 600 m (FMNH, SP), Kinabalu, 1800 m (BMNH); Sipitang District, Mendolong, 1000-1350 m (FMNH); Tambunam District, Sungai Rangkam, 6 km NW of Tambunam, 500 m (FMNH), Sungai Sunsuron, 13 km north of Tambunam, 1230-1455 m (FMNH), Mt. Trus Madi, 1540 m (FMNH); Tenom District, Sungai Purulon, 350 m (FMNH).

Descriptive notes. - Habitus, form of head and limbs as in the unspotted form from Sarawak.

Color in life light to medium brown above, with conspicuous, large, light-edged darker markings; side of head sandy brown with sharply delineated blackish brown spots; tympanum with a dark brown or black mask; ventrally head and trunk white or cream, immaculate. In preservative lateral black spots sometimes with light centers; forelimb tan or medium brown;

upper arm usually without markings; lower arm with dark crossbars. Hindlimb brown with crossbars dorsally, those on calf widely interrupted; anterior face of thigh usually with dark spots between ends of crossbars; ventral surfaces of thigh and calf uniformly dusky. Groin usually without dark spot; when present spot does not extend on to thigh.

SVL: males 31-36 mm, females 39-47 mm, (Table 2). T/SVL 0.50-0.61; HW/SVL 0.30-0.36 (Table 3).

Genus *Leptobrachium*

One of the commonest megophryid frogs of the floor litter in Bornean forests has been referred to as *Leptobrachium hasseltii* Tschudi [Boulenger, 1908 (as *Megalophrys*); Inger, 1966] and *Leptobrachium montanum* Fischer (Dring, *in* Anderson *et al.*, 1982). In the course of field work during the period 1983-1993, we have observed a consistent difference between individuals caught in highlands (>1000 m) and those caught at lower elevations. Live frogs from the highlands invariably show a conspicuous (fig. 2 upper) chalky white arc on the upper part of the eye; in preservation the white arc can be seen only by rolling the eyelid back with a forceps. In contrast, live frogs from the lowlands never show a white orbital arc (fig. 2 lower), although one can be seen in preserved frogs, again, by rolling back the upper eyelid.

These Bornean frogs pose two problems: (1) Are they specifically distinct from the Javan population of *L. hasseltii* (type locality "Java")? (2) Are the highland and lowland populations in Borneo conspecific?

Javan and Bornean frogs differ in two obvious ways: in coloration and in size. The backs of frogs from Java have large black, sometimes confluent spots beginning on the snout and continuing to the sacral area. The sides of the trunk usually have black spots. About one-third of the Bornean frogs have no discernible markings on the dark back and in the remainder dark markings are evident only on the head and anterior portion of the back. They do not have black spots on the sides of the trunk.

Javan frogs are clearly smaller than Bornean frogs (Table 4) and also have shorter legs and narrower and shorter heads (Table 5). All pairwise comparisons of Javan frogs with the three Bornean sets show statistically significant differences ($P<0.02$, Mann-Whitney U tests).

Given these differences between Javan and Bornean frogs in coloration, size, and body proportions, we conclude that the Bornean frogs are not conspecific with the Javan.

Montane and lowland Bornean populations differ not only in the white orbital arc, but also in other aspects of coloration. Ventrally all the frogs from above 1000 m are gray, darker on the belly than on the throat and have small yellowish or whitish dots on the belly and, less commonly, on the throat. The ventral surface of the leg, particularly under the calf, is dark gray to black, uniform or with a few small yellowish dots. In contrast frogs from the lowlands of Sabah have a bold ventral pattern of black and white, varying from mostly black to mostly white. The ventral surface of the calf in these lowland frogs is blotched with black and white or is black medially with large white areas ventrolaterally and ventromedially. About one-fourth of frogs from the lowlands of Sarawak have the belly dark gray with small light dots as in the montane frogs; the remainder have the markings of lowland Sabah frogs.

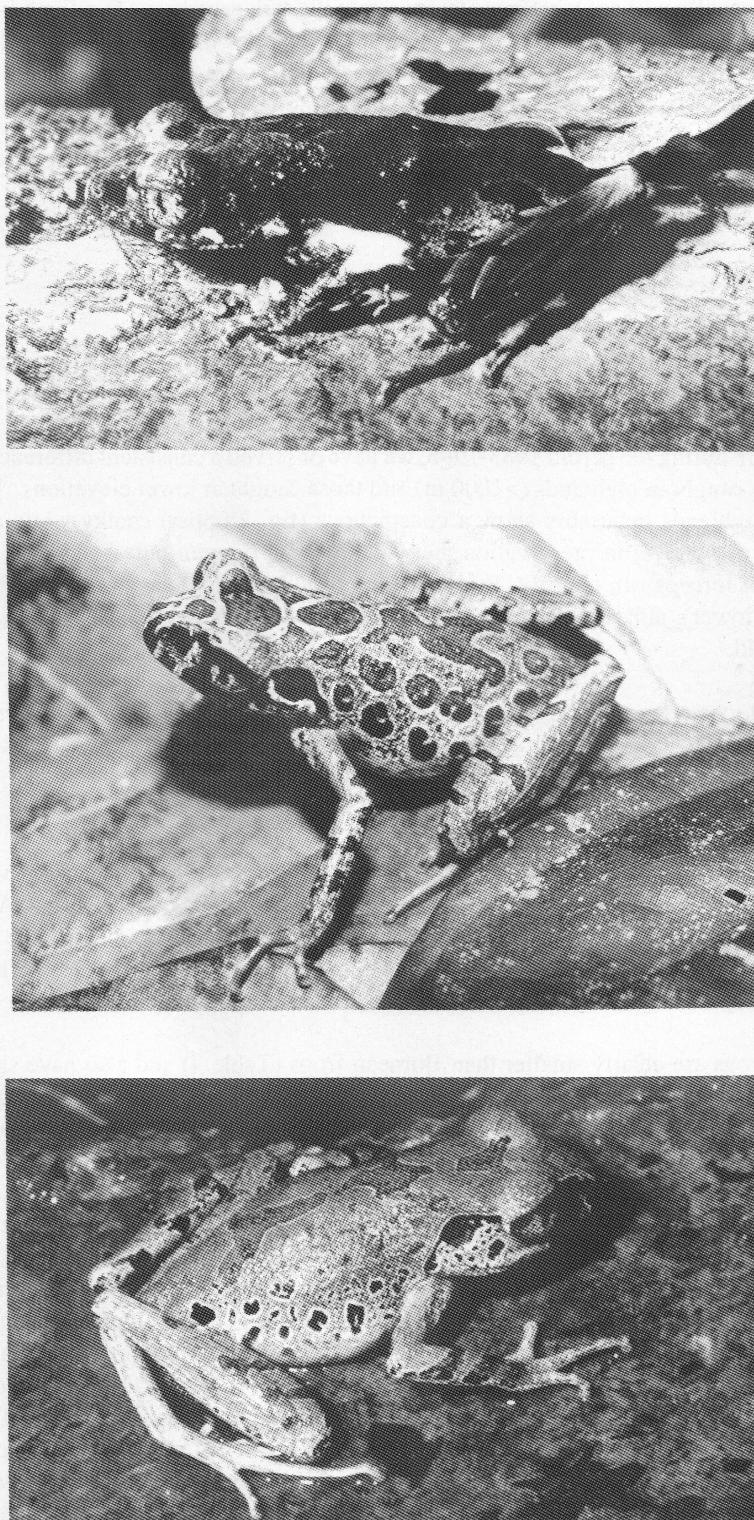


Fig. 1. Top, *Leptolalax gracilis* Günther. Center, *Leptolalax* sp. form with immaculate venter from Sarawak. Bottom, *Leptolalax* sp. form with immaculate venter from Sabah.

The ventral surface of the calf in >85% of the Sarawak frogs resembles that of the lowland Sabah frogs.

The ova of gravid females from high elevations are mostly cream-colored with a small area of dark pigment at the animal pole. Ova of lowland females are black in the entire animal hemisphere. Immature ova are dark in lowland females and light in highland females. The behavioral significance of this difference is not clear, as both forms breed in the same kinds of streams and tadpoles from low and high elevations occupy the same types of microhabitats.

Males of the montane group do not differ much from lowland males in SVL, but the females do, with scarcely any overlap between the montane and the two lowland samples (Table 4). This results in a great difference between montane and lowland groups in the amount of sex dimorphism. Tibia length, head width, and head length relative to SVL differ little between montane and lowland populations (Table 5); the only statistically significant differences in pairwise comparisons appear in relative tibia length between female montane frogs and their counterparts in lowland Sabah and Sarawak ($P \leq 0.02$, Mann-Whitney U test).

The two altitudinal groups act as distinct, though similar species, with the montane form invariable over its currently known range of approximately 155 km (Mt. Kinabalu to Mt. Lumaku, Sabah) and surrounded by the slightly more variable lowland form. These parapatric species meet at least in the Lumaku area; one male (FMNH 234319), collected at 1050 m, has the boldly patterned venter typical of the lowland population and is larger (SVL 58.2 mm) than any other individual collected above 1000 m. We speculate that these two species are juxtaposed through the range of the montane form wherever forest still exists continuously from 800 to >1000 m.

Two names are available for these Bornean frogs. The holotype of *L. montanum* Fischer was collected in the Pramassan-Alai Mountains in southeastern Borneo; these low mountains reach 1890 m, with a number of peaks over 1250 m. The holotype (BMNH 1947.2.5, originally 86.5.15.10) matches the coloration of the montane frogs from Sabah, although in preservation the white arc over the eye is not visible. It also falls within the size range (SVL 58 mm, sex not determined to avoid damage) of the montane group. We, therefore, assign the montane frogs from Sabah to *L. montanum* Fischer.

We also examined the holotype of *L. abbotti* Cochran (USNM 39097), which was collected near sea level at Balikpapan, on the southeastern coast of Borneo. It is a male, SVL = 53.4 mm, but unfortunately is in such poor condition that the coloration cannot be determined now. Cochran (1926) said that it had no dorsal marking and that the ventral surface was yellowish white, which is similar to some specimens from Sarawak. We apply this name to the lowland frogs from Sabah and Sarawak.

Table 4. Snout-vent lengths (mm) of Javan and Bornean frogs related to *Leptobrachium hasseltii* and *L.montanum*. All females had half- or fully developed ova. All males had vocal sac openings.

Source	N	Range	Mean±SE
Males			
Java	3	44.1-46.6	45.47
Sarawak <1000m	24	51.6-74.1	58.62±1.1364
Sabah <1000m	24	42.5-64.8	53.54±1.1050
Sabah >1000m	27	46.7-62.7	52.14±0.6367
Females			
Java	8	45.7-55.5	50.59±1.1890
Sarawak <1000m	12	65.7-95.0	76.13±1.8662
Sabah <1000m	16	60.1-82.5	73.02±1.2942
Sabah >1000m	13	50.2-64.4	60.17±1.5633

Table 5. Body proportions of Javan and Bornean frogs related to *Leptobrachium hasseltii* and *L.montanum*.

	Java	Sarawak	Sabah<1000m	Sabah>1000m
Tibia length/SVL (males)				
Range	0.35-0.37	0.34-0.40	0.36-0.40	0.33-0.42
Median	0.360	0.378	0.383	0.379
N	4	24	24	27
Tibia length/SVL (females)				
Range	0.31-0.34	0.35-0.39	0.35-0.39	0.34-0.43
Median	0.328	0.363	0.371	0.387
N	8	11	16	13
Head width/SVL (males)				
Range	0.41-0.44	0.42-0.47	0.42-0.49	0.39-0.48
Median	0.410	0.438	0.439	0.446
N	4	24	24	27
Head width/SVL (females)				
Range	0.38-0.41	0.40-0.45	0.41-0.45	0.41-0.46
Median	0.390	0.431	0.446	0.428
N	7	11	16	13
Head length/SVL (males)				
Range	0.39-0.42	0.43-0.49	0.43-0.49	0.41-0.52
Median	0.398	0.457	0.463	0.464
N	4	18	24	27
Head length/SVL (females)				
Range	0.38-0.41	0.41-0.48	0.41-0.47	0.41-0.52
Median	0.396	0.450	0.443	0.446
N	7	11	16	13

Genus *Philautus*

Over a period of three years (1989-91), we collected samples of an undescribed species of *Philautus* at localities scattered over 175 km in the mountainous parts of western Sabah. The new species fits Dring's (1987) diagnosis of the *vermiculatus* species group: vomerine teeth present in larger species; no nuptial pad; *m. cutaneus pectoris* absent; *m. geniohyoideus medialis* free; ova half-pigmented. We describe the new species as.

***Philautus bunitus*, new species**

Material examined. - Holotype - male (FMNH 239261), Mt. Lumaku, Sipitang District, Sabah, 1350 m, 11 Sep.1989.

Paratypes (all from Sabah) - 4 ex. (FMNH 239258-60, 239262) same data as holotype; 1 ex. (FMNH 250001), Mt. Trus Madi, Tambunam District, 1455 m; 2 ex. (FMNH 239292, 251517), 13 km north of Tambunam along the Tambunam-Penampang Road, 1525 m; 1 ex. (Sabah Parks Am/KP 171), Kiau View Trail, Mt. Kinabalu Park, 1500 m.

Diagnosis. - A large member of the *vermiculatus* group, males 35-41 mm SVL, females 44-46 mm. Vomerine teeth present. Webbing to distal subarticular tubercle of fourth toe. In life, dorsum green with dark markings, venter orange or pale green with orange tinge.

Description. - Habitus stocky; head wider than long; snout broadly rounded in dorsal view, rounded in profile, not projecting; nostril near end of snout, above symphysis; canthi rounded, but distinct, curved; lores oblique, concave; eye diameter equal to or slightly longer than snout; interorbital wider than upper eyelid; tympanum slightly obscured, but visible, $<1/2$ diameter of eye; vomerine teeth in short rows just medial to choanae; no lingual papilla.

No *m. cutaneus pectoris*; *m. geniohyoideus pars medialis* free.

Fingers with truncated or weakly rounded discs, that of first finger about half disc of third; discs of second to fourth fingers wider than tympanum; fingers with web at base and narrow fringes to bases of discs; one distinct, large subarticular tubercle on each finger; rest of ventral surfaces of fingers and palm with many small, rounded tubercles. Toes with discs slightly smaller than those of two outer fingers; web reaching base of disc of first toe, to between subarticular tubercle and disc on outer side of second toe, to between outer subarticular tubercle and disc on outer side of third and inner side of fifth toes, to distal subarticular tubercle of fourth toe; distal subarticular tubercles of all toes conspicuous, others weak; inner metatarsal tubercle oval, outer one absent; ventral surface of foot with numerous weak tubercles.

A strong supratympanic fold from eye to arm; entire dorsal surface with widely scattered weak tubercles; venter coarsely granular; no folds, fringes or flaps of skin on outer margins of limbs.

Color in life of dorsal surfaces leafy green, with black speckling forming indistinct pattern, usually a dark interorbital bar and dark crossbars on limbs; top of inner fingers yellow or orange; webbing of inner toes yellow; abdomen and ventral surfaces of inner fingers and toes orange or pale green with orange tinge; groin and anterior and posterior faces of thigh flesh colored, immaculate or with 1-5 small dark spots on rear of thigh; iris pale tan with

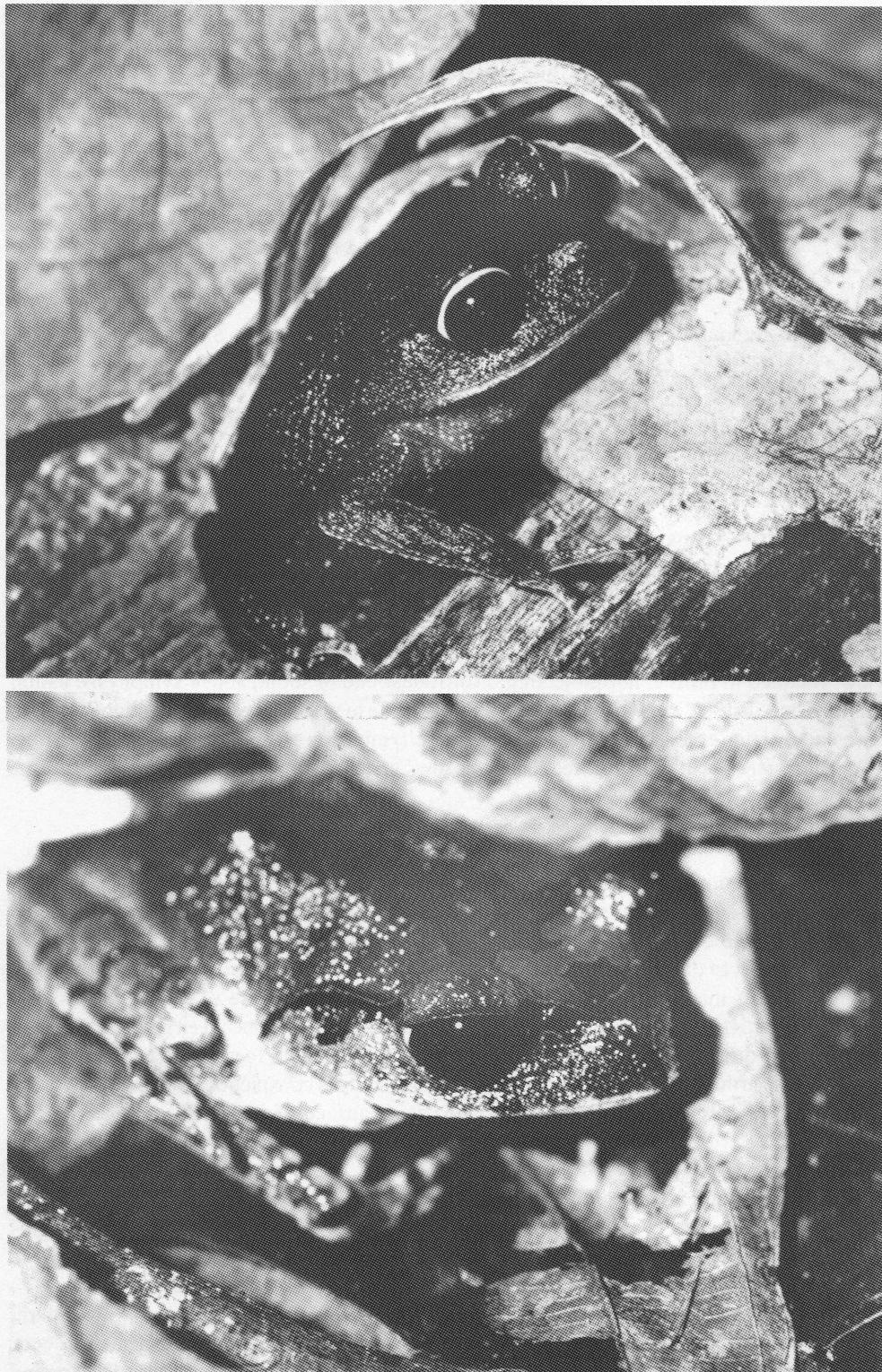


Fig. 2. Upper, *Leptobrachium montanum* Fischer, from Kinabalu Park, Sabah, 1500 m. Lower, *Leptobrachium abbotti* Cochran, from Danum Valley Field Center, Sabah, 150 m.

dark network. In preservative dorsal surfaces purplish; throat and chest often with brown mottling; rear of thigh cream, immaculate or with small dark spots.

Males 34.7-40.8 mm SVL (holotype 40.8) (n=5); T/SVL 0.48-0.52 (holotype 0.48); HW/SVL 0.39-0.41 (holotype 0.40); vocal sacs subgular, not paired; no nuptial pad. Females 43.5-46.3 mm (n=3); immature female 36.7 mm; T/SVL 0.48-0.54; HW/SVL 0.37-0.42.

One female contained 17 ovulated ova measuring 4-5 mm (mean 4.20). The gelatinous envelopes, in preservative, were 7-8 mm in diameter. In preservative the ova were black in one hemisphere and brown in the other. Enlarged pigmented ova were present in the two other adult females.

Habitat notes. - All known specimens were collected in montane forest at 1350-1525 m ASL. Six were found on shrubs 0.5-4.0 m above ground and one was on a small log.

Comparisons. - *Philautus bunitus* is the only member of the *vermiculatus* species group that is green dorsally. The other four species of this group now known from Borneo - *P. acutus* Dring, *P. aurantium* Inger, *P. disgregus* Inger, and *P. kerangae* Dring - are tan, clay brown or reddish brown with darker markings dorsally (Dring, 1987; Inger, 1989). The new species is also the only member of the group that is orange ventrally. Only *P. bunitus* and *P. aurantium* have orange flash coloration on the thighs and groin.

Philautus bunitus is the largest member of the *vermiculatus* group (Table 6). The species differs slightly from *P. disgregus* and *P. kerangae* in relative leg length, but all species of the group are similar in headwidth (Table 6). Only the two largest members of the group, *P. bunitus* and *P. kerangae*, have vomerine teeth.

Remarks. - Mr. Rudolph Malkmus has sent us a photograph of a specimen he collected along the Liwagu River, Kinabalu Park, at 1500 m, and Mr. Peter Hoffmann has collected one near the headquarters of Kinabalu Park (ca. 1500 m).

Etymology. - *Bunitus* from “bounites” (Gr.), dweller in the hills.

Genus *Theloderma*

The genus *Theloderma* Tschudi has been known from northeastern India, northern Burma, and southern China to Sumatra and the Mentawai Islands (Frost, 1985). It has not previously been recorded from Borneo. A party from Field Museum of Natural History recently collected one adult *Theloderma* in eastern Sabah.

Theloderma horridum (Boulenger)

The adult female fits descriptions of *T. horridum* (Boulenger) and is clearly conspecific with specimens (FMNH 186600-02) of that species from Selangor, West Malaysia. *Theloderma horridum*, first described from southern peninsular Thailand (Boulenger, 1903), has also been reported from West Malaysia (Dring, 1979) and the Mentawai Islands (Smith, 1926). We provide a brief description of the Bornean adult.

Table 6. Comparison of species of the *Philautus vermiculatus* group. Data on *acutus*, *kerangae*, and *vermiculatus* from Dring (1987). Data on *aurantium* and *disgregus* from Inger (1989).

	<i>bunitus</i>	<i>acutus</i>	<i>aurantium</i>	<i>disgregus</i>	<i>kerangae</i>	<i>vermiculatus</i>
Snout-vent length (males)						
Range	34.7-40.8	23.4-27.1	23.8-27.7	21.3-23.0	32.6-33.6	29.1-34.6
Mean±SE	37.3±1.12	26.4	25.1±0.36	22.2±0.23	33.1	31.0
N	5	11	13	7	3	10
Snout-vent length (females)						
Range	43.5-46.3		25.6-26.2	24.2-24.8	43	
Mean	44.6		25.9	24.5		
N	3		3	2	1	
Tibia length/snout-vent length						
Range	0.48-0.54	0.49-0.52	0.50-0.57	0.53-0.58	0.54-0.58	0.49-0.53
Median	0.510	0.506	0.538	0.557	0.571	0.517
N	8	11	16	9	3	10
Head width/snout-vent length						
Range	0.37-0.42	0.39-0.41	0.38-0.43	0.39-0.41	0.39-0.41	0.40-0.44
Median	0.399	0.406	0.398	0.399	0.396	0.421
N	8	11	16	9	3	10

Description. - Habitus moderately stocky; snout flattened, obtusely pointed in dorsal view, rounded in side view; nostril lateral, very close to tip of snout; canthi distinct, rounded; lores concave; length of eye less than eye-nostril; tympanum superficial, half diameter of eye; vomerine teeth very small, two on right side and one on left, situated just medial to anteromedial corners of choanae. Digital discs large, truncate, completely circumscribed by grooves; disc of first finger equal to diameter of tympanum; discs of other fingers larger; discs of toes slightly smaller than that of first finger. Fingers and toes extensively webbed; first three fingers webbed to base of discs on outer edges, fourth finger to base of disc; web reaching base of discs on all toes. Subarticular tubercles of fingers and toes well-developed; two small, round, outer palmar tubercles and an elongate inner one; inner metatarsal tubercle oval, outer one conical.

Skin of all dorsal and lateral surfaces with many small, whitish, spiny pustules; pustules clustered in round tubercles on top and side of head, side of trunk, and dorsal surfaces of limbs; pustules on back in irregular lines and clusters.

Color in preservative purplish brown above, with faint dark bars on dorsal surface of limbs; ventral surfaces purplish brown with bold white marbling; several light spots in groin.

Female with fully pigmented ova, 3 mm in diameter. SVL 49.3 mm, T 23.8, HW 17.5, HL 19.4, eye-nostril 6.5, eye-tip of snout 9.5, tympanum 2.3

Habitat. - This frog was caught in selectively logged forest on the trunk of a tree (DBH 1 m), 1 m above ground at Danum Valley Field Centre.

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