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## Zoology

NEW SERIES, NO. 92

### Frogs of Vietnam: A Report on New Collections

Robert F. Inger

Nikolai Orlov

Ilya Darevsky

UNIVERSITY OF CHAMPAIGN  
URBANA-CHAMPAIGN  
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## Zoology

NEW SERIES, NO. 92

### Frogs of Vietnam: A Report on New Collections

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# Frogs of Vietnam: A Report on New Collections

Robert F. Inger

Nikolai Orlov

Ilya Darevsky

## Abstract

Bourret's (1942) review of the amphibians of Vietnam was based on collections made in a very few areas of the country. Since that date little has been published on that fauna. We report here on large samples of anurans from central and northern Vietnam obtained by two of us (NO, ID); these samples comprise 60 species, of which six are new and 12 are not previously reported from Vietnam. With this new material the size of the known anuran fauna of Vietnam is increased from 82 to 100 species.

## Introduction

Despite the thorough review of the amphibian fauna of Indochina by Bourret (1942), the content and distribution of this fauna are still very imperfectly known. Bourret's analysis of the anurans of Vietnam, the focal area of the present paper, was based primarily on three sets of data: (1) observations made by himself and associates in the mountainous northern part of the country, (2) collections made by Smith (1921, 1922, 1924) in the southern part of the central highlands of Vietnam (see map, Fig. 1), and (3) miscellaneous records accumulated in the nineteenth century and the first decade of the twentieth century. The last data set was heavily weighted with species characteristic of agricultural and other severely disturbed environments (see below).

Bourret (1942) reported Vietnamese localities as Tonkin, Annam, and Cochinchine [Cochin China] for 78 species. Dubois (1983, 1987) added two new species, and two more are being described by Lathrop et al. (in press). Papers on the distribution of this fauna have been published in Vietnam (see Literature Cited), but none of these papers has added to the number of species known from Vietnam or amplified descriptions of poorly known species.

Vietnam consists of two primary physiographic areas: a narrow, mainly coastal zone of lowlands and a larger core of mountainous terrain with elevations up to 3143 m (Mt. Fan Si Pan). As re-

cently as 1982, Vietnam had approximately 60,000 square kilometers of rain forest and monsoon forest combined (Collins et al., 1991). Annual rainfall varies from approximately 1,400 mm in the south to 2,700 mm in the north. Given the size of Vietnam (325, 360 km) and its physical attributes, one would expect appreciably more than 82 species of anurans.

Recent intensive sampling by two of us (ID, NO) in central and northern Vietnam uncovered 12 species not previously reported from Vietnam and six species new to science, raising the total fauna to 100 species. A number of the other species found during this sampling have been described or discussed only once in the literature. The bulk of our sampling was carried out in the central highlands, about 300 km north of the area in which Smith worked (see above). Because so little is known of the amphibian fauna of Vietnam, we will report on all of the species included in these new samples.

## General Environment

The bulk of the specimens on which this report is based come from an area about 40 km long on the Tay-Nguyen Plateau in south-central Vietnam (Fig. 1). The plateau has a north-south axis of about 400 km and mountain ridges running parallel to that axis, with elevations varying from 500

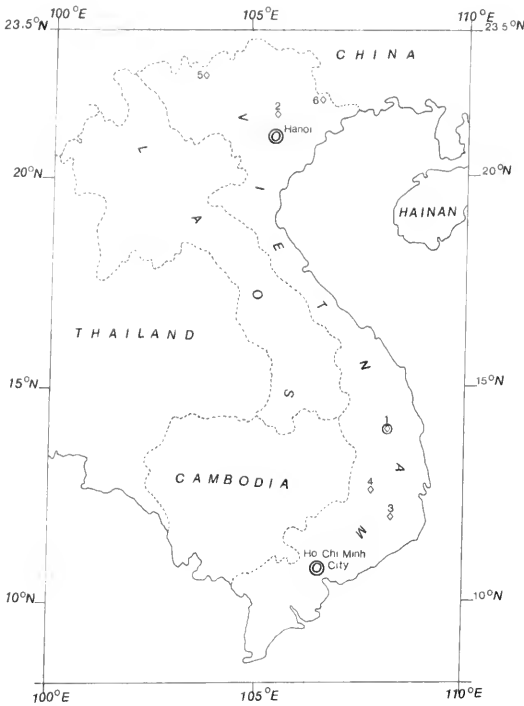


FIG. 1. Map of Vietnam, showing localities of the most important samples. 1: An Khe District; 2: Tam Dao; 3: Sui Kat; 4: Dalat; 5: Sa Pa; 6: Mao Son.

to 2598 m (Mt. Ngoklin). The actual collecting sites were around two villages, Buon Luoi and Tram Lap, and the area of Kon Cha Rang. These sites are 20, 40, and 60 km, respectively, northwest of the town of Kannack ( $14^{\circ}20'N$ ,  $108^{\circ}36'E$ ), in the An Khe District (Fig. 1, no. 1), Gia-Lai Province, Vietnam. The dry season in this region lasts from December to April and the rainy season from June to October.

Buon Luoi (700–750 m), the locality for most of the specimens, has a well-developed humid evergreen tropical forest, with a closed canopy at about 20–30 m and some emergents (mainly of the families Dipterocarpaceae, Leguminosae, and Moraceae) above 40 m. There are few deciduous trees. The principal stream is the Cha River, which has a moderately steep gradient, a rocky bottom, and several 2- to 4-m waterfalls. The width of the riverbed varies from 4 to 10 m, and the depth during the dry season varied from 30 to 70 cm. Five small perennial tributaries flow through the forest, and each is completely under the canopy (except for the lower end of one). Three of the streams have very steep, rocky banks, and four of them flow through rock outcrops. Their widths

vary from 2–3 m to 4–6 m. At the end of the dry season, depths varied from 5 to 50 cm. During the rainy season, depths reached 1 m. Two of the streams have clay beds, with many thick patches of dead leaves; the others have mainly rocky beds. Two of the streams have widened, ponded areas: one  $10 \times 50$  m and the other  $20 \times 150$  m. Fallen trees block the current in places, and swampy areas have developed. Collecting was carried out at Buon Luoi in November 1993 and March–May 1995.

Tram Lap (ca. 900 m), 20 km north of Buon Luoi, is surrounded by essentially the same kind of forest as Buon Luoi, although there are more deciduous trees. A large river (20–40 m) flows through the area. Portions of the forest have been cut, and clearings reach the riverbanks in places. Three small forest streams were worked at this locality; two 2–4 m wide and one 1–2 m wide. All three are under canopy. Two flow out of a swampy area, with vegetation mainly of Araceae. Large tree trunks block the flow and, along one stream, form a swampy area with grassy vegetation 8–10 m wide. One stream has a silty bottom and a second has a sandy clay bed. The depths vary from 10 to 100 cm. Collecting was carried out in November 1993 and April 1995.

Kon Cha Rang (1000–1200 m), 20 km northwest of Tram Lap, has much the same type of vegetation, but the forest is more intact. The streams in this area of rough topography have steep gradients. The major river is the Azun (15–20 m wide), which has a strong current over a rocky bed, but wide pools with moderate currents. Three small streams (3–10 m wide) on the left bank flow over basalt, have rocky waterfalls, and in places flow through rocky canyons. Their beds are rocky. Depths in the dry season are 30–50 cm. Two streams on the right bank of the Azun River flow through karst. The largest (8–15 m wide) of these two flows below the rock surface in places and has a broken canopy above. Collecting was carried out in April 1995.

Tam Dao ( $21^{\circ}26'N$ ,  $105^{\circ}39'E$ ) (Fig. 1, no. 2) lies in a mountainous area that includes karst formations. Most of the fieldwork was carried out at 900–1100 m, where the dominant vegetation is a humid broad-leaved evergreen forest. Most frogs were collected along rocky, steep-gradient streams 3–5 m wide. There were many cascades and waterfalls, some as high as 20 m. In some places the streams run under the surface rock. The mean temperature in the winter (November–March) is  $8^{\circ}C$ ; it is  $20^{\circ}C$  in the summer. Rainfall

from June through September averages 100 mm per month. Collecting was carried out in June 1995 and April–May 1996.

## Methods

Most collecting was done at night between 1800 and 2300 hrs. Specimens were preserved in buffered 10% formalin and transferred to 70% ethanol when they reached museums in the United States. Calls were not recorded. Specimens were measured with electronic calipers. The following abbreviations are used: SVL, snout–vent length; T, tibia length with the hind limb flexed; HW, head width at the tympanum; HL, head length from the rear of the lower jaw to the tip of the snout; TY, horizontal diameter of tympanum; HB, headbody of tadpoles; HBL, headbody length. Measurements are given in millimeters (mm) unless indicated otherwise. Comparisons of body proportions (e.g., T/SVL) within or between species were made with the Mann-Whitney *U*-test.

In synonymies we cite the original description, the source of the present binomial, and a reference to Bourret's (1942) monograph.

Specimens were borrowed from The Natural History Museum, London (BMNH), and the Museum of Comparative Zoology (MCZ). Other abbreviations used are FMNH (Field Museum of Natural History), MAS (Malcolm A. Smith), MVZ (Museum of Vertebrate Zoology), and ZMH (Zoologisches Museum für Hamburg).

## Species Accounts

Ten species are characteristic of anthropogenically modified environments, and all have very wide distributions in Southeast Asia. We collected them in villages, on roads, and in rice fields and other agricultural sites. These species (and their corresponding localities) in our samples are *Bufo melanostictus* (Buon Luoi, Tram Lap, and Kon Cha Ran), *Kaloula pulchra* (Buon Luoi), *Microryla butleri* (Buon Luoi), *M. heymonsi* (Buon Luoi, Tram Lap, and Tam Dao), *M. ornata* (Buon Luoi), *M. pulchra* (Tam Dao), *Micryletta inornata* (Buon Luoi), *Hoplobatrachus rugulosa* (Buon Luoi), *Rana erythraea* (Buon Luoi), and *R. limocharis* (Buon Luoi, Tram Lap, and Kon Cha Ran). These species will not be dealt with further.

## Megophryidae

### *Brachytarsophrys carinensis* (Boulenger)

*Leptobrachium carinense* Boulenger, 1889:748—  
Karen Hills, Burma.

*Brachytarsophrys carinensis* Tian and Hu,  
1983:42.

*Megophrys carinensis* Bourret, 1942:216.

An adult female (SVL 118.4) and an adult male (SVL 116.8) from Buon Luoi both have a palpebral "horn" consisting of a single, broadly based, triangular projection. In this respect they differ from Boulenger's (1908) description of frogs from Burma and from FMNH specimens from northern Thailand and Sichuan, in which the upper eyelid has two to four projecting papillae. In other characters, these Vietnamese frogs agree with other specimens. This is the first record of the species from Vietnam, but the range extension is not surprising, given the known distribution from Burma through northern Thailand to southern China.

Boldly striped megophryid tadpoles with a funnel mouth collected at Buon Luoi may belong to this species or *M. lateralis*, two of which were also collected at Buon Luoi.

Coloration of tadpoles in preservative: HB brown dorsally; a ventrolateral black stripe from oral funnel below eye to end of HB above limb buds; a yellow stripe of same width below black one; ventrally HB brown with irregular yellowish spots and a midventral stripe in rear two-thirds; a large yellowish spot below oral funnel; amount of yellowish spotting ventrally varies. Tail muscle mottled brown in upper half, bordered below by narrow dark brown stripe, a wider yellow stripe, and a wider dark stripe; all stripes merge into dark brown coloration of rear two-fifths of tail; dorsal fin mottled brown anteriorly, ventral fin unpigmented except for several dark marginal spots in proximal half; both fins heavily mottled in distal two-fifths.

MEASUREMENTS—Total length 40.4 (stage 27), 44.0–49.7 (stages 36–37); HBL 12.5 (stage 27), 13.5–15.0 (stages 36–37); tail depth/tail length 0.30 (stage 27), 0.23–0.25 (stages 36–37).

This is the first longitudinally striped larval megophryid. Liu and Hu (1961, Pl. 14) figured a larval *Megophrys* that has transverse light and dark banding ventrally and a dark midlateral stripe on the proximal half of the caudal muscle. Although Liu and Hu (1961) identified this tadpole

as *M. carinensis*, they did not explain why they assigned it to this species.

### *Megophrys feae* Boulenger

*Megalophrys feae* Boulenger, 1887a:512—east of Bhamo, Khakhien Hills, Burma.

*Megophrys feae* Bourret, 1942:218.

A female (SVL 84.0) and two juveniles (SVL 17.2 and 34.0) were collected at Tam Dao. The tibia of the female (T/SVL 0.40) is slightly longer than head length (HL/SVL 0.38) and shorter than head width (HW/SVL 0.46). The species was recorded from Tam Dao by Bourret (1942) and from other areas in northern Vietnam by Tran et al. (1981). Although it was not reported from Yunnan by Yang et al. (1991), the species probably occurs there.

### *Megophrys lateralis* (Anderson)

*Ixalus lateralis* Anderson, 1871:29—Yunnan, China.

*Megophrys lateralis* Liu, 1950:180.

*Megophrys longipes maosonensis* Bourret, 1937:12.

Two subadult females (SVL 54.0–54.5) were collected at Buon Luoi and 11 adults and one juvenile at Tam Dao. These specimens do not differ from descriptions of *M. lateralis* (Boulenger, 1908; Bourret, 1942; both under the name *M. major* Boulenger). Buon Luoi represents an extension of the range of this species southward to central Vietnam. SVL measurements of the Tam Dao specimens: females 83.1–91.7 (mean  $\pm$  standard error [SE]  $87.83 \pm 1.00$ ,  $N = 9$ ), males 67.9–75.3 ( $N = 2$ ); T/SVL 0.48–0.56 (median 0.514,  $N = 11$ ); HW/SVL 0.35–0.39 (median 0.366,  $N = 11$ ); HL/SVL 0.34–0.40 (median 0.363,  $N = 11$ ). The ratio HL/SVL in the two males (0.38–0.40) is greater than that in any of the females. There are no obvious differences between the sexes in HW/SVL or in tibia length.

### *Megophrys palpebralespinosa* Bourret

*Megophrys palpebralespinosa* Bourret, 1937:16—Chapa, Tonkin, Vietnam.

An adult male (SVL 40.9) collected at Tam Dao agrees with Bourret's (1937) description. The specimen has brown nuptial pads on the first and second fingers; several short tubercles on the upper eyelid and a thicker, triangular one projecting from the edge of the eyelid; an obtusely pointed but strongly projecting snout; large, irregularly shaped dark blotches ventrally separated by narrow lighter areas; and distinct, shallow webbing at the base of the toes. T/SVL 0.44, HW/SV 0.33, HL/SVL 0.32. The species is as yet known only from the mountains of northern Vietnam (Tran et al., 1981) and southern Yunnan, China (Yang et al., 1991).

### *Leptobrachium pullum* (Smith)

*Megophrys hasseltii* var. *pullum* Smith, 1921:440—Arbre Broyé [Lang Biang], Annam, Vietnam; Bourret, 1942:214.

*Leptobrachium pullus* Dubois, 1980:476.

Variation among populations of *Leptobrachium* in Southeast Asia is known to be complex (Inge 1983), and the taxonomy is unsettled. Two forms have been described from Vietnam: *L. pullum* Smith (type locality 11°54'N, 108°19'E) and *L. chapaense* Bourret (type locality Chapa, Tonkin 22°24'N, 103°51'E). Both were treated as varieties of *L. hasseltii* by the authors. These differ in coloration and in body proportions (Tables 1 and 2). Four adults (three males, one female) from Buon Luoi, approximately 270 km from the type locality of *L. pullum* and 990 km from that of *L. chapaense*, differ from both forms in coloration and in body proportions (Tables 1 and 2). Males from Buon Luoi are larger than either *L. pullum* or *L. chapaense* (Table 1). Three newly metamorphosed juveniles from Buon Luoi, with completely resorbed tails but remnants of the opercular still visible, measure 42.2–42.7. These juveniles would almost certainly have achieved sexual maturity at larger sizes than the males of *L. pullum* and *L. chapaense*. Smith (1921) reported the SVL of three females of *L. pullum* as 44–52; the four largest females in the type series of *L. chapaense* were 58–62 (Bourret, 1937); the sole female in the Buon Luoi sample is 64.7 mm.

We have also examined specimens of this group from two localities in northern Thailand—Doi Inthanon (18°32'N, 98°32'E) (FMNH 187439–41) and Chiang Dao (19°21'N, 98°59'E) (FMNH 172661, 173973–80). These samples, separated by

TABLE 1. Comparison of coloration in samples of *Leptobrachium* from Vietnam and Thailand.

	Vietnam			Thailand	
	<i>L. pullum</i>	<i>L. chapaense</i>	Buon Luoi	Doi Inthanon	Chiang Dao
Back*	0	2	1, 3	1	4
Chest and belly†	0	3	3	2	1
Sides‡	4	1	2	1	3
Leg ventrally§	1	1	2	1	1

\* Back: 0 = indistinct darker markings; 1 = vermiform black markings; 2 = black network; 3 = black and yellow speckling; 4 = large round black spots.

† Chest and belly: 0 = no spots; 1 = white with large black spots; 2 = dotted light and dark; 3 = black with fine light spots.

‡ Sides: 0 = no spots; 1 = small light spots; 2 = large (half the diameter of the eye) light spots; 3 = large black spots; 4 = small black spots.

§ Leg ventrally: 0 = white, without spots; 1 = blackish with light spots; 2 = blackish without spots.

about 100 km, differ from one another and from all three of the Vietnamese samples (Tables 1 and 2). The frogs from these five samples represent either one species with great geographic variation or five species. We believe the latter is probably correct, but we adopt a conservative approach and group them all under the name *L. pullum* pending an analysis involving more samples.

The Vietnamese collection also includes one juvenile from Tam Dao with SVL 32.6, T/SVL 0.44, and HW/SVL 0.39. It has conspicuous pectoral glands but no opercular scars, thus showing it to be more advanced than the three juveniles from Buon Luoi. It matches the coloration of *L. pullum* (Table 1), but its body proportions, with tibia length greater than head width, differ from those of all of the samples listed in Table 2.

TABLE 2. Comparison of samples of male *Leptobrachium* from Vietnam and Thailand. Data on *L. pullum* from Smith (1921); data on *L. chapaense* from Bourret (1937).

	Vietnam			Thailand	
	<i>L. pullum</i> (N = 5)	<i>L. chapaense</i> (N = 4)	Buon Luoi (N = 3)	Doi Inthanon (N = 3)	Chiang Dao (N = 8)
SVL (mm)	44–49	46–53.5	60.3–64.7	43–47	43–56
T/SVL	0.33–0.35	0.36–0.41	0.36–0.39	0.37–0.41	0.32–0.33
HW/SVL	0.41–0.44	0.45–0.46	0.45–0.47	0.43–0.47	0.39–0.43
HL/SVL	0.33–0.36	0.37–0.40	0.41–0.45	0.44–0.49	0.38–0.42

SVL = snout-vent length; T = tibia length with hind limb flexed; HW = head width at the tympanum; HL = head length from the rear of the lower jaw to the tip of the snout.

## *Leptolalax tuberosus*, new species (Fig. 2)

HOLOTYPE—FMNH 252844, an adult male, collected at Kon Cha Rang Village (1000–1200 m above sea level [ASL]), An Khe District, Gia-Lai Province, Vietnam, 15 April 1995 by Ilya Darvsky and Nikolai Orlov.

PARATYPES—FMNH 252845–59, 14 males and one female from type locality; FMNH 252860, one male from Tram-Lap Village (900 m), An Khe District, Gia-Lai Province, Vietnam.

ETYMOLOGY—Specific name from *tuberosus* L., meaning full of protuberances.

DIAGNOSIS—A small species of *Leptolalax*, males < 30 mm, female 30 mm; tympanum obscured by skin; low, rounded tubercles on snout and eyelids; no ventrolateral glandular ridge; ventral surface of thigh with thin black reticulation enclosing round, white spots.

DESCRIPTION—Habitus stocky; head width equals length. Snout obtusely pointed, rounded or truncate in profile, not projecting; nostril a bit closer to tip of snout than to eye; canthi rounded, constricted; lores sloping, concave; diameter of eye greater than length of snout; interorbital equal to or narrower than eyelid; tympanum obscured by skin, rim not visible; no vomerine teeth.

Tips of fingers blunt; first finger subequal to second; fourth and second fingers equal; subarticular tubercles obscured; a large, round inner metacarpal tubercle, not extending out under first finger; a smaller outer metacarpal tubercle. Tips of toes like fingers; third toe longer than fifth; webbing confined to bases of toes; toes without lateral fringes; subarticular tubercles replaced by keratinous dermal ridges, a relatively short one on each of first two toes, longer ones on third and fifth toes, ridge covering entire underside of fourth toe;



FIG. 2. *Leptotalax tuberosus*, new species. Holotype, male, 26.1 mm.

a small, oval inner metatarsal tubercle, no outer one.

Skin above with many scattered small tubercles of varying sizes; eyelid with low rounded tubercles; top of snout usually with elevated tubercles; sides and venter smooth; small, weak pectoral and femoral glands; a small, round, white gland just above axilla; no ventrolateral glandular ridge.

Color in preservative of dorsal and lateral surfaces dark gray or black, with obscure light speckling, heavier low on sides; usually two dark labial bars; limbs with darker crossbars; venter white, with thin, short black streaks sparse posteriorly, becoming denser anteriorly and on chin and throat forming black network enclosing round white spots; ventral surface of thigh and calf with dark network enclosing round white spots.

Males with slit-like vocal sac openings, but no nuptial pads.

MEASUREMENTS—SVL of males 24.4–29.5 (mean  $\pm$  SE 26.82  $\pm$  0.42,  $N = 16$ ), of single female 30.2. T/SVL 0.48–0.54 (median 0.500,  $N = 12$ ); HW/SVL 0.35–0.39 (median 0.363,  $N = 12$ ); HL/SVL 0.36–0.41 (median 0.381,  $N = 12$ ).

Measurements of holotype: SVL 26.1, T 13.0, HW 9.9, HL 10.0, and diameter of eye 4.3.

COMPARISONS—This is the only species of *Leptotalax* that has whitish speckling dorsally and the only one in which the tympanic rim is not clearly visible. In a few individuals of *L. tuberosus* the tympanum is evident as a smooth, ill-defined area. *Leptotalax pelodytoides* (Boulenger), from northern Vietnam, Thailand, and Sichuan, China (to accommodate the expanded definition of the species by Dubois, 1983) differs from *L. tuberosus* in its superficial tympanum, low glandular ventrolateral ridge, shorter legs, narrower head, and lateral fringes on the toes. Males of *L. pelodytoides* have T/SVL 0.44–0.51 and HW/SVL 0.30–0.39; differences from those values for *L. tuberosus* are statistically significant ( $P < 0.02$ , Mann-Whitney  $U$ -test). *Leptotalax pelodytoides* usually has a distinct dark pattern on the dorsum and several distinct black spots on the sides, but no light speckling dorsally and no dark reticulation under the thighs; in each of these features of coloration, *L. pelodytoides* differs from *L. tuberosus*.

Bourret (1942: 208–209) listed and illustrate



specimens from Chapa, northern Vietnam, as *L. pelodytoides*. These became types of *L. bourreti* Dubois (1983); Bourret's drawings show a frog with a superficial tympanum, a distinct dark pattern on the back, and distinct black spots on the side, thus differing from *L. tuberosus*. Dubois (1983) gave the SVL of *L. bourreti* as 36.3 (male holotype) and 42–45 (female paratypes), i.e., larger than *L. tuberosus*. Two new species from northern Vietnam described by Lathrop et al. (in press), *L. sungi* and *L. nahangensis*, differ from *L. tuberosus* in having SVL of males >40 mm, visible tympana, and the undersides of the thighs immaculate white.

Fei et al. (1990) gave a diagnosis (but no description) for a new species, *Leptolalax alpinus*, emphasizing those characters that differed from *L. pelodytoides*; none of the reported differences between *L. alpinus* and *L. pelodytoides* involved coloration. Fringes along the toes were explicitly mentioned as a common feature of these two taxa. Consequently, we believe that coloration and toe fringes distinguish *L. alpinus* from *L. tuberosus*.

*Leptolalax tuberosus* is smaller than the Bornean species *L. gracilis* (Günther) (males 31–39), *L. dringi* Dubois (males 30–35), and *L. pictus* Malkmus (males 30–35). It also differs from *L. pictus* and *L. heteropus* (Boulenger) of Peninsular Malaysia in the absence of a clearly defined dorsal pattern, and from *L. gracilis*, *L. dringi*, and *L. pictus* in the absence of black spots laterally. All of the Bornean and Malaysian species mentioned have superficial tympana.

### *Leptolalax pelodytoides* (Boulenger)

*Leptobranchium pelodytoides* Boulenger, 1893: 345—Thao, Karin Bia-Po District, Burma.

*Leptolalax pelodytoides* Dubois, 1983:149.

*Megophrys pelodytoides* Bourret, 1942:208.

A large sample of adults was obtained at Tam Dao. Adult females range from 35.3 to 40.7 mm SVL (mean  $\pm$  SE 38.26  $\pm$  0.21, N = 22) and males from 27.7 to 30.9 (29.22  $\pm$  0.21, N = 19). Females have slightly shorter legs (T/SVL 0.42–0.49, median 0.460, N = 22) and slightly shorter heads (HL/SVL 0.32–0.39, median 0.363, N = 22) than males (T/SVL 0.45–0.51, median 0.48, N = 19; HL/SVL 0.34–0.40, median 0.372, N = 17); differences between the sexes are statistically significant (in both ratios  $P < 0.03$ , Mann-Whitney *U*-test). The sexes do not differ in relative head

width (HW/SVL 0.30–0.35; median of males 0.332, of females 0.335). All individuals have black bars on the lip, black markings dorsally, and a broken line of white glands ventrolaterally. The belly is immaculate white or cream-colored (in preservative), and the chin and ventral surface of the calf are dusky with small whitish spots.

These specimens are larger than *L. pelodytoides* from Thailand and Sichuan (including *L. minimum* Taylor and *L. oshanensis* Liu, to follow the taxonomic arrangement of Dubois, 1983), but are very similar in body proportions (Table 3). Females from Tam Dao (35.3–40.7) are also larger than those from Thailand and Sichuan (29.2–35.9). There are slight differences in coloration. Short, dark, vermiform lines occur on the belly in 14 of 15 frogs from Sichuan, but on only four of 19 from Thailand and on none from Tam Dao. The ventral surface of the thigh in Tam Dao frogs has fine black network over white, becoming gradually denser toward the rear surface, which is quite dark. In most of those from Thailand (17/19) and Sichuan (14/15) there is an elongated blackish oval on the ventrolateral surface of the thigh, contrasting sharply with a much lighter area on the anterior half of the ventral surface of the thigh.

*Leptolalax bourreti* Dubois from Chapa (= Sa Pa), northern Vietnam, is clearly larger (females 41–54) than *L. pelodytoides* from Tam Dao (see above). The nine females of *L. bourreti* measured by Bourret (1937, as *L. pelodytoides*) have longer tibia (T/SVL 0.43–0.53, median 0.490), wider heads (HW/SVL 0.33–0.39, median 0.367), and shorter heads (HL/SVL 0.26–0.34, median 0.326) than females from Tam Dao; the differences between the two forms in these body proportions are statistically significant ( $P < 0.01$ , Mann-Whitney *U*-test). In *L. bourreti* the head is wider than long, whereas the reverse is true in *L. pelodytoides*. Neither Dubois (1983) nor Bourret (1937, 1942) mentions a ventrolateral glandular ridge in *L. bourreti*.

### *Ophryophryne* Boulenger

There are three morphotypes in the collection, two from Buon Luoi and one from Tam Dao. All have the very short gape and short snout characteristic of the genus. In all three, the webbing is very reduced, vomerine and maxillary teeth are absent, and the inner metacarpal tubercle extends

TABLE 3. Comparison of males from populations of *Leptotalax pelodytoides*.

	Tam Dao	Thailand	Sichuan
<b>SVL</b>			
Range	27.7–30.9	22.9–28.7	26.4–29.2
Mean $\pm$ SE	29.22 $\pm$ 0.21	26.91 $\pm$ 0.70	27.66 $\pm$ 0.22
N	19	10	14
<b>T/SVL</b>			
Range	0.44–0.51	0.44–0.49	0.44–0.49
Median	0.477	0.468	0.480
N	19	9	14
<b>HL/SVL</b>			
Range	0.34–0.40	0.37–0.41	0.33–0.38
Median	0.372	0.383	0.363
N	19	8	14
<b>HW/SVL</b>			
Range	0.30–0.35	0.33–0.36	0.32–0.36
Median	0.332	0.345	0.342
N	18	10	14

SE = standard error; N = number of frogs; other abbreviations spelled out in footnote to Table 2.

out under the first finger. Each has small orbital "horns."

The three forms differ strikingly in ventral coloration, which is not described for any of the three named taxa to which we assign them. This fact and the slight disparities compared to original descriptions leave the assignments to named taxa tentative. However, the recognition of these forms as distinct species is clear. Besides differing in ventral coloration, the three differ in dorsal coloration, in the length of the orbital horns, and in the pattern of the glandular ridges on the back. There are also minor differences in body proportions.

#### *Ophryophryne microstoma* Boulenger

*Ophryophryne microstoma* Boulenger, 1903: 186—Man Son Mountains, northern Vietnam; Bourret, 1942:161.

Two mature, but not gravid, females (41.6 and 45.4 mm SVL) and one juvenile (25.8) from Buon Luoi. T/SVL (females only) 0.39–0.42, HW/SVL 0.26–0.28, HL/SVL 0.25–0.26, and eye/HL 0.46–0.51. Habitus slender; snout projecting, sloping obliquely back to lower jaw; nostril lateral; tympanum visible, about two-thirds diameter of eye. A distinctly curved supratympanic fold from eye to axilla; back with fine, regular ridges forming a wide, curved V beginning at supratympanic fold

and with its apex near center of interscapular region and a )—(shaped pattern over rear half of trunk; no enlarged tubercles at vent. In preservative, gray-brown above with faint occipital V and dark temporal region; ventrally dark grayish brown on throat and chest; abdomen lighter with scattered small dark spots; ventral surface of hind limb light with denser dark spots. In life, the dorsal surface gray-yellow; venter dark gray.

This series fits Boulenger's (1903) description of the types from northern Vietnam in dermal ornamentation, large, exposed tympanum, and coloration. The one disparity is size; Boulenger (1903) reported that a gravid female measured 5 mm.

This species was in a swampy area at Buon Luoi; one specimen was found under dead leaf and a second on a broad leaf of an araceous plant during a light night rain.

#### *Ophryophryne pachyproctus* Kou

*Ophryophryne pachyproctus* Kou, 1985:41—Zhu shihe, Menghla County, Yunnan, China.

Two adult males (32.2–38.6) and two adult females (45.3–47.8) from Tam Dao. T/SVL 0.42–0.45, HW/SVL 0.25–0.27, HL/SVL 0.25–0.29, and eye/HL 0.38–0.45.

These are the first specimens recorded since the collection of the type series in Yunnan. One c

the diagnostic features according to Kou (1985) is the large projecting tubercles on each side of the vent; these are present in the Tam Dao specimens, but in varying states. The dorsal coloration and regular pattern of low glandular ridges illustrated by Kou (1985) are the same as shown in the Tam Dao specimens. Kou reported the SVL of males as 28–30.

Habitus moderately stocky; snout truncate or weakly pointed, projecting, sloping obliquely back to lower jaw; nostril lateral; diameter of eye longer than snout; orbital horn twice as long as wide; tympanum visible, about half diameter of eye. Supratympanic fold curved; back with thin glandular ridges forming a V over anterior part of back and an H pattern over rear half of trunk; enlarged tubercles just above vent. General coloration in preservative grayish brown; an inverted, dark, interorbital triangle; entire lumbar region dark; irregular dark spots over rest of back; throat dark brown; chest and abdomen with light network surrounding dark blotches; ventral surface of hind limb light with heavy dark mottling.

The form of the supra-anal protuberances varies, although there was only one on each side: one male had a small tubercle; a second male a thick, rounded tubercle; one female a triangular flap; a second female a large conical tubercle.

There is no difference between the sexes in body proportions. Males have nuptial pads on the first two fingers, similar to those in *O. poilani*. The males lacked vocal sacs. Males were heard calling from low leaves of shrubs along rocky banks of a small stream.

### *Ophryophryne poilani* Bourret

*Ophryophryne poilani* Bourret, 1937:8—Dong Tam Ve, Quang-Tri Province, Vietnam; Bourret, 1942:162.

The Buon Luoi specimens are the first reported since the collection of the holotype about 180 km north of Buon Luoi.

Nine males (36.4–43.9 SVL) with nuptial pads and vocal sacs, and four females (53.3–59.9), two with enlarged ova. Habitus moderately stocky; snout projecting, sloping back to lower jaw; nostril lateral; tympanum visible, slightly more than half diameter of eye. Dorsum with low tubercles and fine, low, short, oblique and transverse ridges not forming regular pattern; dorsal tubercles often tipped with fine white cones; supratympanic fold

TABLE 4. Sexual dimorphism in body proportions of *Ophryophryne poilani* Bourret.

	Males (N = 9)	Females (N = 4)
<b>T/SVL</b>		
Range	0.45–0.51	0.41–0.49
Median	0.486	0.435
<b>HW/SVL</b>		
Range	0.29–0.35	0.28–0.30
Median	0.315	0.291
<b>HL/SVL</b>		
Range	0.26–0.31	0.25–0.28
Median	0.289	0.272

almost horizontal; supra-anal area with or without large projecting tubercles, one or two per side. In preservative dorsum very dark, almost uniformly black in some individuals, with large obscure black spots in others; ventrally dark grayish brown on throat and chest; abdomen varying from dark brown with fine light speckles to mostly brown with large light areas to mostly light gray with large dark spots; underside of hind limb dark with small light markings. In life males vary from black with sharply demarked yellow spots to gray-brown with obscure lighter spots; females yellowish gray with obscure, small lighter spots.

Nuptial pads of males a cluster of very fine black spinules on dorsomedial surface of first finger and a much smaller oval patch on the dorsal surface of the second finger. Usually males with minute brown spinules on the dorsal surface of the head.

The sexes differ in body proportions, with the males having relatively longer legs and wider and longer heads (Table 4).

Bourret (1937) stated that *O. poilani* lacked an "orbital horn." This series has a short orbital projection, but it is absent on one side in three individuals. This variation suggests that the holotype represents a deviant individual in this character. The holotype female measured 47 mm, somewhat smaller than the Buon Luoi females.

Many individuals of this species were seen in April 1995 calling from rocks and dead branches projecting above the water along streams with steep gradient. Although males were occasionally seen side by side, they were usually spaced 10 m apart. The call is a trill similar to the sound of large orthopterans.



FIG. 3. *Bufo galeatus* Günther. Pair in amplexus. Male, 50.5 mm; female, 85.3 mm.

## Bufoidea

### *Bufo galeatus* Günther (Fig. 3)

*Bufo galeatus* Günther, 1864:421—Cambodia;  
Bourret, 1942:179.

Specimens were collected at Buon Luoi (7), Kon Cha Rang (16), Tram Lap (5), and Tam Dao (1). SVL of males 45.2–51.8 (mean  $\pm$  SE 48.43  $\pm$  0.67, N = 10), of adult females 76.1–89.1 (N = 4).

Although both sexes have a thick bony crest between the eye and the parotoid gland, only in adult females is the canthal crest conspicuously raised and arched. Smith (1921) referred to prominent spiny “warts” on the sides, but did not note that these represent a secondary sex character found only in females. Adult females have large, sharply pointed, conical tubercles (or warts) behind the rictus in an oblique band to above the axilla, similar but slightly smaller tubercles along the sides, the largest of these forming an oblique row from the parotoid to the groin. There are also

large, pointed tubercles on the limbs. Males have tubercles in the same positions, but none are long and those on the sides are very low and rounded. Females, besides being larger, have shorter legs and wider heads than males. T/SVL of female 0.38–0.40 (N = 4), of males 0.40–0.44 (median 0.422, N = 11); HW/SVL of females 0.41–0.4 (N = 4), of males 0.33–0.39 (median 0.352, N = 11).

All of these specimens were found along forested streams. Three were actually in shallow water. According to Tran et al. (1992), who listed *Bufo galeatus* in the *Red Data Book of Vietnam*, the species lives on the floor of bamboo forests in central and northern Vietnam.

### *Bufo macrotis* Boulenger

*Bufo macrotis* Boulenger, 1887b:422—Teinzu  
Burma; Bourret, 1942:169.

Four subadults (32.2–39.3) from Buon Gen (12°52'N, 107°48'E) fit the original description very closely. Most descriptions of *B. macrotis* in

TABLE 5. Comparison of *Calluella guttulata* from Buon Luoi and *C. yunnanensis*. Data on the latter are from Yang et al. (1991).

	Buon Luoi	<i>C. yunnanensis</i>
<b>SVL males</b>		
Range	40.1–45.1	30.0–37.2
Mean ± SE	42.6 ± 0.62	32.7
N	9	20
<b>SVL females</b>		
Range	42.9–53.2	40.0–48.8
Mean ± SE	48.6 ± 0.96	44.0
N	10	10
<b>T/SVL</b>		
Range	0.37–0.42	0.42–0.49
Median	0.404	0.46
N	10	30

dicates no cranial crests, but Boulenger's (1887b) illustration shows a clear, thick glandular ridge between the eye and the parotoid that is also present in two of these specimens. The tympanum is somewhat smaller than stated by Boulenger (tympanum/eye 0.50–0.65 instead of about equal to the eye), but it is large for a species of *Bufo* and is very close to the eye. This is the first report of the species from Vietnam.

## Microhylidae

### *Calluella guttulata* (Blyth)

*Megalophrys guttulata* Blyth, 1856:717—Pegu, Burma.

*Calluella guttulata* Günther, 1869:490; Bourret, 1942:481.

Twenty-two specimens were collected on the road in Buon Luoi village after heavy rain. This is the first report of this species from Vietnam; it was previously known from Burma to southern Thailand (Bourret, 1942; Frost, 1985). These specimens agree very closely with Parker's (1934) description of coloration. They differ from the geographically closest species, *C. yunnanensis* Boulenger, in color pattern, in larger size, and in lesser T/SVL (Table 5).

### *Microhyla annamensis* Smith

*Microhyla annamensis* Smith, 1923:47—Sui Kat, Annam, Vietnam; Bourret, 1942:513.

A series of 27 specimens (26 from Buon Luoi, 1 from Kon Cha Ran) is tentatively assigned to *M. annamensis*. They match Smith's (1923) description in all respects except one: they have a small, but distinct, outer metatarsal tubercle. Smith (1923), confirmed by Parker (1934), reported that the types lacked an outer tubercle. Although the first finger is much shorter than the second, not extending beyond the subarticular tubercle of the second finger when adpressed, it is not as short as that of *M. annectans*. In these specimens of *M. annamensis* the third toe is fully webbed to just below the disc, whereas in *M. annectans* the webbing does not extend beyond the distal tubercle of the third toe (Parker, 1934); the webbing in *M. butleri*, which Parker placed near *M. annamensis*, reaches only between the two outer subarticular tubercles on the third toe. In *M. butleri* there is a short, distinct, diagonal tarsal fold from the inner metatarsal tubercle (Parker, 1934); there is no tarsal fold in the present sample of *M. annamensis*. SVL of males 17.5–21.0 (mean ± SE 18.97 ± 0.19, N = 21), of two females 20.0–22.2. T/SVL 0.57–0.68 (median 0.631, N = 15).

If correctly identified, this sample represents only the second record of the species. The type locality is about 250 km south of Buon Loy and about 300 m higher (Buon Luoi 700–750 m ASL). Kon Cha Ran is 40 km farther north, but at about the same elevation (1000–1200 m) as the type locality.

Specimens were collected along the silty banks of ponded areas of forest streams and along a small silty stream.

### *Microhyla bermorei* (Blyth)

*Engystoma bermorei* Blyth, 1856:720—Pegu, Burma.

*Microhyla bermorii* Boulenger, 1882:166; Bourret, 1942:509.

A large sample of this species was obtained at Buon Luoi (80), Kon Cha Ran (20), and Tram Lap (4). SVL of females 36.9–41.6 (mean ± SE 38.96 ± 0.70), of males 30.9–38.2 (mean ± SE 35.15 ± 0.68).

Most specimens were found on forest floor in leaf litter. A few were found on banks of forest streams in litter.



FIG. 4. *Amolops spinapectoralis*, new species.

## Ranidae

### *Amolops spinapectoralis*, new species (Fig. 4)

**HOLOTYPE**—FMNH 252725, adult male, collected at Kon Cha Ran (1000 m ASL), An Khe District, Gia Lai Province, Vietnam, 16 April 1995 by Ilya Darevsky and Nikolai Orlov.

**PARATYPES**—FMNH 252726–74, seven adult males, 15 adult females, and 27 juveniles and subadults, collected 15–16 April 1995 at the type locality.

**ETYMOLOGY**—Specific name from *spina* L., thorn, and *pectoralis* L., of the breast, referring to the pectoral spines in adult males.

**DIAGNOSIS**—An *Amolops* with the anterior two-thirds of the tympanum visible; disc of first finger with circummarginal groove, distinctly larger than disc of second finger; male with nuptial pad consisting of whitish conical spines; chest of male with oval area of similar spines; no outer metatarsal tubercle.

**DESCRIPTION**—Habitus stocky; snout obtusely pointed or rounded in dorsal view, rounded in pro-

file, slightly projecting; nostril midway between tip of snout and eye; canthi rounded, not constricted; lores sloping, concave; diameter of eye longer than length of snout; pupil horizontal; interorbital wider than eyelid; tympanum visible rim obscure at rear; vomerine teeth in short oblique patches, two to four teeth per group groups nearer to midline than to choanae. Fingers with truncate discs; disc of first finger with circummarginal groove; disc of second finger distinctly smaller than that of first finger, discs of two outer fingers wider than tympanum; first finger shorter than second; fingers without webbing; no skin folds or ridges on fingers; subarticular tubercles conspicuous. Discs of toes smaller than those of fingers; all toes fully webbed to discs; first toe with narrow skin fold medially, fifth toe with wider fold laterally; inner metatarsal tubercle low, oval; no outer metatarsal tubercle; a low dermal ridge on tarsus. Skin of back granular, tubercular on sides; venter smooth.

Color in life of back and head olive brown network surrounding large black spots; iris olive brown with fine black network. Venter in preservative white with varying amounts of dark pig-

ment from immaculate white to almost completely black on throat; heavily mottled with black on abdomen and undersides of limbs.

Male with prepollex conspicuous and bowed outward; nuptial pad consisting of ca. 100 white, conical spines on dorsal and medial surfaces and around end of prepollex; an oval group of similar spines on each side of chest just medial to axilla, each group with 100–150 spines; small colorless spinules cover side and top of head; gular pouches present.

SVL of males with nuptial pads 47.3–53.2 ( $N = 5$ ), of males with vocal sacs but no nuptial pads 41.0–45.1 ( $N = 3$ ), mean  $\pm$  SE of all eight 46.95  $\pm$  1.37; SVL of adult females 52.3–66.9 (60.17  $\pm$  1.02;  $N = 15$ ).

T/SVL of males 0.52–0.56 (median 0.547,  $N = 7$ ), of females 0.46–0.53 (median 0.501,  $N = 11$ ); HW/SVL of males 0.36–0.39 (median 0.365,  $N = 7$ ), of females 0.36–0.39 (median 0.373,  $N = 11$ ); HL/SVL of males 0.33–0.38 (median 0.369,  $N = 8$ ), of females 0.33–0.38 (median 0.345,  $N = 11$ ). Differences between the sexes are significant only in T/SVL ( $P = 0.002$ , Mann-Whitney  $U$ -test).

Measurements of holotype: SVL 53.1, tibia 27.5, head width 20.0, head length 18.8, diameter of eye 8.6, tympanum 1.9, interorbital 5.0, and eyelid width 4.3.

REMARKS—The sample includes one stage 45 metamorphosing individual with remnants of the ventral sucker and tail still present. SVL of that specimen is 26.9. Ripe ova in two females are white. Specimens were collected from wet vertical faces of rock at a waterfall.

COMPARISONS—*Amolops spinaepectoralis* is the only known species of *Amolops* in which the disc of the second finger is smaller than that of the first finger and in which males have pectoral patches of spines. Only three species of *Amolops* have spinose nuptial pads: *A. spinaepectoralis*, *A. ricketti* (Boulenger), and *A. wuyiensis* (Liu & Hu). All other species of *Amolops* have velvety nuptial pads, except *A. hainanensis* (Boulenger) and *A. torrentis* (Smith), both of which apparently lack nuptial pads. *Amolops spinaepectoralis* differs from *A. ricketti*, *A. wuyiensis*, *A. hainanensis*, *A. torrentis*, and 10 of the other species recognized by Yang (1991) in its possession of gular pouches.

The six species that are similar to *A. spinaepectoralis* in having gular pouches differ in other secondary sex characters. *Amolops afghanus* (Günther), and *A. macrorhynchus* Yang females are much larger (SVL > 72), *A. larutensis* (Boulenger) and *A. nepalicus* Yang differ in having an

outer metatarsal tubercle, and *A. chunganensis* (Pope) and *A. monticola* (Anderson) differ in having dorsolateral folds.

*Amolops spinaepectoralis* differs from species in the related genera, *Huia* Yang and *Meristogenys* Yang, in having the crossbar of the terminal phalanx more than 0.6 times the length of the phalanx, as well as in the male's secondary sex characters.

### *Amolops ricketti* (Boulenger)

*Rana ricketti* Boulenger, 1899:168—Guandun, Fujian Province, China.

*Amolops ricketti* Yang, 1991:23.

*Staurois ricketti* Bourret, 1942:387.

A sample from Tam Dao, including adult males and females, agrees well with published descriptions (Bourret, 1942; Yang, 1991) and specimens from Fujian. The snout is depressed and projecting, the canthi sharp, lores concave and vertical, the tympanum visible but with obscured rim, and all toes fully webbed to the discs. Males lack gular pouches and vocal sacs, but have a large nuptial pad consisting of about 100–125 large, white, conical spines. All of the Tam Dao specimens have the black spotting on the throat that occurs in only one-third of the specimens from Fujian (FMNH 24682–90). The Fujian frogs are larger than those from Tam Dao. SVL of males from Fujian measure 54.6–58.5 ( $N = 3$ ), those from Tam Dao 42.9–46.0 ( $N = 9$ ); females from Fujian measure 55.0–60.0 ( $N = 6$ ), those from Tam Dao 50.0–56.2 ( $N = 7$ ).

The sexes differ slightly but significantly in certain body proportions. Males have slightly longer legs (T/SVL 0.53–0.57), wider heads (HW/SVL 0.32–0.35), and longer heads (HL/SVL 0.31–0.36) than females (T/SVL 0.48–0.54, HW/SVL 0.33–0.34, and HL/SVL 0.33–0.34); differences were at the  $P < 0.05$  level (Mann-Whitney  $U$ -test) for each comparison.

### *Huia nasica* (Boulenger)

*Rana nasica* Boulenger, 1903:187—Mao Son, Tonkin, Vietnam; Bourret, 1942:352.

*Huia nasica* Yang, 1991:31.

Sixteen adult males and one adult female collected at Tam Dao agree with the original descrip-

tion in every detail. The strongly depressed and projecting snout and the deeply concave lores are especially distinctive in this species. All of the frogs in this series have a sharply defined black stripe just below the canthus, and the temporal region and lower border of the dorsolateral fold are black; these are color features noted by Boulenger (1903). Characters not mentioned by Boulenger (1903) or Bourret (1942), who had specimens from Tam Dao, are: males with small, white asperities on the rear of the back; discs of the toes same diameter as those of fingers.

SVL measurements of males 44.0–49.8 (mean  $\pm$  SE  $46.33 \pm 0.33$ , N = 16), T/SVL 0.56–0.63 (median 0.590), HW/SVL 0.27–0.30 (median 0.287), and HL/SVL 0.36–0.41 (median 0.390). The single female measured 77.7 mm.

Parts of Yang's (1991) description of *Huia nasica* were based on two males (FMNH 215970–71) from Kanchanaburi Province, Thailand. These specimens, which are not conspecific with the Tam Dao series, have much longer legs (T/SVL 0.71), a nonprojecting and nondepressed snout, nostril much closer to the tip of the snout than to the eye (as opposed to equidistant between snout and eye), toe discs larger than those of fingers, and pineal body hidden (visible in Tam Dao specimens). However, in other characters important for generic assignment (Yang, 1991), such as relative lengths of first and second metacarpals, shape of terminal phalanges, and shape of sternum, the Tam Dao and Thailand frogs are identical.

### *Occidozyga martensii* (Peters)

*Phrynoglossus martensii* Peters, 1867:29—Bangkok, Thailand.

*Ooeidozyga laevis* (part) Bourret, 1942:401.

One adult female from Tram Lap and 11 females, eight males, and three juveniles from Buon Luoi constitute this sample. The males have weak, pale, but distinct nuptial pads on the first finger. Six of the females have enlarged nonpigmented ova.

The species is widely distributed in Vietnam (Bourret, 1942). Reasons for placing this species in *Occidozyga* are given elsewhere (Inger, 1996).

Six were collected in rice fields, one along a forest road, and three from the silty bank of a stream where it flowed into a large pond.

### *Rana attigua*, new species (Fig. 5)

HOLOTYPE—FMNH 252775, an adult female, collected at Buon Luoi, An Khe District, Gia La Province, Vietnam, 25 April 1995 by Ilya Darevsky and Nikolai Orlov.

PARATYPES—FMNH 252776–816, MVZ 222932–34, 222936, 222941–43 from the type locality FMNH 252817–30 from Kon Cha Ran, An Khe District, Gia Lai Province, Vietnam; FMNH 252831–32 from Tram Lap, An Khe District, Gia Lai Province, Vietnam. All were collected by Ilya Darevsky and Nikolai Orlov.

ETYMOLOGY—Specific name from *attiguus* L. meaning neighboring, referring to its similarity to *R. milleti* Smith.

DIAGNOSIS—Digit tips expanded, discs of inner fingers without circummarginal groove; first finger longer than second; dorsolateral fold present; outer metatarsal tubercle present; males with large humeral gland, but lacking gular pouches; SVL of males 40–45, of females 55–65; underside of call immaculate white or with faint dark speckling.

DESCRIPTION—Habitus moderately stocky; head longer than broad. Snout obtusely pointed, projecting, rounded in profile; nostril closer to tip of snout than to eye, lateral; canthi distinct, not constricted; lores very slightly oblique, concave; diameter of eye equal to snout; interorbital equal to width of eyelid; tympanum distinct, one-half to two-thirds diameter of eye, larger in males (see below); vomerine teeth in short oblique rows, well-removed from choanae.

Finger tips dilated into distinct, small discs less than twice diameter of penultimate phalanges; discs without circummarginal grooves or with weak grooves on outer fingers; first finger longer than second; subarticular tubercles prominent; supernumerary tubercles on three outer fingers. Discs of toes equal to or slightly larger than those of fingers; all with circummarginal grooves; webbing on first and second toes between subarticular tubercle and disc, on third and fifth toes narrowly to disc, on fourth toe between middle and distal tubercles, fourth toe with two to two-and-one-third phalanges free; inner metatarsal tubercle oval, less than half length of first toe, outer metatarsal tubercle distinct, round, much smaller than inner; no flaps of skin on margins of first and fifth toes.

Conspicuous, continuous dorsolateral folds; skin of back granular with numerous small tubercles; sides with larger tubercles; dorsal surfaces





FIG. 5. *Rana attigua*, new species. Male, 44.9 mm.

of hind limb with tubercles; ventral surfaces smooth.

Color in life dorsally medium brown, with or without small darker spots on back; dark brown or black band from snout through eye and tympanum, sharply defined on snout, less so in temporal area; upper lip with white to yellow stripe, extending to axilla; upper half of iris light golden brown; limbs with dark brown crossbars dorsally. In preservative ventral surfaces whitish; brownish spots or mottling on throat and usually on chest and anterior part of abdomen; rear of abdomen without dark pigment; ventral surface of thigh without dark pigment; underside of calf immaculate or with very fine dark speckling; rear of thigh dusted with dark pigment, but without clear pattern.

Measurements of holotype: SVL 63.7, T 34.3, HW 21.4, HL 24.0, and tympanum 5.5.

Males have vocal sac openings at the corners of the floor of the mouth, but lack gular pouches. A velvety nuptial pad covers the medial and dorsal surfaces of first finger from its base to the proximal end of the penultimate phalanx; the ventral margin of the nuptial pad is straight. Males

also have a large, conspicuous, flat humeral gland that occupies almost the entire anteromedial aspect of the upper arm.

VARIATION—The dorsal and temporal areas in about half of the individuals have tubercles set with whitish, spinose tips. This condition is seen in both males and females.

SVL of males with nuptial pads 36.2–45.5, only four <39.0 (mean  $\pm$  SE 41.34  $\pm$  0.28, N = 43), of females with mature oviducts 57.7–63.7 (59.66  $\pm$  0.87, N = 6); T/SVL males 0.51–0.58 (median 0.535, N = 26), females 0.53–0.57 (median 0.554, N = 6); HW/SVL males 0.30–0.34 (median 0.325, N = 27), females 0.31–0.35 (median 0.339, N = 6); HL/SVL males 0.38–0.43 (median 0.396, N = 27), females 0.36–0.38 (median 0.375, N = 6); tympanum/SVL males 0.089–0.115 (median 0.099, N = 27), females 0.077–0.089 (median 0.086, N = 6).

COMPARISONS—*Rana attigua* is very similar to and co-occurs with *R. milleti* Smith. In preservative, the latter has dark spotting on the ventral surface of the calf and dark speckling or mottling under the thigh, whereas in *R. attigua* the underside of the thigh is immaculate whitish and the

TABLE 6. Comparison of *Rana attigua* with similar species from Southeast Asia. Males only. Data sources: *R. guentheri*, *R. leptoglossa*, and *R. mortenseni* from Boulenger (1920); *R. cubitalis* from Smith (1917); *R. spinulosa* from Smith (1923); other species from present study.

	SVL	HW/SVL	HL/SVL	Typanum/SVL		
				Range	Sexual dimorphism	Gular pouches
<i>R. attigua</i>	36–46	0.30–0.34	0.38–0.43	0.089–0.115	Yes	Absent
<i>R. milleti</i>	34–40	0.30–0.36	0.38–0.44	0.099–0.121	Yes	Absent
<i>R. guentheri</i>	60–80	0.29–0.33	0.34–0.37	0.067–0.088	No	Present
<i>R. leptoglossa</i>	51–60	0.34–0.35	0.36–0.37	0.098–0.100	?	Present
<i>R. cubitalis</i>	66–68	0.30–0.31	0.31–0.35	0.088–0.091	?	Present
<i>R. nigrovittata</i>	44–57	0.36–0.39	0.39–0.45	0.081–0.103	Yes	Absent
<i>R. spinulosa</i>	37–42	0.33–0.37	0.38–0.41	0.073–0.083	No	Absent
<i>R. mortenseni</i>	50–71	0.35–0.36	0.35–0.36	0.066–0.085	No	Absent
<i>R. johnsi</i>	44–49	0.32–0.34	0.38	0.089–0.100	Yes	Absent

underside of the calf is immaculate or has very faint dark speckling. The rear of the thigh in *R. attigua* has a light dusting of dark pigment, in contrast to the distinct pattern in *R. milleti* (see description below). The nuptial pad in male *R. milleti* has a distinct notch or constriction of the ventral margin, which is straight in *R. attigua*. The most conspicuous differences between these two involve size. Although the size ranges of males partially overlap, only one of 52 adult males of *R. milleti* was larger than 40.0 mm, whereas 81% of 43 male *R. attigua* exceeded 40.0. Size ranges of adult females (determined by condition of the oviduct) of the two species did not overlap; the largest female *R. milleti* measured 49.6 mm. The difference between mean SVL of males and females in *R. attigua* (18 mm) is much greater than the corresponding measure in *R. milleti* (8.25 mm).

In a suite of characters—discs of inner fingers without grooves, dorsolateral fold present, first finger much longer than second, outer metatarsal tubercle present—*R. attigua* and *R. milleti* resemble seven congeners from Southeast Asia: *R. cubitalis* Smith, *R. guentheri* Boulenger, *R. johnsi* Smith, *R. leptoglossa* (Cope), *R. mortenseni* Boulenger, *R. nigrovittata* (Blyth), and *R. spinulosa* Smith. Males of *R. cubitalis*, *R. guentheri*, and *R. leptoglossa* have gular pouches and are larger (Table 6) than those of *R. attigua*, and males of *R. cubitalis* have an extension of the nuptial pad up the arm (Smith, 1930). *Rana nigrovittata* has sides darker than the back, a much smaller humeral gland (only half the length of the upper arm), a much bolder pattern on the rear of the thigh, and full web to the distal tubercle of the

fourth toe. *Rana mortenseni* differs from *attigua* in having larger males, more extensive webbing head as wide as long, and apparently no sex dimorphism in size of tympanum (Table 6). *Rana johnsi* is sharply different from *R. attigua* in coloration, having a very dark rhomboidal mark covering the temporal region, a dark longitudinal streak along the calf and tarsus, but no light stripe along the lip; males of *R. johnsi* lack humeral glands. *Rana spinulosa* lacks sex dimorphism in size of tympanum and has very warty dorsal surfaces and a wider head than *R. attigua*.

HABITAT.—All individuals were found along forested streams. About 40% (19) were sitting on sandy banks, about 30% on dead leaves, and the rest on rocks. On 7 nights, we collected individuals of both *R. attigua* and *R. milleti* in a single habitat; in these samples, which were made on two streams at each of two localities, *R. attigua* was more numerous in three and *R. milleti* in four. Most specimens were caught on the banks of two streams at Buon Luoi; we collected 33 *R. attigua* and 21 *R. milleti* on Stream N5 and 17 *R. attigua* and 26 *R. milleti* on Stream N3. Although these data, arranged into a 2 × 2 table, show statistically significant departure from randomness ( $\chi^2 = 4.46$ ,  $P < 0.05$ ), the segregation by streams is modest. Most specimens were found on four types of substrate: bare sand or silt, rocks, logs, and dead leaves. The two species show no segregation by substrate ( $\chi^2 = 4.88$ ,  $df = 3$ ,  $P > 0.10$ ).

#### *Rana cf. blythii* Boulenger (Fig. 6)

Large samples of this species were collected at Buon Luoi, Kon Cha Rang, and Tram Lap at el



FIG. 6. *Rana cf. blythii*. Male, 73.8 mm.

evations from 700 to 1200 m ASL. Males have enlarged odontoids at the front of the mandible and distinctly enlarged heads, but they lack nuptial pads and vocal sacs. The tympanum is superficial. Although these frogs are clearly part of the *R. blythii* species group, they differ significantly in a number of ways from typical *R. blythii* of the Malay Peninsula and Thailand. In the Vietnam

form, full webbing reaches only to the distal sub-articular tubercle of the fourth toe (to the base of the swollen tip in *R. blythii*), SVL and T/SVL are smaller (Table 7), and ripe ova are bicolored with a black animal hemisphere (ova are pale and unicolor in *R. blythii*).

The canthus is rounded. The three outer fingers have a ridge of skin on the medial border, widest

TABLE 7. Comparison of *Rana cf. blythii* from Vietnam with *R. blythii* from the Malay Peninsula. Adults only. Males with enlarged odontoids; females with enlarged, convoluted oviducts.

	Males		Females	
	Vietnam	Malay Peninsula	Vietnam	Malay Peninsula
<b>SVL</b>				
Range	58.5–93.1	66.6–208.0	53.7–79.6	71.6–156.0
N	24	21	28	32
<b>T/SVL*</b>				
Range	0.43–0.56	0.47–0.58	0.47–0.55	0.49–0.59
Median	0.507	0.541	0.523	0.545
N	20	21	18	32

\* Differences between Vietnamese and peninsular samples were statistically significant at  $P < 0.01$  for both sexes (Mann-Whitney *U*-test).



FIG. 7. *Rana johnsi* Smith. Female, 46.7 mm.

on the second finger. The first and fifth toes have movable flaps of skin externally. The first three toes and the fifth are fully webbed to the base of the swollen tips. There are two wide, black bars from the eye to the lip. The upper half of the tympanum and the supratympanic fold are covered by a black streak. In about one-fourth of the individuals, there is a light vertebral stripe.

SVL and T/SVL are given in Table 7. HW/SVL of males 0.39–0.46 (median 0.421, N = 36), of females 0.36–0.41 (median 0.383, N = 21); HL/SVL of males 0.42–0.50 (median 0.445, N = 35), of females 0.38–0.46 (median 0.410, N = 21). For the largest males (SVL > 80.0, N = 8) HW/SVL 0.40–0.45, HL/SVL 0.42–0.48.

Parker (1925) reported *Rana macrodon* from Bao-Ha (76 m ASL) in the Red River valley of northern Vietnam and, without comment or reference to specimens, gave the range as “Siam and Annam.” These and Bourret’s (1942) citation of Parker are the only previous mentions of this species group in Vietnam.

Most individuals were seen along the banks of rapid streams, though some were observed along banks of large forest ponds.

#### *Rana johnsi* Smith (Fig. 7)

*Rana sauteri johnsi* Smith, 1921:434—Sui Kat Annam, Vietnam.

*Rana (Hylarana) sauteri johnsi* Bourret, 1942:322.

The present sample from Buon Luoi, Tram Lap and Kon Cha Ran matches Smith’s (1921) description and illustration in all details of the distinctive color pattern and in having very long legs (T/SVL of males 0.62–0.65 in Smith’s sample 0.63–0.73 in present sample), a distinctly raised continuous dorsolateral fold, full webbing to discs of third and fifth toes and to distal tubercle of fourth toe, and an inverted V-shaped glandular fold between the shoulders. They also match one of Smith’s specimens (MCZ A8801) that we have examined. However, there are several conspicuous differences. Smith (1921) stated that males of *R. johnsi* had internal vocal sacs and brown nuptial pads, whereas the four males from Buon Luoi have swollen inner fingers, without the fine spinules of the typical ranid nuptial pad, and lack

TABLE 8. Characters of males from several samples of frogs related to *Rana sauteri* Boulenger.

	<i>R. sauteri</i> Taiwan	<i>R. johnsi</i>	
		Types	Buon Luoi
SVL	35.3–40.8	40–45	43.5–48.9
T/SVL range	0.55–0.61	0.62–0.64	0.63–0.73
T/SVL median	0.577	0.628	0.652
Vocal sac openings	Present	Present	Absent
Nuptial pad	Present	Present	Absent
Testes pigmented	Yes	?	Yes
Pigmented vomerine ridges	No	No	Yes

vocal sac openings. Males from Buon Luoi also lack humeral glands. Although these differences may be related to levels of sexual maturity, the Buon Luoi males (SVL 43.5–48.9) are as large or larger than the five males in the type series (40–45). The four Buon Luoi females having mature, convoluted oviducts measure 49.4–55.5, larger than those in the type series (40–50). All of the Buon Luoi frogs have a heavy concentration of melanophores on the vomerine dental ridges. Smith (1921) did not mention this character, although he examined the vomerine teeth of *R. johnsi*, but the specimen that we examined from his series lacks palatal pigment.

Smith (1921) separated the Annamese frogs from typical *R. sauteri* Boulenger (type locality Taiwan) on the basis of these characters: more pointed snout, longer leg, more prominent dorsolateral folds, and smaller size. Smith (1921) based his comparison on the four females that constituted the type series of *R. sauteri*. We have examined a more recently collected sample of *R. sauteri* from Taiwan (FMNH 127569–99), including nine males. Our specimens from Taiwan have shorter legs (T/SVL 0.55–0.61, median 0.577) and less conspicuously raised dorsolateral folds than *R. johnsi*, confirming several of Smith's (1921) observations. However, the Taiwanese males measure 35.4–40.8 SVL, and because they are smaller than males in Smith's series, his statement that *R. johnsi* is smaller than typical *R. sauteri* is incorrect. Instead, Taiwanese males are smaller than those from Vietnam (Table 8). Taiwanese males have vocal sac openings and velvety brown or gray nuptial pads, agreeing with Smith's description of *R. johnsi*, but differing from the present Vietnamese sample. None of the Taiwanese frogs has pigment on the vomerine dental ridges. One

striking, shared feature of males from Taiwan and Buon Luoi is heavily pigmented testes.

### *Rana kuhlii* Tschudi

*Rana kuhlii* Tschudi, 1838:40—Java; Bourret, 1942:278.

Samples were collected at Kon Cha Rang and Tam Dao. Adult males (with nuptial pads) and females (with enlarged, convoluted oviducts) from Kon Cha Rang measure 40.3–49.2 (N = 2) and 45.4–59.0 (N = 5), respectively. Adult males and females from Tam Dao measure 41.9–84.8 (N = 8) and 52.0–83.7 (N = 6), respectively. T/SVL 0.41–0.48 (females), 0.42–0.48 (males); HW/SVL 0.36–0.40 (females), 0.39–0.44 (males); HL/SVL 0.35–0.39 (females), 0.35–0.46 (males). The frogs from Tam Dao have distinct dermal flaps along the lateral margin of the third finger; such flaps are absent in all except two (one male and one female) from Kon Cha Rang.

All of the Kon Cha Rang specimens were taken along the banks of streams at about 1200 m—two on rocks in midstream and the rest on silty banks close to the water's edge.

### *Rana livida* (Blyth)

*Polypedates lividus* Blyth, 1856:718—Tenasserim, Burma.

*Rana livida* Boulenger, 1887b:484.

*Rana (Hylarana) livida* Bourret, 1942:371.

Two large samples, one from the An Khe District (Buon Luoi, Kon Cha Ran, and Tram Lap) and another from Tam Dao, agree with a sample from Huai Kha Kaeng, Thailand, near the Tenasserim area of Burma, type locality of the species. All of these frogs have a ridge or flap of skin along the median edge of the third finger and a narrow ridge of skin along the median edge of the first toe. All lack outer metatarsal tubercles. Males have gular pouches.

Bourret (1942) suggested that geographic variation in development of a dorsolateral glandular fold divides this species into a "northern" population, to which Boulenger's (1899) *Rana graminea* applies, and a "southern" one, or *Rana livida* in the strict sense. That distinction cannot be supported because there is no difference between the northern and southern samples at hand in this

character; in fact, there is variation within the Buon Loy sample. However, females from the An Khe District (SVL 74.0–99.9, mean  $\pm$  SE 86.49  $\pm$  1.81, N = 17) are smaller than those from Tam Dao (95.5–104.4, 100.70  $\pm$  0.90, N = 11) and have relatively longer tibia length (T/SVL An Khe females 0.58–0.69, median 0.634, N = 18; Tam Dao females 0.57–0.62, median 0.594, N = 11). The Tam Dao sample included only a single male, preventing comparisons of this sex.

### *Rana maosonensis* (Bourret)

*Hylarana maosonensis* Bourret, 1937:36—Mao Son, Tonkin, Vietnam.

*Rana (Hylarana) maosonensis* Bourret, 1942: 351.

The present sample consists of 12 males and 16 females from Tam Dao. Bourret (1937, 1942) did not refer to humeral glands as part of the male suite of secondary sex characters, but weak humeral glands are present in the males from Tam Dao and in two males from the type series (FMNH 123909–10). Males lack gular pouches. The Tam Dao series matches the original description and the two paratypes in distinctive coloration, spinose tuberculation of the skin, habitus, and webbing. Full webbing reaches just beyond the middle subarticular tubercle of the fourth toe. In the Tam Dao sample, females are much larger (SVL 51.0–61.1, mean  $\pm$  SE 56.29  $\pm$  0.72) than males (37.9–43.1, 41.49  $\pm$  0.46). Males have slightly narrower heads than females; HW/SVL of males 0.32–0.35, median 0.33; of females 0.33–0.36, median 0.34 ( $P < 0.05$ ). Males also have slightly longer heads; HL/SVL of males 0.37–0.41, median 0.390; females 0.36–0.39, median 0.378 ( $P < 0.05$ ). There is no sexual dimorphism in relative length of the tibia (T/SVL of males 0.50–0.57, median 0.527; females 0.50–0.56, median 0.528;  $P > 0.10$ ) or diameter of the tympanum (TY/SVL of males 0.075–0.099, median 0.086; females 0.063–0.097, median 0.084;  $P > 0.10$ ).

Coloration in life (based on a female) dark reddish brown dorsally, with irregular, obscure black spots; concavity of lores black; upper lip yellowish; upper half of iris dark brown, lower half blackish; tympanum dark brown, with black spot at posterior corner; sides changing from dark brown dorsally through yellow brown to white near belly, with many black spots; limbs with dark brown crossbars. In preservative, Tam Dao frogs

with whitish venter suffused with dark brown; pair of blackish rectangular dark markings at rear of throat.

Tran et al. (1981) listed this species from four provinces in northern Vietnam, and Nguyen et al. (1994) reported it from Tam Dao. Although Yan et al. (1991) did not include it in the fauna of Yunnan, it probably occurs there because the type locality is on the border.

### *Rana milleti* Smith

*Rana milleti* Smith, 1921:432—Dalat, Annam, Vietnam.

*Rana (Hylarana) milleti* Bourret, 1942:312.

These specimens from Boun Luoi, Tram Lag and Kon Cha Ran constitute only the second record of the species, and they agree well with Smith's (1921) description, differing in only one important detail. Smith stated that males lacked a vocal sac, but a male collected with the type series (MAS field no. 5110, FMNH 128298) has small round vocal sac openings at the corners of the mouth; males in the new sample have vocal sac openings in the same position. The tympanum is larger in males than in females, a character not mentioned by Smith (1921) but clear from the measurements he presented. The nuptial pad has a noticeable ventral constriction that in a few males completely divides the pad into proximal and distal halves. Males have a large, flat, whitish humeral gland. The following notes amplify Smith's (1921) description.

Web on first toe to subarticular tubercle or a little beyond, on second toe between subarticular tubercle and base of disc, on third toe between distal tubercle and base of disc, narrowly reaching base of disc, on fifth toe to base of disc, on fourth toe to middle tubercle on medial side, between middle and distal tubercles on lateral side. Skin between dorsolateral folds granular and with small tubercles, many of which are capped with a small spinule; sides with larger tubercles; ventral surfaces smooth. Color in preservative medium brown dorsally, slightly darker on sides; a sharply defined dark band from tip of snout through eye to tympanum; upper lip with a wide or thin white line extending to axilla; underside of head and chest usually with dark mottling; entire abdomen often with small dark spots; underside of calf with heavy dark spotting; rear of thigh dark brown

forming a network around small light spots or blotches.

SVL of males with nuptial pads 34.2–40.4 (mean  $\pm$  SE 37.01  $\pm$  0.18, N = 52), of females with mature oviducts 41.1–49.6 (45.26  $\pm$  0.70, N = 15); T/SVL males 0.51–0.57 (median 0.540, N = 23), females 0.51–0.58 (median 0.531, N = 15); HW/SVL males 0.30–0.36 (median 0.326, N = 23), females 0.29–0.33 (median 0.313, N = 15); HL/SVL males 0.38–0.44 (median 0.407, N = 23), females 0.35–0.40 (median 0.376, N = 15); tympanum/SVL males 0.099–0.121 (median 0.112, N = 23), females 0.080–0.104 (median 0.090, N = 15).

Many of these frogs were collected with *R. atigua* (see above). All were on stream banks, mostly on sand or silt (23) or dead leaves (16). Only five were on rocky substrate.

### *Rana montivaga* Smith

*Rana montivaga* Smith, 1921:436—Dalat, Annam, Vietnam.

*Rana (Hylarana) montivaga* Bourret, 1942: 346.

An adult male (51.9 mm) from Buon Luoi agrees closely with Smith's (1921) description and illustration in general form and coloration. However, it has a gular pouch, whereas Smith reported that males in the type series had "internal vocal sacs." The Buon Luoi male has no humeral gland; because Smith did not mention this structure, we assume topotypic males also lacked them. The Buon Luoi male has the head distinctly longer than wide, whereas the measurements given by Smith show HW  $\geq$  HL. We have examined three immature topotypes (FMNH 135343, MCZ 8785–86) collected by Smith at the same time as the types, and these frogs also have HL > HW. The new specimen and the topotypes have a circummarginal groove around the small disc of the first finger, which is longer than the second; all lack an outer metatarsal tubercle; and all have vomerine teeth in short series widely separated from the choanae. In these characters and in webbing, coloration, and skin surface, these four specimens match Smith's (1921) description.

One adult female (64.3 mm) from Tam Dao agrees closely with Smith's description and illustration. The main differences from Smith's description are the presence of a weak outer metatarsal tubercle (absent in types), HL slightly great-

er than HW, and indistinct light spots on a darker background (the reverse of *R. montivaga*). Vomerine teeth in the Tam Dao specimen are in long series narrowly removed from the choanae, and thus they differ from Smith's description and the four specimens discussed above.

Pope (1931) identified frogs from Fujian Province, China as *R. montivaga*, although they were later referred to *R. swinhoana* Boulenger by Liu and Hu (1961). However, Pope's material (examined in FMNH) is not conspecific with *R. swinhoana*, differing greatly in size and in secondary sex characters (based on the redescription of *R. swinhoana* by Wang & Chan, 1977). Pope's (1931) specimens also differ from *R. montivaga* in having a narrower head (HW/SVL 0.31–0.33 compared to 0.35–0.38 in Smith's types), first finger shorter than second, and a sharply defined, black loreal stripe; the Fujian specimens are also smaller than Smith's types (53–59 mm, vs. 58–75).

### *Rana nigrovittata* (Blyth) (Fig. 8)

*Limnodytes nigrovittatus* Blyth, 1856:718—Pegu, Burma.

*Rana nigrovittata* Sclater, 1892:345.

*Rana (Hylarana) nigrovittata* Bourret, 1942: 317.

A large series from Buon Luoi, Tram Lap, and Kon Cha Ran matches Smith's (1922) second morphotype from northeastern Thailand and Laos: SVL often > 55 mm, dark lateral band broken up, and venter often with dark pigment. Males of the present sample have wrinkled skin at the corners of the throat, as noted in this form by Smith, but they do not have gular pouches, such as occur in *R. humeralis* Boulenger or *R. leptoglossa* (Cope). Males have gray nuptial pads on the dorsal and medial surfaces of the first finger; a large gland on the proximal fourth or third of the upper arm; and light, cornified spinules on the back and sides.

In this sample, males and females do not differ in SVL or T/SVL. SVL of males 43.3–61.8 (mean  $\pm$  SE 51.53  $\pm$  0.58, N = 52), of females 45.0–65.3 (52.92  $\pm$  0.68, N = 53); T/SVL of males 0.50–0.55 (median 0.522, N = 14), of females 0.50–0.56 (median 0.525, N = 16). The sexes do differ in relative size of head and tympanum. HW/SVL of males 0.35–0.39 (median 0.369, N = 15), of females 0.32–0.36 (median 0.344, N = 16); HL/SVL of males 0.39–0.45 (median 0.414, N =



FIG. 8. *Rana nigrovittata* (Blyth). Male, 52.9 mm.

15), of females 0.37–0.41 (median 0.390,  $N = 16$ ); tympanum/SVL of males 0.081–0.109 (median 0.093,  $N = 15$ ), of females 0.074–0.091 (median 0.083,  $N = 16$ ). Differences between the sexes in these three body proportions are significant at the  $P < 0.01$  level (Mann-Whitney  $U$ -test).

### *Rana taipehensis* Van Denburgh

*Rana taipehensis* Van Denburgh, 1909:56–Taipei, Taiwan.

*Rana (Hylarana) taipehensis* Bourret, 1942: 335.

Adult males (with nuptial pads) measure 23.6–30.2 (mean  $\pm$  SE 27.29  $\pm$  0.79,  $N = 11$ ); adult females measure 37.2–42.5 (40.07  $\pm$  0.75,  $N = 7$ ). The whitish, velvety nuptial pad covers the medial and dorsal surfaces of the first finger from its base to the level of the distal edge of the sub-

articular tubercle. None of the males has vocal sacs. Males have much larger tympana than females; tympanum/SVL of males 0.124–0.13 (median 0.130,  $N = 11$ ), of females 0.086–0.095 (median 0.093,  $N = 7$ ). Specimens in the present samples were taken at Buon Luoi and Buon Gen, Lanh, both in central Vietnam. Smith (1923) recorded this species from southern Annam, although Bourret (1942) reported it only from northern Vietnam.

### *Paa verrucospinosa* (Bourret)

*Rana spinosa verrucospinosa* Bourret, 1937:26–Chapa, Fan-Si-Pan, and Tam Dao, Tonkin Vietnam.

*Rana verrucospinosa* Bourret, 1939:8; Bourret, 1942:295.

Eleven specimens from Tam Dao, four adult



males 95.1–103.6 (mean 97.97), four adult females 72.6–103.8 (mean 92.74), four juveniles 53.3–72.6. The largest juvenile is a male lacking secondary sex characters. The smallest adult female has widened, coiled oviducts but immature ova. Bourret's (1937) description and illustration depict a frog having a very rough back covered by short, thick ridges and round tubercles and sides covered by oval or round tubercles. The Tam Dao specimens have the same skin rugosity, and all have flattened melanic cones on many of the dorsal ridges. Males have melanic spines covering the entire chest and most of the abdomen, leaving only a patch of smooth skin in the center of the rear third of the abdomen. Similar spines cover the dorsal and medial surfaces of the first two fingers. The ventral surfaces of the thighs are smooth.

One series of tadpoles was collected at Tam Dao. They agree very closely to Bourret's (1942) description and have heavily spotted tails, as he illustrated. Denticular formulae vary only slightly: 6(2–6)/3(1) or 6(3–6)/3(1). Total lengths in stages 27–29 were 71.1–75.4.

Dubois (1987) considered *P. verrucospinosa* to be conspecific with *P. boulengeri* (Günther). However, in adults of the latter from Sichuan (FMNH specimens), Yunnan (illustrations in Yang et al., 1991), and Guizhou (Wu et al., 1986), China the center of the back is smooth, and males have the entire abdomen and ventral surface of the thigh covered with black spines. *Paa yunnanensis*, which is known from southern Yunnan, close to the border with Vietnam, differs from *P. verrucospinosa* in having the pectoral spines arranged in two separated groups and in having round rather than elongate ridges on the back. *Paa spinosa* has scattered rounded tubercles on the back, and the male lacks melanic spines along the sides of the abdomen. *Paa microlineata* has widely spaced, narrow ridges on the back and coarsely granular rather than tubercular sides (Bourret, 1942).

## Rhacophoridae

### *Chirixalus doriae* Boulenger

*Chirixalus doriae* Boulenger, 1893:341—Karin Bia-po, Burma; Bourret, 1942:376.

An adult female (33.5 mm) and a subadult

(27.0) were collected at Buon Luoi. Although known from Burma, northern Thailand (Taylor, 1962), and southwestern Yunnan (Yang et al., 1991), this is the first record from Vietnam.

### *Chirixalus nongkhorensis* (Cochran)

*Philautus nongkhorensis* Cochran, 1927:179—Nongkhor, southeastern Thailand.

*Rhacophorus (Chirixalus) nongkhorensis* Ahl, 1931:107.

*Chirixalus nongkhorensis* Bourret, 1942:473.

An adult male (19.9 mm) collected at Buon Luoi agrees with specimens from eastern Thailand (FMNH 182594–611) in several significant characters: the nuptial pad is glandular, lacking fine spinules typical of most rhacophorids; dorsal surfaces of head, trunk, and limbs with fine, colorless asperities; limbs with dark spots dorsally, but no complete crossbars. It also agrees with the Thai frogs in most other characters. The principal difference is in SVL; the Thai males measure 24–31 mm. The species has also been recorded from Burma (Ahl, 1930, as *C. striatus*).

This specimen was perched in a bush at the edge of a pond.

### *Chirixalus palpebralis* (Smith)

*Philautus palpebralis* Smith, 1924:233—Langbian Peaks, Annam, Vietnam.

*Rhacophorus (Chirixalus) palpebralis* Ahl, 1931:104.

*Chirixalus palpebralis* Bourret, 1942:474.

Large samples from Buon Luoi and Kon Cha Ran match Smith's (1924) description of the unique type very closely, except that the tympanum is conspicuous, not "almost hidden." Smith noted that the inner fingers were "partially opposed" to the two outer ones; this was presumably the basis for Ahl's (1931) placement of the species in *Chirixalus*. Females in the sample from Buon Luoi have bi-pigmented ova, a black hemisphere and a brown one; the ova are not greatly enlarged (1.5–1.8 mm). The left ovary of one female held 52 pigmented ova. The pigmentation, size, and number of the ova do not fit the reproductive pattern of *Philautus*, but they confirm Ahl's (1931) generic assignment of the species. Yang et al. (1991) reported *C. palpebralis* from

Yunnan as a *Philautus*. We amplify Smith's (1924) description.

Full webbing on first toe to distal edge of subarticular tubercle, on second toe between tubercle and base of disc, on third and fifth toes between distal subarticular tubercle and disc, and on fourth toe to distal edge of middle tubercle or between the two outer tubercles. Males have slit-like vocal sac openings; a whitish, velvety nuptial pad covering dorsal and medial surfaces of the first finger from its base to the level of the subarticular tubercle; and many small, whitish pustules dorsally on the trunk.

SVL measurements of males 24.4–26.2 (mean  $\pm$  SE 25.21  $\pm$  0.16, N = 18), of females 29.2–32.1 (30.90  $\pm$  0.27, N = 10); T/SVL (males only) 0.48–0.53 (median 0.508, N = 15); HW/SVL (males) 0.28–0.32 (median 0.297, N = 15).

One tadpole at stage 39 is assigned to this species. The two inner fingers are opposed to the outer two, and full webbing of the third and fifth toes almost reaches the discs. The labial tooth formula is 5(2-5)/3(1), and there is a wide median gap in the marginal papillae of the lower lip. The head-body is black dorsally and ventrally. The caudal muscle and fins are black except for a wide vertical yellow band immediately behind the body; there is a black spot on the muscle in the center of the light band. Headbody is 13.75 mm; total length is 36.6.

The fingers and toes of the tadpole agree with adult *C. palpebralis*. In larval *C. vittatus* the distal third of the tail is black and there is a dark lateral stripe on the body (Heyer, 1971b); larval *C. nongkhorensis* have a blotched tail and only three or four upper rows of labial teeth (Heyer, 1971b); and larval *C. doriae* have a black stripe on the caudal muscle only, and only three upper rows of labial teeth (Pope, 1931; determined as *C. doriae* by Heyer, 1971).

This species was observed at Buon Luoi in October–December 1993 and March–May 1995. Most individuals were perched on broad-leaved Araceae in swampy portions of the banks of a stream, within 1 m of the water's surface. Pairs in amplexus were seen in April–May 1995; most of these were seen after night rains. The tadpole was caught in a ponded portion of a forest stream.

### *Chirixalus vittatus* (Boulenger)

*Ixalus vittatus* Boulenger, 1887b:421—Bhamo, Burma.

*Chirixalus vittatus* Liem, 1970:95.

*Philautus vittatus* Bourret, 1942:462.

All specimens were caught at Buon Luoi. SVL of males 19.4–21.4 (mean  $\pm$  SE 20.46  $\pm$  0.13, N = 14), of females 22.5–24.2 (mean 23.42, N = 4). T/SVL (males) 0.47–0.51 (median 0.488, N = 11), HW/SVL (males) 0.29–0.32 (median 0.30, N = 11).

Males have very fine colorless spinules on dorsal surfaces of head and trunk; the back is smooth in females. Males have a white, velvety nuptial pad on the dorsal and medial surface of the first finger, from its base to the level of the subarticular tubercle.

This species was seen at Buon Luoi in October–December 1993 and March–May 1995. The frogs were perched on branches of shrubs and small trees forming thickets at the edge of a large forest pond. Perch height was between just above the water level and 3 m. The species had a very high density; counts of > 100 were made within a 10-m strip of bank vegetation. It was never seen in the forest away from the pond.

### *Polypedates leucomystax* (Gravenhorst)

*Hyla leucomystax* Gravenhorst, 1829:26—Java.

*Polypedates leucomystax* Tschudi, 1838:75.

*Rhacophorus leucomystax* Bourret, 1942:425.

Samples of two morphotypes fitting the general definitions of *P. leucomystax* and *P. megacephalus* (Matsui et al., 1986) were collected at Buon Luoi. One form has four narrow, dark, dorsal stripes; the second only rarely (2/50) has dorsal stripes, and those unusual specimens have only two stripes. The two forms differ in other respects. In the striped form the rear of the thigh has large light spots circled by a thin black network, the throat and chest have small dark spots, the sides have dark spots, the disc of the third finger is almost as wide as the tympanum, and males lack vocal sacs. In the nonstriped form, the rear of the thigh has small light spots on a black background, the throat and chest may be suffused with dark pigment but lack distinct spots, the sides have light spots surrounded by a dark network, the disc of the third finger is much narrower than the tympanum, and the males have vocal sacs. Differences in body proportions are shown in Table 9.

We also observed differences between the two

TABLE 9. Comparison of striped and nonstriped forms of *Polypedates leucomystax (sensu lato)* from Buon Luoi, Vietnam.

	Striped	Nonstriped	P*
SVL males			
Range	49.8–61.6	49.1–62.4	NS
Mean ± SE	53.93 ± 0.53	55.35 ± 0.80	
N	25	21	
SVL females			
Range	71.6–79.3	71.7–86.4	NS
Mean ± SE	75.15 ± 0.87	78.88 ± 1.90	
N			
T/SVL males			
Range	0.50–0.55	0.46–0.51	<0.01
Median	0.536	0.499	
N	11	10	
T/SVL females			
Range	0.50–0.57	0.48–0.54	<0.02
Median	0.549	0.517	
N	9	9	
HW/SVL males			
Range	0.30–0.33	0.31–0.35	0.03
Median	0.316	0.326	
N	14	17	
HW/SVL females			
Range	0.32–0.35	0.31–0.36	NS
Median	0.326	0.343	
N	9	10	
Tympanum/SVL males			
Range	0.061–0.071	0.066–0.093	<0.01
Median	0.066	0.077	
N	13	17	
Tympanum/SVL females			
Range	0.057–0.073	0.071–0.080	<0.01
Median	0.068	0.075	
N	9	10	
DiscF3+/SVL males			
Range	0.057–0.064	0.045–0.057	<0.01
Median	0.061	0.051	
N	13	16	
DiscF3+/SVL females			
Range	0.054–0.070	0.051–0.059	<0.01
Median	0.062	0.054	
N	9	10	

\* Significance level. For proportions, the Mann-Whitney *U*-test was used. NS = not significant.

† Width of disc of third finger.

forms in habitat distribution at Buon Luoi. The nonstriped form was found mainly in open situations: in rice fields (26 individuals), at the border between rice fields and forest (8), along a village road (4); only 12 were found in forest. All individuals (31) of the striped form were found in forest at swampy lakes feeding forest streams. The two forms co-occurred at the lake feeding

Stream N3 (see General Environment above)—26 striped, seven nonstriped, and at the lake feeding Stream N1—four striped and three nonstriped.

At Tam Dao, in northern Vietnam, we found the same two forms. The striped form there has large white spots surrounded by a thin dark network on the rear of the thigh, lacks vocal sacs (one adult male), and has body proportions match-

ing the striped form at Buon Luoi:  $T/SVL > 0.54$ ,  $\text{tymp/}SVL < 0.068$ , and width of disc of third finger  $> 0.067$  (compare with Table 9). The nonstriped form at Tam Dao has small light spots on a dark background on the rear of the thigh, has vocal sacs (one adult male), and has body proportions matching the same form at Buon Luoi:  $T/SVL < 0.50$ ,  $\text{tymp/}SVL > 0.071$ , and disc of third finger  $< 0.056$ .

These two forms behave as distinct species; there are both clear morphological differences and significant ecological isolation. Various authors have tried to clarify the relationship of *P. leucomystax* (Gravenhorst) and *P. megacephalus* (Hallowell), the names commonly applied to these frogs, and several have treated them as subspecies (e.g., Pope, 1931; Inger, 1966). Matsui et al. (1986) related acoustic and karyological differences between Bornean and Taiwanese populations to morphological differences and concluded that two species were involved; these authors applied the name *P. leucomystax* (type locality Java) to the striped Bornean frogs, and *P. megacephalus* (type locality Hong Kong) to the nonstriped Taiwanese frogs. Matsui et al. (1986) also suggested that there were differences between Taiwanese and mainland Chinese populations and perhaps even differentiation among the mainland populations. In fact, the striped frogs from Buon Loy have the thigh pattern that Matsui et al. (1986) attributed to the nonstriped *P. megacephalus*, whereas the nonstriped frogs from Buon Loy have the thigh pattern that the same authors attributed to the striped Bornean frogs. Our analysis shares the main weakness of previous taxonomic discussions of these tree frogs, namely, failure to include samples from throughout the wide range of *P. leucomystax* (*sensu lato*). However, we believe that the demonstration of morphologically and ecologically distinct populations from a single locality is ample proof that at least two species are at issue. The absence of vocal sacs in one of these Buon Luoi populations suggests that acoustic differences are also likely.

### *Philautus abditus*, new species (Fig. 9)

HOLOTYPE—FMNH 252833, collected at Buon Luoi, An Khe District, Vietnam, 7 May 1995 by Ilya Darevsky and Nikolai Orlov.

PARATYPES—FMNH 252834 and MVZ 222118, 222121, adult males; MVZ 222119–20, adult females; FMNH 252835–38 and MVZ 222101, juve-

niles. All were collected at the type locality on shrubs and grassy vegetation 2–10 m from forested streams.

ETYMOLOGY—Specific name from *abditus* L hidden, concealed, referring to the bold black spots on the legs that are hidden when the limbs are flexed.

DIAGNOSIS—A *Philautus* with extensive webbing on the foot; tympanum completely hidden under skin; large black spots on anterior and posterior faces of thigh, not visible when legs are flexed; no dermal fringes or tubercles on limbs;

DESCRIPTION—Habitus stocky; snout rounded, feeble prominence at end; nostril closer to tip of snout than to eye; canthi distinct, rounded, constricted behind nares; lores oblique, concave; eye diameter greater than snout; interorbital equal to eyelid; tympanum not visible, but present under skin; no vomerine teeth. Finger tips with round discs having circummarginal grooves; disc of third finger wider than tympanum (when skin lifted over tympanum); three outer fingers with rudiment of web at base; subarticular tubercle conspicuous. Discs of toes smaller than those of fingers; web of first toe to edge of subarticular tubercle or slightly beyond that, on second toe between subarticular tubercle and disc, on third and fifth toes to edge of distal tubercle, to between tubercle and disc, or to base of disc; on fourth toe web to distal edge of middle tubercle; inner metatarsal tubercle low, oval; no outer metatarsal tubercle. Skin smooth dorsally and laterally; weakly curved supratympanic fold; ventrally finely granular; no dermal fringes, flaps, or tubercle on limbs.

Color in preservative pinkish brown or gray dorsally and laterally on head and body; temporal region darker than dorsal ground color; wide vertical dark bar from center of eye to lip; second narrower dark bar from anterior corner of eye to lip; labial bars obscure in some individuals; a obscure dark interorbital mark narrowing over occipital region; a dark gray mark beginning between shoulders, bifurcating in lumbar area, an ending in a large black spot low on side; ventrally head, body, thighs, and tarsi grayish brown; dorsal surface of limbs same ground color as body; dark crossbars of thigh and calf ending in large conspicuous black spots on anterior and posterior surfaces of thigh and ventrally on calf; proximal black spot on anterior face of thigh, extending into groin.

Males lack nuptial pads; vocal sac opening slightly elongated, but not slit-like; vocal sac me-



FIG. 9. *Philautus abditus*, new species. Paratype, male, 28.1 mm.

dian. The absence of the nuptial pad is probably not a reflection of seasonal reduction because adult males were collected both in the wet and dry seasons.

MEASUREMENTS—SVL of males 26.4–28.1 mm (mean 27.49, N = 4), of females 27.3–29.6 (N = 2); T/SVL 0.46–0.50 (median 0.484, N = 6); HW/SVL 0.37–0.41 (median 0.391, N = 6); HL/SVL 0.35–0.39 (median 0.364, N = 6).

Measurements of holotype: SVL 28.1, T 12.9, HW 10.4, HL 9.8, and eye diameter 4.3.

COMPARISONS—This species lacks the *m. cutaneus pectoris*, and its *m. geniohyoideus medialis* is free of the *lateralis* portion. These two features, plus the absence of nuptial pads, relate *P. abditus* to Dring's (1987) *P. vermiculatus* group. The combination of large black spots on hidden surfaces of the hind limb and the completely hidden tympanum distinguishes *P. abditus* from other species in the *P. vermiculatus* group and from all other *Philautus* in Southeast Asia. Species with the tympanum completely hidden include *P. banaensis* Bourret, *P. gryllus* Smith, *P. parvulus* (Boulenger), *P. kempiae* (Boulenger), and possibly *P. amandalii* (Boulenger). None of these has the heavy black spots on the flash surfaces of the leg that characterize *P. abditus*. In addition, *P. amandalii*, *P. parvulus*, and *P. kempiae* differ from *P. abditus* in having webbing confined to the bases of the toes, and *P. banaensis* differs in having dermal fringes along the limbs. The most variable of this group in terms of coloration is *P. gryllus*, but *P. abditus* is invariant in its black spotting, a pattern that is not included in the known repertoire of *P. gryllus* (Smith, 1924; Bourret, 1942).

### *Philautus parvulus* (Boulenger)

*Ixalus parvulus* Boulenger, 1893:339—Karen Biao-Po, Burma.

*Rhacophorus (Philautus) parvulus* Ahl, 1931:70.

*Philautus parvulus* Bourret, 1942:451.

A series from Tam Dao matches Boulenger's (1893) description point for point except for two characters: (1) the nostril is slightly closer to the tip of the snout than to the eye (midway between eye and end of snout in the types), and (2) the anterior rim of the tympanum is visible (tympanum hidden in the types). Diagnostic characters are: small size (SVL of adult females 21–25 mm);

toes short and web reaching base of distal sub-ticular tubercles of third and fifth toes or not there; thigh with a single, wide black bar crossing rear, dorsal, and anterior faces; lumbar region with white area enclosed by heavy dark brown or black spots. We use the Tam Dao specimens to expand the species description.

*M. cutaneus pectoris* absent. Habitus rather stocky. Snout projecting only slightly, notched to the labial margin of the tip; diameter of eye shorter than length of snout; tympanum partially obscured by the skin, posterior rim hidden; no vomerine teeth. Tongue without erect papilla, broad with oval, smooth area near the front of the center; modified area set off from adjacent tissue by a semicircular groove at its anterior margin and by a narrower groove at its posterior. Disc of the finger equal to or wider than tympanum. Outer margins of limbs smooth, no tubercle or spur on heel. Although the webbing reaches the distal sub-articular tubercles of the third and fifth toes, the actual extent of webbing is small because the outer metatarsals are fused for most of their length.

SVL measurements of males 19.0–22.1 mm (mean  $\pm$  SE 20.20  $\pm$  0.38, N = 9), of females 21.1–25.2 (23.30  $\pm$  0.49, N = 8); T/SVL 0.46–0.52 (median 0.468, N = 17); HW/SVL 0.37–0.44; HL/SVL 0.38–0.39. Nuptial pad white, velvety, on medial and dorsal surfaces of first finger from base to beginning of last phalanx. Female with weakly indicated rostral cone. Six ova encased in gelatinous envelopes on left side of largest female; diameter of ova 2.4–2.9. Six enlarged ova on left side of smallest female; diameter of ova 2.3–2.75.

This is the first record of the species from Vietnam. The known range through the mountainous area from Burma through northern Thailand (Taylor, 1962) to northern Vietnam is a common distributional pattern in Southeast Asian amphibians (Inger, 1999).

### *Philautus maosonensis* Bourret

*Philautus maosonensis* Bourret, 1937:51—Mekong Son, Tonkin, Vietnam; Bourret, 1942:467.

A specimen from Tam Dao agrees very closely with Bourret's (1937) description. Bourret stated that the female had a smooth dorsum, whereas the male was covered with small tubercles on the head, back, and limbs. The Tam Dao female is



FIG. 10. *Rhacophorus annamensis* Smith. Female, 84.5 mm.

embles the male of the type series in this character.

Three characters set this species aside from all except a few continental *Philautus*: distinct tympanum, toes almost completely webbed, fingers with at most a rudiment of web. In *P. maosonensis* the tympanum is about two-thirds the diameter of the eye; the disc of the third finger is about two-thirds the diameter of the tympanum; the canthus rostralis is rounded or indistinct, the toes (except for the fourth) are webbed to the base of the discs; and a large, dark, reddish brown mark occupies most of the back behind the shoulders. Adult females are 29–32 mm SVL. *Philautus carinatus* (Boulenger) (type locality Karen Hills, Burma) has the tympanum half the diameter of the eye, none of the toes webbed to the discs, and a bold (-shaped marking on the back; it appears to be larger (38 mm) than *P. maosonensis*. *Philautus argus* (Annandale) (type locality northeastern India) has a smaller tympanum (about one-

third diameter of eye), a distinct canthus, and a pale reticulation on the back.

Measurements of the Tam Dao female: SVL 29.0, T 15.7, HW 10.3, HL 11.1, eye 4.1, and tympanum 2.4. The female contained large ova that had a black hemisphere.

#### *Rhacophorus annamensis* Smith (Fig. 10)

*Rhacophorus annamensis* Smith, 1924:229—Daban, Annam, Vietnam.

*Rhacophorus pardalis annamensis* Bourret, 1942:443.

The present sample from Buon Luoi, Tram Lap, and Kon Cha Ran is the first record of this species since the collection of the unique male holotype. It agrees closely with Smith's (1924) original description. According to Smith, one distinctive character of *R. annamensis* is the slope of the

snout in front of the nostrils, but this feature is clearly sexually dimorphic. All of the males in the sample at hand have the snout gently sloping, in profile, to a sharp point projecting beyond the lower jaw. In the females, however, the snout is rounded, not sloping, and not projecting. Most of the features of coloration that were noted by Smith (1924) from the holotype are subject to much variation, as will be shown below; the dark webbing Smith observed appears to be constant. Wolf's (1936) treatment of *R. annamensis* as a subspecies of *R. pardalis* was an egregious case of superficial phenetics, especially because he had not seen a specimen and because Smith (1924) had clearly pointed out significant differences between the two species. Besides the differences noted by Smith, the two species are remarkably different in coloration, with red and orange being major components in *R. pardalis* and brown predominant in *R. annamensis*. We use this large new series to amplify the original description.

Habitus stocky; snout sharply pointed in males, obtusely pointed in females (see also above); nostril closer to tip of snout in females and some males, equidistant between eye and tip of snout in most males; canthi distinct, rounded or sharp, weakly constricted; tympanum distinct, less than half diameter of eye. Discs of fingers rounded, those of outer fingers wider than tympanum; web reaching edge of subarticular tubercle of first finger, to disc of three outer fingers; subarticular tubercles conspicuous. All toes webbed to base of discs; low inner, but no outer metatarsal tubercle. Heel in half of the sample with a small, bluntly pointed projection; no supra-anal projection; infra-anal area usually with two to three long tubercles, bases of tubercles rarely fused.

Color in life brown dorsally and laterally, with irregular black, red, or green spots on the back and faint dark crossbars on limbs; webbing dark grayish brown dorsally; ventrally ivory or cream; iris silvery, with a pinkish cast and irregular, thin dark lines. In preservative medium to dark gray, with obscure darker markings; lower half of sides white with dark marbling or network; ventrally white, usually with few small dark spots on throat and chest; limbs with obscure dark crossbars, not visible in some individuals; front and rear of thigh brown with irregular lighter markings, these surfaces rarely pinkish white with black spots; web dark brown or gray.

Males with white nuptial pad on dorsal and medial surfaces of base of first finger; vocal sac opening round.

TABLE 10. Sexual dimorphism of body proportions in *Rhacophorus annamensis* Smith.

	Range	Median	N
<b>T/SVL</b>			
Males	0.47–0.54	0.498	9
Females	0.50–0.54	0.521	9
<b>HW/SVL</b>			
Males	0.30–0.33	0.309	10
Females	0.31–0.33	0.326	9
<b>HL/SVL</b>			
Males	0.33–0.36	0.340	8
Females	0.32–0.34	0.324	9

SVL of males 57.8–71.7 (mean  $\pm$  SE 64.04  $\pm$  1.37, N = 10), of females 75.0–86.8 (82.01  $\pm$  1.26, N = 9). Body proportions are subject to sexual dimorphism; the differences between the sexes for each of the ratios (Table 10) are significant at the  $P < 0.02$  level (Mann-Whitney *U*-test). The sexes do not differ in relative size of the tympanum: tympanum/SVL of males 0.049–0.062, females 0.051–0.056.

*Rhacophorus annamensis* was the most commonly observed tree frog in the Buon Luoi-Tram Lap—Kon Cha Ran area. Pairs in amplex were seen in both spring and autumn. Nests were placed on rock faces of stream banks above quiet water and on trunks of trees in swampy flood plains.

### *Rhacophorus baliogaster*, new species (Fig. 1)

HOLOTYPE—FMNH 252839, an adult male from Buon Luoi, An Khe District, Vietnam, collected 27 April 1995 by Ilya Darevsky and Nikolai Colov.

PARATYPES—MVZ 222040–42, 222100, 222103, three adult females and one adult male; FMNH 252840, subadult female. All from the type locality.

ETYMOLOGY—Specific name from *balius* Greek, spotted or dappled, and *gaster* Greek, belly.

DIAGNOSIS—Third finger webbed to edge of proximal subarticular tubercle, fourth toe between the subarticular tubercles or to base of distal tubercle; no dermal flaps or ridges on limb; no dermal appendages around vent; ventral surfaces of head and trunk white with black spots; females with a strong rostral cone.

DESCRIPTION—Snout obtusely pointed, males with a weak median prominence, females with





FIG. 11. *Rhacophorus baliogaster*, new species. Holotype, male, 33.0 mm.

strong rostral cone; nostril closer to tip of snout than to eye, in a raised prominence; canthi rounded, constricted; lores oblique, concave; eye prominent, diameter equal to snout in females, longer than snout in males; interorbital about equal to eyelid; tympanum distinct, less than half diameter of eye; vomerine teeth in oblique groups, near to but not touching anterior corner of choanae. Fingers with round discs having circummarginal grooves; disc of third finger equal to or smaller than tympanum; fingers webbed at bases; subarticular tubercles conspicuous. Discs of toes smaller than those of fingers; webbing on first toe to between subarticular tubercle and base of disc; webbing on second, third, and fifth toes just short of base of discs, on fourth toe to distal subarticular tubercle or not quite so far; low inner but no outer metatarsal tubercle.

Skin smooth dorsally and laterally, no tubercles on eyelid; supratympanic fold weak, curved; throat smooth, chest and abdomen coarsely granular; limbs without dermal flaps, folds, or conspicuous tubercles; very weak tubercles on outer edge of tarsus in some individuals; no dermal appendages around vent.

Color in life dark brown above, with small irregular darker spots; usually blackish spots at shoulder continued as broken streak ending near groin; area below canthus dark brown; a broad dark brown bar below front half of eye; iris golden brown in upper third, reddish brown in remainder; sides lighter brown than back, black spots low on sides. In preservative gray dorsally with pinkish tinge, darker on snout; an obscure dark interorbital bar; dark markings on back also obscure and variable; most have faint dark streak above shoulder, ending in a large dark blotch on side at groin; venter whitish with conspicuous dark spots, varying in size from smaller than disc of first finger to larger than disc of third finger; limbs dorsally gray or brown, with dark crossbars; underside of leg heavily marbled with brown; rear of thigh gray brown, with or without small irregular light markings.

MEASUREMENTS—SVL of males 33.0–33.3 (N = 2), of females with mature, coiled oviducts 35.8–41.5 (mean 38.57, N = 4); T/SVL 0.44–0.52 (median 0.498, N = 6); HW/SVL 0.34–0.37 (median 0.356, N = 6); HL/SVL 0.34–0.39 (median 0.367, N = 6). Nuptial pad of male white, on dorsal and medial surfaces of first metacarpal. Vocal sac openings slightly elongated.

Measurements (mm) of holotype: SVL 33.0, T

15.8, HW 11.8, HL 11.4, eye diameter 5.2, tympanum 2.2.

LARVAE—Two lots of tadpoles from Buon Lu are assigned tentatively to this species. The specimens do match any larval species described by Bourret (1942). The most advanced tadpole, stage 39, has fingers webbed at the bases as adult *R. baliogaster*.

Headbody oval, slightly flattened above and below; snout obtusely pointed; eyes dorsolateral; spiracle midway between eye and end of body pointed slightly upward, tube not free of body wall. Oral disc subterminal, one-third of body width; papillae short, crowded, not interrupted midline; labial teeth 6(2-6)/5(1); jaw sheath black in marginal third, upper with a weak convexity. Tail lanceolate; dorsal fin origin at end of body, rising slightly to mid-length; tail tapering gradually to rounded tip. Color in preservative gray dorsally; a fine dusting of melanophores ventrally; caudal muscle finely dusted with melanophores, fins unpigmented. HBL 13.3 (stage 35) 15.5 mm (stage 39); total length 34.6–40.3 mm HBL/total 0.36–0.39; tail depth/tail length 0.3–0.36.

REMARKS—All specimens were collected on the banks of forest streams perched on grassy vegetation 20–50 cm above the surface and about 3 m from the water. The two lots of tadpoles were collected in a swampy pond in forest at Buon Loy.

COMPARISONS—The reduced webbing between the outer fingers distinguishes *R. baliogaster* from *R. annamensis* Smith, *R. pardalis* (Günther), *R. reinwardtii* (Schlegel), *R. nigropalmatus* Boulenger, *R. maximus* Boulenger, and *R. robinsoni* Boulenger. In addition, all of these fully webbed species differ from *R. baliogaster* in lacking black ventral spotting as the typical pattern and in having conspicuous dermal flaps or ridges on the limbs. *Rhacophorus baliogaster* differs from other Southeast Asian species of *Rhacophorus* that have less than fully webbed outer fingers—that is, *R. appendiculatus* (Günther), *R. bipunctatus* Ahl, *R. calcaneus* Smith, *R. notater* Smith, *R. taronensis* Smith, *R. turpes* Smith, and *R. verrucosus* Boulenger—in the absence of dermal flaps or fringes on the limbs. *Rhacophorus baliogaster* also differs from all of the previously mentioned species (except *R. appendiculatus* and *R. verrucosus*) in the presence of a rostral cone in females. The two species differ from *R. baliogaster* in lacking black spotting ventrally.



FIG. 12. *Rhacophorus bipunctatus* Ahl. Male, 37.3 mm.

*Rhacophorus bimaculatus* (Peters)

*Leptomantis bimaculatus* Peters, 1867:32—Aguson Valley, Mindanao, Philippine Islands.  
*Rhacophorus (Philautus) bimaculatus* Ahl, 1931:64.  
*Philautus bimaculatus* Bourret, 1942:471.

A single adult male (40.2 mm) from Buon Luoi shows comprehensive agreement with *R. bimaculatus* from Borneo and the Philippines. The coloration of this species is distinctive: medium dark brown dorsally; side of head darker with a large subocular enamel white or bluish spot; flash surfaces at front and rear of thigh black with small bluish white spots. The Buon Luoi frog differs from the described coloration of *R. bimaculatus* Peters, 1867; Inger, 1966) only in having the venter heavily suffused with brown (white in Bornean and Philippine frogs). The Buon Luoi frog is larger than those from Borneo (28–35 mm), but like them it has a vocal sac but no nuptial pad. This is the first report of the species north of peninsular Thailand.

*Rhacophorus bipunctatus* Ahl (Fig. 12)

*Rhacophorus bimaculatus* Boulenger, 1882:90—Khasi Hills and Assam, India.  
*Rhacophorus bipunctatus* Ahl, 1927:46 (substitute name).  
*Rhacophorus rhodopus* Liu and Hu, 1959:525—Meng-yang, Yunnan, China.  
*Rhacophorus reinwardtii bipunctatus* Bourret, 1942:446.

Liu and Hu (1959) distinguished *R. rhodopus* from *R. bimaculatus* Boulenger (*R. bipunctatus* Ahl) on the basis of red webbing, pointed snout, and reddish brown dorsal coloration; they assumed that Boulenger's species was green, possibly because Boulenger (1882) reported that it resembled *R. reinwardtii*. The same comment by Boulenger may have led Liu and Hu to assume that *R. bipunctatus* had a round snout; in fact, *R. bipunctatus* has a pointed snout. None of the characters that, according to Liu and Hu (1959), separated *R. rhodopus* from *R. bipunctatus* do, in

fact, distinguish these taxa. All of the characters mentioned in the original description of *R. rhodopus* agree with those of *R. bipunctatus*.

Although the present sample (all from Buon Luoi) is the first one reported from Vietnam, it merely fills out the known range: Assam, Burma (Boulenger, 1893), northern and eastern Thailand (Taylor, 1962; Inger & Colwell, 1977), and Yunnan (Liu & Hu, 1959). In terms of size, webbing, leg length, vomerine teeth, relative size of tympanum (less than half eye diameter), and other characters, the specimens from Vietnam and Thailand (FMNH 187509–14, 187516–17) agree very closely with those from Assam (FMNH 72406–07) and Mt. Karen, Burma (ZMH Hamburg, Germany [ZMH] 736 [3]), a locality from which Boulenger (1893) reported the species. The Vietnamese frogs differ from the Thai frogs in one respect; in the former, the dermal appendage at the tibiotarsal joint is a simple transverse fold, whereas in the Thai specimens the transverse fold is drawn out to a point.

Males in the Buon Luoi sample measure (SVL) 33.1–39.8 mm (mean  $\pm$  SE 36.16  $\pm$  0.24, N = 37), females 46.0–52.2 (mean 47.93, N = 4). T/SVL of males 0.45–0.51 (median 0.484, N = 14), of females 0.48–0.49 (N = 4); HW/SVL of males 0.34–0.38 (median 0.353, N = 14), of females 0.32–0.36 (N = 4).

Tadpoles and metamorphs from stages 25–44 have labial teeth 6(2–6)/3(1), short marginal papillae continuous across the lower lip. HBL (stages 31–40) 16.7–18.3 mm, total length (stages 31–40) 45.4–55.4. HBL/total length (stages 31–40) 0.33–0.38.

We found this species at Buon Luoi in forest up to 20 m from a large pond and at Tram Lap along swampy banks of a forest stream. Males called from trees about 1–2.5 m above the surface. Density in both October–December 1993, and March–May 1995 was very high, and it was possible to see >10 males vocalizing in an area of 20–25 m<sup>2</sup>. Larval samples were taken in ponded portions of forested streams at Buon Luoi. The absence of this abundant species at Kannack (400 m) and Kon Cha Ran (1000–1500 m) suggests that its main zone of distribution in these southern Annam mountains lies in the belt of 600–900 m elevation.

### *Rhacophorus calcaneus* Smith (Fig. 13)

*Rhacophorus calcaneus* Smith, 1924:228–Langbian Peaks, Annam, Vietnam.

These frogs from Buon Luoi (7), Tram Lap (8), and Kon Cha Ran (15) appear to be the first specimens of *R. calcaneus* collected since the unique holotype was described by Smith (1924). They match Smith's description and figure in diagnostic characters, such as the sharply pointed, sloping snout, the sharp, light-edged canthi, the long pointed projection at the heel, and the extent of webbing. None of the new specimens has the black axillary spot and small yellow spots at the rear of the back found on the holotype. Given the variation within the new sample, those differences appear to fall within the range of individual variation.

Smith (1924) thought that *R. calcaneus* was a member of the *Rhacophorus bimaculatus* Boulenger (= *R. bipunctatus* Ahl) species group. However, the sharply pointed, sloping snout and shallow canthi, webbing, and dermal fringes along the limbs are more similar to *Rhacophorus anguifer* rostris Ahl. The present large sample allows amplification of the original description.

Habitus stocky; snout sharply pointed, sloping downward in front of nostrils, projecting beyond lower jaw; nostril closer to tip of snout than to eye; canthi sharp, weakly constricted; lores sloping, weakly concave; diameter of eye less than length of snout; interorbital wider than eyelid; tympanum less than half diameter of eye; vomerine teeth in oblique groups beginning near anterior corners of choanae. Finger tips with large, rounded discs, those of outer fingers wider than tympanum; first finger webbed to subarticular tubercle; second finger to just below disc, third finger to distal edge of distal subarticular tubercle laterally and fourth finger midway between disc and tubercle; subarticular tubercles conspicuous. Discs of toes smaller than those of fingers; web to base of discs of first three toes laterally and fifth to medially, narrowly to disc laterally on fourth to a low oval inner but no outer metatarsal tubercle.

Skin generally smooth above; a straight, strong supratympanic fold extending just beyond level of axilla; throat finely granular; belly coarsely granular; a smooth-edged ridge of skin along outer edge of lower arm and fourth finger, ending at elbow in a dull point; a similar, but narrower ridge along the tarsus and fifth toe; a long, pointed projection at tibiotarsal joint; a low supra-anal ridge; several large, pointed tubercles below vent.

Color in life dorsally gray brown to reddish brown, with oval or round dark brown spots, or with small enamel white spots, or pinkish dorsal lateral bands; lower part of sides with thin black



FIG. 13. *Rhacophorus calcaneus* Smith. Male, 35.4 mm.

network enclosing large white spots; iris light tan or yellowish brown in upper half, darker grayish brown below; front and rear of thigh reddish brown. In preservative ground color dorsally gray or pinkish; no large black spots laterally in present sample; lateral black network faint in some individuals; supra-anal ridge pinkish white; ventrally white usually with fine dark dots or immaculate white; limbs with dark crossbars; ventral surfaces of thigh and calf with small black dots; front and rear of thigh pale pinkish or flesh-colored, immaculate (10) or dotted with black (4), or rear of thigh dark brown (11).

Male nuptial pad white, on dorsal and medial surfaces of first metacarpal; vocal sac openings elongated.

SVL of males 35.2–40.1 mm (mean  $\pm$  SE  $3.20 \pm 0.26$ ,  $N = 10$ ), of females 48.5–55.0 mm (mean  $52.93$ ,  $N = 4$ ). T/SVL 0.49–0.56 (median  $0.516$ ,  $N = 14$ ), HW/SVL 0.36–0.39 (median  $0.373$ ,  $N = 14$ ).

Five juveniles (females 37.0–40.4 mm) were

collected at Tam Dao. They share all of the diagnostic features of frogs from the central highlands: sharp, sloping snout; weak dermal ridge along the lower arm; weak, pinkish supra-anal ridge; discs of outer fingers wider than tympanum; long pointed projection at heel. All of these juveniles have black dots on the white venter and underside of the thigh and have the rear of the thigh immaculate flesh-colored.

At Buon Luoi and Kon Cha Ran we found this species as single individuals in trees about 2–3 m above ground and 3–15 m from banks of forested streams. Two pairs were caught in amplexus perched on branches 3 m above the ground.

***Rhacophorus exechopygus*, new species (Figs. 14, 15)**

HOLOTYPE—FMNH 252841, adult male collected at Tram Lap, An Khe District, Gia-Lai Province.



FIG. 14. *Rhacophorus exechopygus*, new species. Holotype, male, 46.5 mm.

Vietnam, 21 April 1995 by Ilya Darevsky and Nikolai Orlov.

PARATYPES—FMNH 252842–43, adult males collected at the type locality.

ETYMOLOGY—Specific name from *exechos* Gr., jutting out, and *pygos* Gr., buttocks, referring to the infra-anal projection.

DIAGNOSIS—A *Rhacophorus* with fully webbed outer fingers; a wide, transverse, white infra-anal projection; forearm and tarsus with wide, weakly crenulated dermal ridge; rear face of thigh black; lower half of side with black spots or band.

DESCRIPTION—Habitus stocky; snout pointed, projecting (only males known); nostril about midway between eye and tip of snout; canthi round, weakly constricted; lores sloping, concave; eye prominent, diameter less than snout; interorbital wider than eyelid; tympanum distinct, less than half the diameter of the eye; vomerine teeth in transverse groups, touching anterior corner of choanae. Discs of fingers round, with circummar-

ginal grooves; disc of third finger larger than tympanum; three outer fingers webbed to discs, first finger webbed to subarticular tubercle; subarticular tubercles conspicuous. Discs of toes small, less than those of fingers; all toes webbed to disc; inner metatarsal tubercle low, oval, no outer metatarsal tubercle.

Skin smooth dorsally, with very fine, colorless asperities (in males only?); limbs with scattered weak tubercles dorsally; throat smooth or weakly rugose; chest and abdomen coarsely granular; outer margin of forearm and fourth finger and tarsus and margin of fifth toe with wide, weakly crenulate dermal fringe; heel with a narrow transverse ridge, usually ending laterally in a weak projection; a strong, wide, white-edged, horizontal infra-anal dermal projection.

Color in life gray to brown dorsally, uniform or with obscure dark blotch at rear of head; limbs with brown or reddish brown crossbars; tubercles on limbs pinkish; iris silvery with fine dark net-



FIG. 15. *Rhacophorus exechopygus*, new species. Paratype, male, 46.4 mm.

work in upper half, darker in lower half. In preservative uniform purplish gray on all dorsal surfaces and upper half of side; lower part of side with black band from axilla to groin, or black at axilla and groin only, or with a row of large black spots; one specimen with light spots (blue in life?) within black area at groin; throat and abdomen white; rear face of thigh black; front face of thigh white or black; ventral surface of calf black or white; dorsal surface of outer fingers and toes with coloration of back, inner digits without dark pigment; web dark on dorsal surface, colorless or pale reddish ventrally.

Males with white nuptial pad on dorsal and medial surfaces of first finger; vocal sac opening longate.

MEASUREMENTS—Holotype: SVL 46.5, T 22.4, HW 15.6, HL 16.8, snout 7.5, eye 6.7, tympanum 7.5, and interorbital 5.6. Paratypes: SVL 45.9–

46.4, T/SVL 0.45–0.48 (N = 2), HW/SVL 0.34 (N = 2), and HL/SVL 0.36–0.38 (N = 2).

REMARKS—All three specimens were found about 3 m above the ground in trees on swampy banks of a forest stream.

COMPARISONS—The fully webbed outer fingers of *Rhacophorus exechopygus* match the character in *R. annamensis* Smith, *R. dulitensis* Boulenger, *R. maximus* Boulenger, *R. nigropalmatus* Boulenger, *R. pardalis* Günther, *R. prominans* Smith, *R. reinwardtii* (Schlegel), and *R. robinsoni* Boulenger. However, *R. exechopygus* is the only species having a projecting, infra-anal dermal ridge; *R. dulitensis*, *R. prominans*, and *R. reinwardtii* have a supra-anal dermal ridge, whereas the others listed have no dermal appendage in this area. In addition, *R. exechopygus* is smaller than *R. maximus* (males 80–86 mm), *R. nigropalmatus* (75–91), and *R. annamensis* (55–65). *Rhacophorus execho-*



FIG. 16. *Rhacophorus reinwardtii* (Schlegel). Female, 85.2 mm.

*pygus* differs from other syntopic species of *Rhacophorus* in dermal appendages (*R. verrucosus* Boulenger, *R. bipunctatus* Ahl, *R. annamensis* Smith, *R. calcaneus* Smith, and *R. baliogaster*, new species, without a wide infra-anal projection) and coloration (*R. baliogaster* with boldly spotted abdomen, *R. bipunctatus* with black spots on the side, *R. calcaneus* with dark dorsal markings, and *R. annamensis* with black dotted throat). Other *Rhacophorus* from Southeast Asia differ from *R. exechopygus* in (1) the type of dermal appendages (*R. appendiculatus* [Günther] with strong crenulated fringe or row of conical tubercles along forearm and tarsus; *R. taronensis* Smith and *R. turpes* Smith without infra-anal projection), and (2) coloration (none of the listed species has an immaculate dorsal pattern).

#### *Rhacophorus reinwardtii* (Schlegel) (Fig. 16)

*Hyla reinwardtii* Schlegel, 1837:105—Java (restricted by Wolf, 1936).

*Rhacophorus reinwardtii* Tschudi, 1838:73.

Although these are the first specimens recorded from Vietnam, their occurrence is not surprising because the species has been known from Yunnan for some time (Yang, 1991). The present sample from Buon Luoi, consisting of eight adult females and three adult males, matches specimens from Java in coloration and dermal appendages. They are green dorsally, have webbing of the three outer fingers and of the foot black dorsally, and have a large black area in the axilla. The front and rear of the thigh are immaculate cream or white. They have a wide, smooth-edged fringe of skin along the outer edge of the forearm, a similar, though narrower fringe along the tarsus, a squarish fringe at the heel, and a conspicuous, transverse projection above the vent. The supra-anal flap immediately distinguishes these frogs from the other large green species of *Rhacophorus* in Southeast Asia: *R. nigropalmatus* Boulenger and *R. maximus* Günther.

The Vietnamese specimens are larger than Javan frogs: SVL of males 65.6–69.7 mm ( $N = 3$ ) of females 81.8–92.7 (mean  $\pm$  SE 87.66  $\pm$  1.38;  $N = 8$ ). Two males with vocal sacs from Java



TABLE 11. Comparison of *Rhacophorus verrucosus* and related forms.

	<i>R. verrucosus</i> Buon Luoi	<i>R. bisacculus</i> Thailand	<i>R. appendiculatus</i> Borneo	Tam Dao‡
<b>SVL males</b>				
Range	23.8–28.0	29.2–35.5	29.6–37.0	29.1–33.5
Mean ± SE	26.25 ± 0.40			31.59 ± 0.36
N	13	6	53	17
<b>T/SVL</b>				
Range	0.46–0.52	0.51–0.54	0.50–0.52	0.42–0.51
Median	0.480	0.528*	0.515	0.462†
N	7	6	6	17
<b>HW/SVL</b>				
Range	0.37–0.41	0.35–0.39		0.31–0.37
Median	0.402	0.361		0.346
N	8	6		17
<b>Tympanum/SVL</b>				
Range	0.045–0.062	0.063–0.071	0.060–0.069	0.051–0.060
Median	0.056	0.065*	0.062*	0.056
N	9	6	6	6

\* Difference between *R. verrucosus* and indicated samples significant at  $P < 0.03$ ; Mann-Whitney  $U$ -test.

† Difference between Tam Dao and Buon Loy samples significant at  $P < 0.05$ ; Mann-Whitney  $U$ -test.

‡ Species not determined. See text discussion under *Rhacophorus verrucosus*.

measured 46.4–54.6 mm, and six adult females from Java were 56.2–65.7 mm (mean 63.15). Frogs from Yunnan are the same size as those from Vietnam: SVL of males 66–72 (N = 10), of females 74–95 (N = 5) (Yang et al., 1991). The Vietnamese frogs also have relatively shorter legs (T/SVL 0.48–0.53, N = 11), narrower heads (HW/SVL 0.32–0.35), and shorter heads (HL/SVL 0.32–0.34) than Javan frogs (0.50–0.55, 0.36–0.39, and 0.34–0.37 for the three proportions, respectively; N = 8).

Sexually active frogs planned down to the surface of a large pond from vegetation 3–5 m above ground. Pair formation occurred at the water's surface. Oviposition took place on leaves of branches overhanging water. The foamy egg masses were 18–22 cm long. Most nests were seen at the end of April and early May. Vocalization and breeding activity were observed predominantly on rainy nights.

#### *Rhacophorus verrucosus* Boulenger

*Rhacophorus verrucosus* Boulenger, 1893:337—Thao, Karen Hills, Burma.

*Rhacophorus appendiculatus verrucosus* Bourret, 1942:418.

Twenty frogs from Buon Luoi and two from

Kon Cha Ran have all of the dermal features of *R. appendiculatus* (Günther), except in reduced condition. All of the fringes are less protruding, especially the per-anal one, but they are all present. Most females of *R. verrucosus* have a distinct knob on the snout, but it is not as protuberant as in *R. appendiculatus*.

The Thai form *R. bisacculus* Taylor is clearly closely related to *R. appendiculatus*. Both of these forms are larger than *R. verrucosus* and differ from it in certain body proportions (Table 11). Females show comparable differences in SVL: *R. verrucosus* 29.8–35.8 (N = 6), *R. appendiculatus* (Borneo) 42.4–50.1 (N = 8); no females of *R. bisacculus* were available. In addition, vomerine teeth, which are always present in *R. bisacculus* and *R. appendiculatus*, are usually absent (15 of 20 examined) in Vietnamese *R. verrucosus*. The infra-anal dermal appendages of these species differ; *R. appendiculatus* from the Philippines and Borneo has a conspicuous transverse flap with a papillate edge, *R. verrucosus* has two to six long whitish tubercles that may join basally, and *R. bisacculus* usually has no prominent projections in this area but may have several low, pointed tubercles.

We amplify the original description on the basis of the Buon Luoi specimens. Finger discs round, that of third finger equal to diameter of tympanum; first two fingers webbed at base, web of

third finger not reaching distal subarticular tubercle, web of fourth finger to base of distal tubercle; subarticular tubercles conspicuous. Disc of toes smaller than those of fingers; web to subarticular tubercle of first toe, to between tubercle and disc on second toe, between distal tubercle and disc of third and fifth toes, to just below distal tubercle of fourth toe. Dorsally with small scattered tubercles; heel with a low conical tubercle. Nuptial pad white, on dorsal and medial surfaces of first metacarpal; vocal sac opening a short slit. One female had ovulated, gelatin-encapsulated, yellow ova; an exact count could not be made without damage, but there appeared to be fewer than 30 ova on the left side. The ova measured 2.5–3.0 mm.

A sample of 21 frogs generally similar to this group of species was collected at Tam Dao in northern Vietnam. They resemble *R. bisacculus* in having short tubercles or no dermal appendages below the vent, and they resemble both *R. appendiculatus* and *R. bisacculus* in size (Table 11; SVL of four adult females 44.7–50.5 mm), in the large rostral cone of the female, and in having vomerine teeth. In each of these characters they differ from the Buon Luoi specimens. However, the Tam Dao frogs differ from all of the others in this group in having very large dark spots occupying most of the abdomen and in having a shorter leg (Table 11). Specific assignment of the Tam Dao population is problematic. They appear to be closest to *R. bisacculus*, but the intervening geographic position of the Buon Luoi *R. verrucosus* makes assignment to *R. bisacculus* uncertain.

Liu and Hu (1959, 1961) and Yang et al. (1991) reported a species of this group from southern Yunnan under the name *R. cavirostris* (Günther), which is otherwise known only from Sri Lanka and is considered to be a synonym of *Rhacophorus microtypanum* (Frost, 1985). Zhao and Adler (1993) list this Chinese form as *Philautus cavirostris*. SVL measurements of the Yunnan frogs (males 27–33.8, female 43 mm). The frilled tarsi, their lack of long infra-anal tubercles, and their possession of vomerine teeth (Liu & Hu, 1961; Yang et al., 1991) agree with those of the Tam Dao frogs; unfortunately, there is no information on ventral coloration.

Tran et al. (1981) and Nguyen et al. (1994) listed *R. cavirostris* as part of the fauna of northern Vietnam, although they gave no descriptive notes or comments that would confirm the identification. Their records are probably based on frogs conspecific with the present sample from Tam Dao. *Rhacophorus cavirostris* (Günther) should

be removed from the faunal list of Vietnam, but for reasons given above the proper name of the northern Vietnamese frogs is uncertain.

Most individuals from Buon Luoi were found about 1 m above ground on shrubs 20–100 m from any stream; four were caught within 3 m of a stream.

### *Theloderma corticalis* (Boulenger) (Fig. 17)

*Rhacophorus corticalis* Boulenger, 1903:188—Man-Son Mountains, Tonkin, Vietnam.

*Theloderma corticalis* Liem, 1970:94.

*Rhacophorus leprosus corticalis* Bourret, 1942:412.

Two adult females (SVL 70.5, 70.6) with developing, strongly pigmented ova, and an adult male (SVL 69.2 mm) were collected at Tam Dao. They agree very closely with Boulenger's (1903) description. They are the same size as the type (SVL 70 mm), the finger discs are very wide, the vomerine teeth are in small groups, and the male lacks vocal sacs. However, there are slight differences from the original description. Boulenger stated that the fingers lacked webbing and that the toes were completely webbed; in the Tam Dao specimens there is a rudiment of webbing between the third and fourth fingers, and full webbing ends at the distal edge of the distal subarticular tubercle of the fourth toe. The other toes are webbed to the discs. Boulenger also reported that the tympanum was as large as the eye; in the Tam Dao frogs at hand the tympanum is clearly smaller than the eye (see below).

In the Tam Dao frogs, the disc of the third finger is equal to or wider than the tympanum. Body proportions are: T/SVL 0.48–0.50, HW/SVL 0.41–0.43, tympanum/SVL 0.069–0.078, disc of third finger divided by SVL 0.069–0.080, tympanum 0.60–0.69 of diameter of eye. The nuptial pad is a cream-colored mass on the mediadorsal surface of the first finger from its base to the level of the subarticular tubercle, then medially to just beyond the tubercle.

### *Theloderma gordonii* Taylor

*Theloderma gordonii* Taylor, 1962:511—Doi Suthep, Chiang Mai Province, Thailand.

One female from Buon Luoi, one male from



FIG. 17. *Theloderma corticalis* (Boulenger). Female, 70.0 mm.

ram Lap, and one female from Tam Dao. These are clearly conspecific with the holotype of *T. gordoni* (FMNH 172248). The skin is extremely rough, with many pustulose ridges and tubercles on top of the head, temporal region, back, and dorsal and lateral surfaces of the limbs. There is a very dense cluster of large spinose tubercles on the parts behind the tympanum, and the chin and throat have small pustulose tubercles, in sharp contrast with the smoothly granular chest and belly. The vomerine teeth are in small, widely separated, oblique groups near the anterior corners of the choanae. The distinct tympanum is slightly more than half the diameter of the eye. The Tam Dao female differs from the other two in having the rows of the dorsal warts coalesced into ridges.

In life, these frogs were almost black dorsally and laterally, with the crests of some ridges on the head and back light brown. In preservative, the cluster of warts behind the tympanum is pale brown. The palmar tubercles and prehallux are white (flesh-colored in life?), in sharp contrast to the dark color of the remainder of the ventral surface of the hand; although the holotype is faded, it is still possible to see a contrast between the

base of the palm and the rest of the hand. Broad webbing on the first finger reaches between the subarticular tubercle and the disc, on the lateral margins of the second and third fingers and the medial margin of the fifth to between the distal subarticular tubercle and the disc, and on the fourth toe to the middle tubercle or between the middle and distal tubercles. The male measures 47.0 mm (SVL) and the two females 44.2 and 50.9 mm; the larger female has enlarged ova.

The male has a nuptial pad of fine spinules covering the medial and dorsal surface of the swollen prehallux and extending in a narrow line along the median edge of the first finger to the base of the disc. There are no vocal sac openings.

In all of these characters (except the secondary sex characters of the male), these three specimens match the female holotype (SVL 48 mm) of *T. gordoni*. However, they also agree with descriptions of *T. leporosa* Tschudi (type locality Padang, Sumatra) except for having slightly less webbing and being somewhat smaller. *Theloderma leporosa* from the Malay Peninsula reaches 65 mm and has nearly fully webbed toes (Boulenger, 1912).



FIG. 18. *Theلودerma stellatum* Taylor. Female, 32.3 mm.

One specimen was found on the trunk of a fallen tree in a small forest clearing. Another was perched on the broad leaf of a shrub about 5 m from a forest stream.

***Theلودerma stellatum* Taylor (Fig. 18)**

*Theلودerma stellatum* Taylor, 1962:514—Khao Sebab, Chantaburi Province, Thailand.

Two males and two females from Tram Lap and three males, three females, and four juveniles from Buon Luoi are assigned to this species. The males, all with nuptial pads, measure 30.2–35.1 mm SVL and the females 31.2–35.8 mm. These frogs have the tympanum smaller than the eye, the two outer fingers webbed to the distal edge of the subarticular tubercles, most of the white asperities scattered and not gathered in rings around a larger one, a conspicuous large, black marking

beginning between the shoulders, and males small vocal sac openings. They lack vomerine teeth.

Taylor (1962) pictured *T. stellatum* with a tinctive dark dorsal marking that is still evident in the holotype (FMNH 172249) and in a more recent sample (FMNH 183711–15) from Thailand. The dorsal pattern is exactly as in the Vietnamese frog *T. stellatum* the two outer fingers are webbed to the edge of the subarticular tubercles. Male *T. stellatum* from Thailand (holotype and two others) measure 27.4–32.7 SVL; a single adult male measures 34.8 mm. In these characters in the absence of vomerine teeth, the Vietnamese frogs agree with *T. stellatum*. However, Taylor (1962) stated that *T. stellatum* lacked vocal sac openings (confirmed in the holotype), and the two other adult males from Thailand (large nuptial pads present) also lack them.

Two other species, *T. horridum* (Boulenger) (type locality Pattani, peninsular Thailand) and

*phrynoderma* (Ahl) (type locality northern Burma), lack vomerine teeth and have webbing between the fingers. The Vietnamese frogs differ from each of these. *Theloderma horridum* has more extensive webbing on the hand, with full web reaching the bases of the discs of the two outer fingers (FMNH 186600-02, peninsular Malaysia), although Boulenger (1893) merely noted that the fingers were "half-webbed." In addition, the specimens of *T. horridum* from Malaysia have clearly longer snouts relative to the diameter of the eye (eye/snout 0.61-0.71) than *T. stellatum* from Vietnam and Thailand (0.81-0.89). The three *T. horridum* from Malaysia measure 38.0-44.2 and the holotype 40 mm SVL. *Theloderma phrynoderma* has no dark dorsal marking, and its tympanum equals the diameter of the eye (Boulenger, 1893); both of these characters differ from those of the Vietnamese sample. SVL measurements of the types of *T. phrynoderma* were 45 mm (Boulenger, 1893), about 10 mm longer than those of the Vietnamese specimens.

We assign a sample of tadpoles (MVZ 222115) from Buon Luoi to this species. The headbody is distinctly flattened and oval. The eyes are dorsal and pointing directly upward. The oral disc is almost terminal, less than half the width of the body, and lacks a lateral notch. The labial papillae are long, continuous across the lower lip and at the corners of the upper. The jaw sheaths are completely black and finely serrated; the upper jaw sheath has a wide median convexity. The labial teeth are 4(2-4)/3. The spiracle is ventrolateral and lacks a free tube. The caudal muscle is much deeper than the fins. The dorsal fin has its origin at the end of the body. The headbody is black dorsally and laterally and a bit lighter below. The tail is completely black.

## Species Doubtfully Reported from Vietnam

### *Megophrys longipes* Boulenger

*Megalophrys longipes* Boulenger, 1885:850—Perak, Malaysia.

*Megophrys longipes* Bourret, 1942:197.

Bourret (1941, 1942) recorded this species from Bach Ma, Annam, based on two juveniles he had originally (1939) identified as *Ophryophryne microstoma*. The identity of these juve-

niles is doubtful. Tran et al. (1981) listed this species from six provinces in Vietnam, but gave no specimen information or any reason for their identification.

### *Meristogenys jerboa* (Günther)

*Hylarana jerboa* Günther, 1872:599—Matang, Sarawak, Borneo.

*Meristogenys jerboa* Yang, 1991:34.

Bourret (1937) assigned a juvenile frog from Tam Dao to this species, but he reported that it had a shorter leg and more reduced webbing than *M. jerboa*. This species was also listed as part of the fauna of Tam Dao by Tran et al. (1981) and Nguyen et al. (1994), although it is not clear whether they were merely repeating Bourret's (1937) record or reporting new findings. At any rate, there is no authentic record of this species outside of Borneo (Yang, 1991) and it should be removed from the faunal list of Vietnam.

### *Rhacophorus nigropalmatus* Boulenger

*Rhacophorus nigropalmatus* Boulenger, 1895:170—Akah River, Sarawak, Borneo.

Tran et al. (1981) recorded this species from four provinces. However, it seems evident that they were referring to the form cited by Bourret (1942) as *R. nigropalmatus feae* Boulenger. According to current usage (Frost, 1985), the records of Tran et al. (1981) should be treated as *Rhacophorus feae* Boulenger, and *R. nigropalmatus* removed from the faunal list.

### *Rana miopus* Boulenger

*Rana miopus* Boulenger, 1918:11—Khao Wang Hip and Nakhon Si Thammarat, Thailand.

Tran et al. (1981) reported this species from Lang Son Province in extreme northeastern Vietnam. It was also reported by Ho and Nguyen (1982) from the Tay Nguyen plateau. Neither paper gave descriptive notes. The species is otherwise known only from southern Thailand and nearby Peninsular Malaysia. The identity of these Vietnamese specimens must be confirmed before

the species can be added to the faunal list of Vietnam.

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