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A NEW SPECIES OF CASCADE FROG (AMPHIBIA: RANIDAE) FROM THAILAND, WITH NEW DATA ON *RANA BANAORUM* AND *RANA MORAFKAI*

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ABSTRACT

A new species of cascade ranid belonging to the *Rana livida* species complex is described from Nakhon Ratchasima and Nakhon Nayok Provinces, eastern Thailand. The new species is differentiated from other cascade ranids by the following combination of characters: males with snout-vent length 54.3–69.1 mm (mean 61.8 mm), females 92.8–101.0 mm (mean 96.9 mm); males with gular pouches; finger II shorter than I; all digit tips expanded, with circummarginal grooves; no outer metatarsal tubercle; smooth dorsal skin, dorsolateral folds weak or absent; legs banded; males with white spinules on dorsal and ventral surfaces; posterior portion of thigh creamy white with brown marbling in preservative; and eggs without pigment. New data are presented for two similar, recently described species in the complex that also bear white spinules, *Rana banaorum* and *Rana morafkai*.

Key words: Laos, Southeast Asia, Vietnam, *Rana indeprensa*, *Rana livida*, species complex

INTRODUCTION

TAYLOR's (1962) monograph remains the major work on the amphibian fauna of Thailand, although new diversity continues to be reported (e.g. INGER & CHAN-ARD, 1997; MATSUI *ET AL.*, 1998, 1999, 2001; STUART & CHAN-ARD, 2005). Recent research has shown that some amphibians across Southeast Asia (Fig. 1) previously considered to be single, widespread species are actually complexes of cryptic species, implying that our understanding of amphibian diversity in the region is currently underestimated (e.g. MATSUI *ET AL.*, 2001; BAIN *ET AL.*, 2003; EVANS *ET AL.*, 2003). Among these cryptic species complexes are cascade frogs allied to *Rana livida*, a morphologically similar group of species ranging across southern China, Indochina, Thailand, Assam, Myanmar, Malaya, Sumatra, and Borneo (BOURRET, 1942; TAYLOR, 1962; INGER & CHAN-ARD, 1997; INGER *ET AL.*, 1999; BAIN *ET AL.*, 2003; ORLOV *ET AL.*, 2003, BAIN & NGUYEN, 2004). These frogs are dorsoventrally compressed with long, powerful legs, webbed feet, and enlarged digital pads with circummarginal grooves that enable them to swim through torrents and climb high on boulders, rock ledges, and vegetation above swift streams. They exhibit great sexual size dimorphism, with some species having females twice the body size of males. Most species

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Figure 1: Map of mainland Southeast Asia with collection localities for referable specimens. 1) Khao Yai National Park, Nakhon Ratchasima Province, Thailand, 2) Sarika Waterfalls, Nakhon Nayok Province, Thailand, 3) Huong Son Forest Reserve, Ha Tinh Province, Vietnam, 4) Xe Sap National Biodiversity Conservation Area, Xe Kong Province, Laos, 5) Dong Hua Sao National Biodiversity Conservation Area, Champasak Province, Laos, 6) Ngoc Linh Mountain, Quang Nam Province, Vietnam, 7)An Khe District, Gia Lai Province, Vietnam.

of the complex have eggs that lack pigment. Their ability to emit toxic odoriferous secretions unites them in *Odorrana*, a grouping either ignored or alternately referred to as a genus or subgenus in the literature (BAIN *ET AL.*, 2003: 5). Often multiple species in the group occur sympatrically (BAIN *ET AL.*, 2003; BAIN & NGUYEN, 2004). At least one species of the complex, *R. chloronota*, appears to occupy a large portion of the complex's distribution (BAIN *ET AL.*, 2003). Other species in the complex appear to have more limited ranges, although further surveys of the region and re-evaluation of natural history collections may show some of them to be widespread as well (BAIN *ET AL.*, 2003). KHONSUE & THIRAKHUPT (2001) and CHAN-ARD (2003) have reported three described species of this complex from Thailand: *R. archotaphus, R. hosii*, and *R. livida*. Given the diversity of this complex in nearby Vietnam (BAIN *ET AL.*, 2003), it is not unexpected that more species may be found in Thailand.

INGER & CHAN-ARD (1997) noted distinct differences in size, shape, colour, and presence of spinules among specimens referred to *R. livida* from Thailand, southern Vietnam and China. They found no clear pattern of local differentiation that would permit them to recognize these specimens as separate species or subspecies, so they recommended treating *Rana livida* (now *R. chloronota*; see BAIN *ET AL.* 2003) as a widespread, geographically variable species. BAIN *ET AL.* (2003) also recognized geographic variation in *R. chloronota*, but did find diagnostic characters in some populations. Consequently, BAIN *ET AL.* (2003) described two new species, *R. banaorum* and *Rana morafkai*, from the same locality of Vietnamese specimens examined by INGER & CHAN-ARD (1997). Herein, we describe a new species from Khao Yai National Park, Thailand. This series, also examined by INGER & CHAN-ARD (1997), has been housed in the collection of The Field Museum of Natural History, Chicago, since the early 1970s. Because the new Thai species, *R. banaorum*, and *R. morafkai* all exhibit spinules, we also provide new data on the morphology and geographic distribution of the latter two species.

MATERIALS AND METHODS

Collection Abbreviations:

AMNH	American Museum of Natural History, New York
BMNH	The Natural History Museum, London
CAS	California Academy of Sciences, San Francisco
FMNH	Field Museum of Natural History, Chicago
IEBR	Institute of Ecology and Biological Resources, Hanoi
ROM	Royal Ontario Museum, Toronto

Specimens of *R. banaorum* and *R. morafkai* were collected in Vietnam and Laos by opportunistic searching, euthanised using a solution of chlorotone within 24 hours of collection, and fixed in 10% buffered formalin after preserving tissue samples of muscle and liver in 95% ethanol. Specimens were transferred to 70% ethanol and tissues were stored frozen upon arrival at the AMNH or FMNH. Comparative specimens were examined from the collections of the AMNH, BMNH, CAS, FMNH, IEBR, and ROM (appendix 1).

Measurements were made to the nearest 0.1 mm with digital calipers. Measurements included snout-vent length (SVL); snout length (SNT) measured from anterior corner of

the eye to tip of snout; head length (HDL) from tip of snout to the rear of the jaw; head width (HDW), maximum head width; eye diameter (EYE), diameter of the exposed portion of the eyeball; inter-orbital distance at narrowest point (IOD); horizontal diameter of the tympanum (TMP); shortest distance between tympanum and eye (TEY); hand length (HND), from base of the palm to tip of finger III; femur length (FEM), from vent to outer edge of knee; tibial length (TIB); foot length (FTL), from proximal edge of inner metatarsal tubercle to tip of fourth toe.

SPECIES ACCOUNTS

Rana indeprensa, new species
Figures 2–5

Holotype.—FMNH 183666 (Field Number 1831), an adult male from Khao Yai National Park, Nakhon Ratchasima Province, Thailand, collected on 22 May 1969 by W. Ronald Heyer. The holotype has an incision running ventrally from behind the arm insertion on the left side, to the posterior end of the belly, and up to behind the arm insertion on the right side.

Paratypes.—Seven adult males, 9 adult females, and 1 subadult female. Six adult males from Khao Yai National Park, Nakhon Ratchasima Province, Thailand collected throughout 1969 by W. Ronald Heyer: 14 August 1969 (FMNH 183665); 9 October 1969 (FMNH 183653); 12 November 1969 (FMNH 183660, 183663, 183664). One adult male (FMNH 183651) from Sarika Waterfalls, Nakhon Nayok Province, Thailand collected on 7 October 1969 by W. Ronald Heyer. Nine adult females from Khao Yai National Park, Nakhon Ratchasima Province, Thailand collected throughout 1969 and early 1970 by W. Ronald Heyer: 22 May 1969 (FMNH 183650); 12 June 1969 (FMNH 183652); 12 November 1969 (FMNH 183649, 183654–183658, 183662); 05 January 1970 (FMNH 183659). One subadult female from Khao Yai National Park, Nakhon Ratchasima Province, Thailand collected 9 October 1969 (FMNH 183661) by W. Ronald Heyer.

Diagnosis.—*Rana indeprensa* is a ranid frog characterized by a combination of the following characters: SVL of males 54.3–69.1 mm (mean 61.8 mm), females 92.8–101.0 (mean 96.9 mm); male SVL 54–74% female SVL; males with paired gular pouches; finger II shorter than I; all digit tips expanded with circummarginal grooves; no outer metatarsal tubercle; dorsal skin smooth, granular on flanks, dorsolateral folds weak or absent; males without humeral gland; males with white spinules on dorsal and ventral surfaces; posterior portion of thigh creamy white with brown marbling in preservative; eggs without pigment.

Description of holotype.—Habitus moderately stocky; head narrow, longer than wide; snout short, obtusely rounded in dorsal view, rounded in profile (wrinkle between nares and snout tip an artifact of preservation; Fig. 3), not depressed, sloping weakly, protruding beyond margin of lower jaw; nostril lateral, closer to snout tip than eye; canthus rostralis distinct, slightly constricted behind nostrils; loreal region concave, oblique; eye diameter 81% of snout; interorbital distance equal to width of upper eyelid; pineal body visible; tympanum round, distinctly visible, separated from eye by distance less than tympanum diameter, 53% eye diameter, not depressed relative to skin of temporal region, tympanic

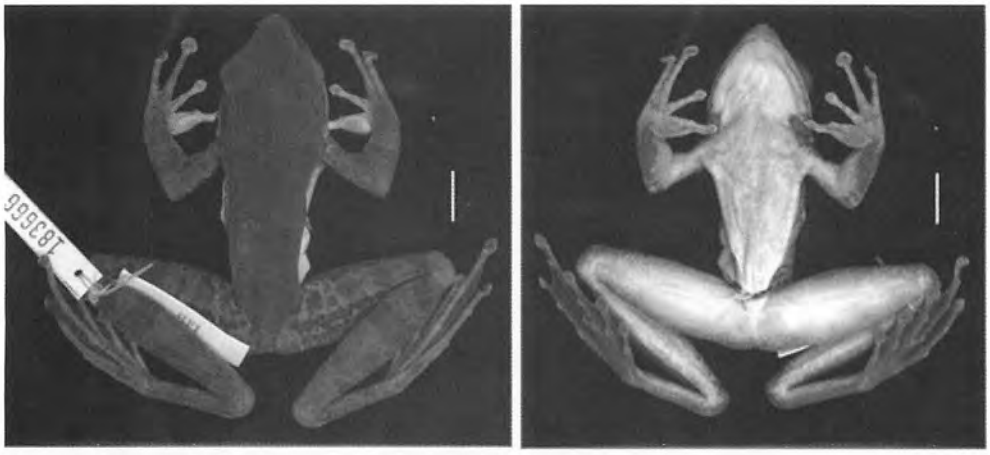

Figure 2. Holotype of *Rana indeprensa*, new species (FMNH 183666), an adult male from Khao Yai National Park, Nakhon Ratchasima Province, Thailand: dorsal view (left), ventral view (right). Scales equal 10 mm.

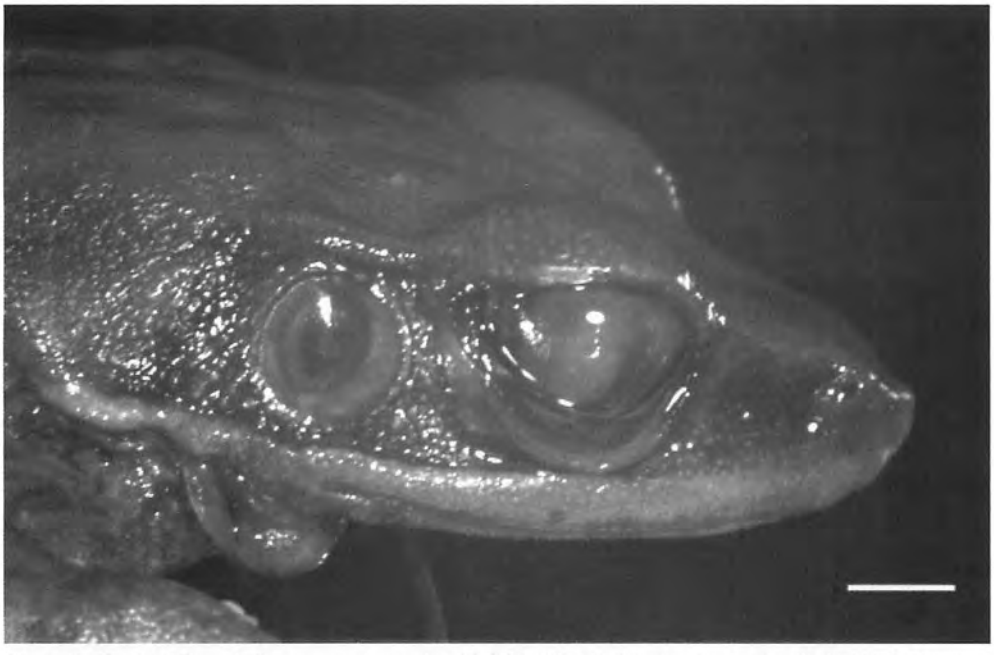

Figure 3. Head of *Rana indeprensa*, new species (FMNH 183666), holotype in profile. Scale equals 5 mm.

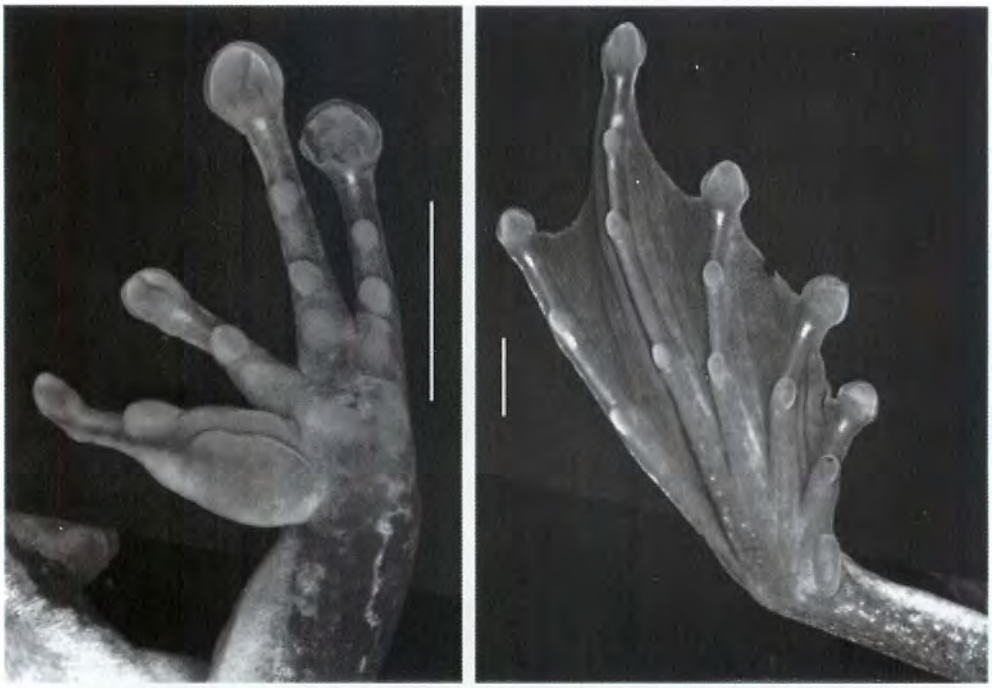

Figure. 4. Palmar view of left hand (left) and plantar view of right foot (right) of *Rana indeprensa*, new species (FMNH 183666), holotype. Scales equal 5 mm.

Figure 5: *Rana indeprensa*, new species from Khao Yai National Park, Nakhon Ratchasima Province, Thailand: **(left)** FMNH 183666, holotype, an adult male; **(right)** FMNH 183662, female paratype. Photographs by W. Ronald Heyer.

Table 1. Variation in measurements (mm) and body proportions of *Rana indeprensa*. See Materials and Methods for abbreviations.

Measurement	Adult males (holotype and paratypes) Range; Mean ± S.D. (N=8)	Adult females (paratypes) Range; Mean ± S.D. (N=9)
SVL	54.3–69.1; 61.8 ± 4.5	92.8–101.0; 96.9 ± 2.6
HDL	22.1–28.5; 24.1 ± 2.1	34.2–37.4; 36.0 ± 1.2
HDW	18.1–23.0; 20.4 ± 1.5	31.6–34.2; 32.9 ± 1.0
SNT	8.4–10.6; 9.6 ± 0.7	14.6–16.4; 15.7 ± 0.6
EYE	6.6–8.07; 7.1 ± 0.6	9.0–10.3; 9.6 ± 0.4
IOD	4.6–6.2; 5.5 ± 0.6	8.2–9.8; 8.9 ± 0.6
TMP	3.8–4.4; 4.0 ± 0.2	4.7–5.1; 4.9 ± 0.2
TEY	1.5–2.5; 2.1 ± 0.4	4.1–5.2; 4.7 ± 0.3
HND	16.4–19.5; 18.6 ± 1.0	26.7–29.6; 27.9 ± 1.0
TIB	36.1–42.6; 39.5 ± 2.3	55.4–63.8; 61.2 ± 2.5
FEM	31.9–39.2; 35.7 ± 2.4	53.3–58.4; 56.1 ± 1.5
FTL	29.1–36.5; 32.6 ± 2.7	50.1–53.8; 51.9 ± 1.3
	Range; Median	Range; Median
HDL:HDW	1.09–1.24; 1.19	1.04–1.14; 1.09
SNT:HDL	0.37–0.43; 0.40	0.41–0.47; 0.44
TMP:EYE	0.53–0.63; 0.56	0.48–0.53; 0.50
EYE:SNT	0.66–0.83; 0.75	0.57–0.67; 0.61
TIB:SVL	0.62–0.69; 0.63	0.56–0.68; 0.63

rim elevated relative to tympanum; vomerine teeth on two prominent ridges, oblique, medial to choanae, equal in distance to each other as to choanae; tongue cordiform, distinctly notched posteriorly, free for approximately 2/3 of its length; vocal sac opening at corner of floor of mouth; sac-like gular pouch at corner of throat.

Tips of all four fingers expanded to fleshy discs at tips, with circummarginal grooves; width of finger III disc greater than 2x width of phalanx, about 60% diameter of tympanum; relative finger lengths II < I < IV < III; medial callous pad on fingers II, III, and IV from distal edge of proximal subarticular tubercle to base of disc; movable flap of skin on preaxial side of fingers II and III; subarticular tubercles very large, rounded, fleshy, one subarticular tubercle on fingers I and II, two subarticular tubercles on fingers III and IV; smaller supernumerary tubercle proximal to proximal subarticular tubercle on fingers II, III, and IV; two palmar tubercles, large, oval, in contact; velvety nuptial pad on finger I, covering the dorsal surface to the level of the distal edge of the subarticular tubercle, covering the medial surface to base of finger disc; forearm robust.

Tips of toes expanded, width of toe IV disc > 2x base of phalanx, smaller than width of finger III disc; toe III < V; toes I, II, III, and V fully webbed to base of disc; toe IV fully webbed to distal subarticular tubercle with narrow extension to base of disc; movable flap of skin on preaxial side of toe I and postaxial side of toe V; subarticular tubercles prominent; tall, conical elongate, oval inner metatarsal tubercle with a free edge; no outer metatarsal tubercle.

Skin smooth on dorsum and dorsal surface of limbs, slightly shagreened on sacrum, granular on flanks; glandular supratympanic fold straight from posterior corner of eye, curving obliquely to dorsoposterior edge of tympanum; two rictal glands, anterior gland continuous with upper lip; no humeral gland; very weak dorsolateral folds reaching to near sacrum; skin granular on posterior surface of thigh, continuing to posteroventral surface of thigh; white spinules on loreal region, temporal region, tympanic region, upper and lower lip, rictal gland, posterior corner of upper eyelid, supratympanic fold, dorsal surface of elbow, dorsolateral region, sacrum, upper surface of tibia, in a row on dorsal surface of thigh, and tarsus to postaxial side of toe V; venter smooth, with spinules on lower jaw, chest, anterior two-thirds of belly; anus unmodified, directed posteriorly, at upper level of thighs.

Measurements of holotype.—(in mm) SVL 64.4; SNT 9.7; HDL 24.4; HDW 20.6; EYE 7.9; IOD 5.8; TEY 2.0; TMP 4.2; HND 19.5; FEM 39.2; TIB 42.2; FTL 35.7.

Colour of holotype in life.—Dorsum green; side of head reddish-brown from tip of snout, continuing as reddish-brown streak below edge of dorsolateral fold; upper lip stripe, rictal glands creamy yellow, greyish white towards the snout; upper one-third of iris gold, middle one-third dark, lower one-third dark with gold flecking; canthus rostralis with narrow orange-brown stripe, from tip of snout along margin of upper eyelid to posterior corner of upper eyelid; flank light brown, becoming darker ventrally; dorsal surface of limbs light brown with narrow, diffuse dark brown crossbars, interspersed with small dark brown spots; foot webbing dark grey; spinules white.

Colour in preservative.—Dorsum dark green-blue; loreal region, side of head brown; tympanum brown, translucent; upper lip greyish-white, more grey near snout; flank grey, with brown and dark grey diffuse spotting; dorsal limbs brown with dark brown banding; nuptial pad grey-white; anterior surface of thigh with dark brown spots, posterior portion of thigh creamy white with brown marbling; ventral surfaces creamy yellow, with grey dusting on calves (thighs immaculate); underside of foot dark grey; webbing dark grey, outer edge cream.

Variation.—Measurements of types summarized in Table 1. Males and females exhibit sexual dimorphism: male SVL 54–74% female SVL, male SVL 54.3–69.1 mm (mean 61.8 mm), females 92.8–101.0 mm (mean 96.9 mm); females lack white lip stripe found in males; males have a slightly larger TMP:EYE, 0.53–0.63, median 0.56 for males, 0.48–0.53, median 0.50 for females. Two adult female paratypes have IOD greater than width of upper eyelid, and four have IOD equal to width of upper eyelid. Some paratypes exhibit round head profiles without the weak sloping snout seen in the holotype. In some paratypes, the webbing reaches the disc of toe IV. Some paratypes have dorsal surface of limbs shagreened. Dorsolateral fold is weakly visible or absent in all females and some male paratypes. Three adult females (FMNH 183649, 183652, 183655) with conspicuous, densely packed spinules, particularly on the rictal glands, sometimes extending to the dorsum at the level of the arm insertion; four adult females with spinules, but in lower density than males, not on ventral surfaces; two adult females without any spinules. Dorsum colouration in preservative is variable, from grey-blue with brown spots, to red-brown. The venter is usually immaculate; a few paratype specimens have light to moderate mottling. Ova in

preservative uniformly yellow, without pigmented hemisphere, approximately 2–2.5 mm diameter.

Female paratype (FMNH 183662) differs in colour from the holotype as follows: dorsum dark brown with some dark green wash; upper lip stripe, rictal glands yellow, brown towards the snout; tubercles in tympanic and temporal area yellowish white; flank dark brown, with yellow marbling towards underside; dorsal surface of limbs dark brown with narrow, diffuse black crossbars, interspersed with numerous dark brown spots; foot webbing dark grey; spinules white

Comparisons.—Four other ranid species on mainland southeast Asia have males with paired gular pouches; finger II shorter than I, all digit tips expanded with circummarginal grooves; no outer metatarsal tubercle; dorsal skin smooth, dorsolateral folds weak or absent; males without humeral gland; and eggs without pigment: *R. banaorum, R. chloronota, R. livida,* and *R. morafkai. Rana indeprensa* differs from *R. banaorum* by its larger males (*R. indeprensa* 54.3–69.1 mm, mean 61.8 mm; *R. banaorum* males SVL 42.5–54.6 mm, mean 50.2 mm), presence of numerous spinules on males (*R. indeprensa* with numerous spinules on side of head, posterior corner of upper eyelid, supratympanic fold, dorsal surface of forearm, dorsolateral region, and chest to anterior two-thirds of belly; *R. banaorum* without spinules on upper surfaces listed above, or on ventral surfaces), and the absence of a lip stripe in females (present in *R. banaorum*). *Rana indeprensa* differs from *R. chloronota* by the skin condition of the flanks (granular in *R. indeprensa*, only slightly so in *R. chloronota*), the presence of white spinules on the dorsal and ventral surfaces of males (absent in *R. chloronota*), and the absence of a white lip stripe in females (present in *R. chloronota*). *Rana indeprensa* differs from *R. livida* in skin texture (flanks granular in *R. indeprensa*, smooth in *R. livida*), the presence of spinules on the dorsal surfaces of females (absent in *R. livida*), the absence of a white lip stripe in females (present in *R. livida*), and leg colour in preservative (posterior portion of thigh creamy white with brown marbling in *R. indeprensa*, brown with distinct whitish round spots in *R. livida*). *Rana indeprensa* differs from *R. morafkai* by its larger males (*R. indeprensa* 54.3–69.1 mm, mean 61.8 mm; *R. morafkai* 39.2–45.9 mm, mean 43.2), and the presence of white spinules on the chest (absent in *R. morafkai*).

Etymology.—The specific name is derived from the Latin *indeprensus*, meaning unobserved or undiscovered, in reference to the hidden identity of this new species for over 35 years in a natural history collection.

Distribution and Ecology.—Currently, *R. indeprensa* is only known from Khao Yai National Park, Nakhon Ratchasima Province, and Sarika Waterfalls, Nakhon Nayok Province, Thailand. Specimens were collected at night (1830–2003 h) in dry evergreen and gallery evergreen forest on rocks, vines, trees, and stream banks within 4.5 m of 3.5–18 m wide streams, except for FMNH 183657, which was taken on the forest floor away from water. Vertical position of specimens varied from ground level to ~1.5 m height. Tadpoles are unknown.

Remarks.—TAYLOR (1962: 468–471) reported three large male specimens of *R. livida* from Loei Province, Thailand, having SVL of 65–71 mm, which we have examined (see Appendix 1). Although these males overlap in size with *R. indeprensa*, there are morphological differences between them, and Taylor's specimens are not conspecific with

R. indeprensa. CHAN-ARD (2003: 136) reported specimens of *R.* cf. *livida* having males larger than 65 mm from several localities in Thailand, including the type locality for *R. indeprensa*, Khao Yai National Park in Nakhon Ratchasima Province. These might represent *R. indeprensa*, but we have not examined the material on which the account is based.

Rana banaorum Bain, Lathrop, Murphy, Orlov, and Ho, 2003

We expand the description of this species based on 15 topotype males from Gia Lai Province, Vietnam (Appendix I). Preaxial fringe on toe I runs from toe tip to metatarsal tubercle; postaxial fringe on toe V runs from toe tip to just distal to or at level of proximal subarticular tubercle. Dorsolateral folds weak, wide and granular, joining just anterior to anus. In preservative, upper lip dull grey with dark grey mottling, lower lip lightly and irregularly outlined in grey; dorsum brown with grey network; black stripe just below dorsolateral fold from posterior edge of eye to anus; flanks grey with brown spots, flash marbling on thighs grey-white; fingers I and II tan; webbing grey with dark grey spots.

Males of *R. banaorum* have been noted to exhibit small spinules (BAIN *ET AL.*, 2003: 50). These white spinules are loosely grouped along the upper lip to the rictal gland, around the tympanum, across the dorsum, the chin, the calf and along the tarsus, and in a line along the postaxial side of toe V, giving the appearance of a saw-tooth edge. Adult

Table 2. Variation in measurements and body proportions of male *Rana banaorum* from An Khe District, Gia Lai Province, Vietnam (measurements in mm). See Materials and Methods for abbreviations.

Measurement	Gia Lai (topotypes) Range; Mean ± SD (N = 15)
SVL	44.5–51.4; 48.4 ± 2.0
HDL	18.9–23.2; 21.4 ± 1.3
HDW	15.1–17.3; 16.5 ± 0.64
SNT	7.4–8.2; 7.8 ± 0.2
EYE	6.2–7.7; 7.0 ± 0.4
IOD	3.6–4.7; 3.9 ± 0.3
TMP	3.2–5.1; 4.4 ± 0.5
TEY	0.8–2.0; 1.5 ± 0.3
HND	13.0–15.4; 14.2 ± 0.7
TIB	27.8–31.3; 29.6 ± 1.1
FTL	36.6–40.4; 38.6 ± 1.1
	Range; Median
HDL:HDW	1.18–1.39; 1.30
SNT:HDL	0.15–0.17; 0.16
TMP:EYE	0.47–0.72; 0.62
EYE:SNT	0.77–1.01; 0.90
TIB:SVL	0.56–0.68; 0.61

Table 3. Variation in measurements and body proportions of *Rana morafkai* from Laos and Vietnam (measurements in mm). See Materials and Methods for abbreviations.

Measurement	Quang Nam	Ha Tinh Range (N = 2)	Gia Lai Range; Mean ± SD (N = 10)	Xe Kong Range; Mean ± SD (N = 4)	Champasak Range; Mean ± SD (N = 3)
Males					
SVL	45.6	45.4, 45.9	39.2–45.7; 41.9 ± 2.3	44.7–45.9; 45.1 ± 0.6	44.4–47.4; 46.1 ± 0.5
HDL	17.7	18.7, 21.4	16.5–20.3; 19.0 ± 1.4	15.8–17.5; 16.7 ± 0.7	16.4–17.6; 17.0 ± 0.7
HDW	14.4	14.5, 15.6	12.9–15.1; 13.7 ± 0.6	14.0–14.8; 14.4 ± 0.4	13.8–15.7; 15.0 ± 0.0
SNT	7.0	7.4, 7.6	6.3–7.8; 6.9 ± 0.4	7.4–7.9; 7.6 ± 0.2	6.9–7.8; 7.3 ± 0.4
EYE	6.0	5.5, 6.3	5.0–7.1; 6.0 ± 0.6	5.6–7.4; 6.4 ± 0.8	6.2–7.5; 6.7 ± 0.6
IOD	4.4	4.7, 4.8	3.8–4.6; 3.9 ± 0.3	3.4–4.2; 4.0 ± 0.4	3.3–4.2; 3.6 ± 0.5
TMP	3.4	3.4, 3.4	3.2–3.7; 3.5 ± 0.2	3.6–4.4; 3.9 ± 0.4	3.2–4.2; 3.7 ± 0.5
TEY	1.6	1.5, 1.4	1.0–1.9; 1.4 ± 0.3	1.2–1.8; 1.5 ± 0.2	1.2–1.8; 1.5 ± 0.3
HND	13.4	14.2, 15.6	12.0–13.6; 12.7 ± 0.5	12.9–14.4; 13.7 ± 0.6	13.8–14.6; 14.1 ± 0.4
TIB	27.9	28.1, 31.3	24.8–28.9; 26.2 ± 1.2	29.1–32.0; 30.2 ± 1.4	27.3–29.7; 28.2 ± 0.3
FTL	37.0	36.2, 41.3	31.7–36.7; 34.3 ± 1.5	25.1–37.9; 34.5 ± 6.2	35.7–37.2; 36.2 ± 0.9
		Range	Range; Median	Range; Median	Range; Median
HDL:HDW	1.24	1.29, 1.38	1.22–1.52; 1.41	1.13–1.24; 1.13	1.09–1.19; 1.13
SNT:HDL	0.40	0.40, 0.35	0.32–0.40; 0.36	0.42–0.50; 0.45	0.40–0.46; 0.42
TMP:EYE	0.56	0.63, 0.54	0.51–0.68;0.58	0.58–0.66; 0.61	0.50–0.61; 0.56
EYE:SNT	0.85	0.74, 0.83	0.68–1.01; 0.91	0.72–1.01; 0.82	0.87–0.96; 0.94
TIB:SVL	0.61	0.62, 0.68	0.59–0.67; 0.63	0.65–0.71; 0.66	0.59–0.63; 0.62

Measurement	Quang Nam Range; Mean ± SD (N = 6)	Xe Kong Range; Mean ± SD (N = 6)	Champasak Range; Mean ± SD (N = 3)
Females			
SVL	84.3–95.1; 89.3 ± 3.5	87.0–103.4; 93.1 ± 6.5	87.4–89.2; 88.1 ± 1.0
HDL	34.3–36.8; 35.4 ± 1.0	32.8–37.6; 34.8 ± 2.0	31.4–35.8; 34.1 ± 2.4
HDW	28.7–32.2; 30.5 ± 1.2	27.7–34.5; 30.6 ± 2.4	29.4–31.9; 30.4 ± 1.3
SNT	14.2–15.6; 15.0 ± 0.5	14.0–16.4; 15.1 ± 0.9	14.2–15.8; 15.1 ± 0.8
EYE	9.9–10.9; 10.3 ± 0.3	10.0–12.0; 11.0 ± 0.7	9.2–11.9; 10.4 ± 1.3
IOD	7.2–10.8; 8.9 ± 1.4	6.8–10.4; 8.8 ± 1.4	7.8–10.7; 9.1 ± 1.5
TMP	3.8–5.2; 4.4 ± 0.5	3.8–5.3; 4.6 ± 0.5	4.6–5.1; 4.9 ± 0.2
TEY	4.6–5.7; 5.1 ± 0.5	3.4–5.1; 4.1 ± 0.7	3.2–4.7; 4.1 ± 0.8
HND	24.7–27.8; 25.8 ± 1.1	24.2–28.6; 25.9 ± 1.6	24.9–26.6; 25.6 ± 0.9
TIB	58.6–62.2; 60.6 ± 1.3	58.8–66.8; 61.4 ± 3.0	58.0–61.6; 59.9 ± 1.8
FTL	74.1–82.7; 77.7 ± 3.4	72.0–83.4; 76.6 ± 3.8	72.3–76.7; 74.8 ± 2.3
	Range; Median	Range; Median	Range; Median
HDL:HDW	1.11–1.21; 1.16	1.09–1.19; 1.14	1.07–1.16; 1.12
SNT:HDL	0.40–0.45; 0.43	0.42–0.45; 0.43	0.44–0.45; 0.44
TMP:EYE	0.37–0.51; 0.42	0.36–0.45; 0.42	0.39–0.55; 0.48
EYE:SNT	0.66–0.71; 0.69	0.69–0.79; 0.73	0.60–0.75; 0.69
TIB:SVL	0.64–0.70; 0.68	0.62–0.71; 0.66	0.66–0.69; 0.68

female topotypes of *R. banaorum* exhibit very few or no spinules around the tympanum. See Table 2 for geographic variation of *R. banaorum*.

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We report new specimens from Champasak and Xe Kong Provinces, Laos, and Ha Tinh and Quang Nam Provinces, Vietnam (Appendix I). This species has previously only been recorded from Gia Lai Province, Vietnam (type locality), and Ban Sepian, Pakxong District, Champasak Province, Laos (TEYNIÉ *ET AL.*, 2004).

The new specimens closely match the description, however we elaborate on some characters based on the new specimens and 10 topotypes from Gia Lai Province, Vietnam (Appendix I). Some specimens have snouts that are sloping in profile, not rounded as in the original description. Webbing on males and females reaches base of toe discs, sometimes on toe IV as a fringe from the distal subarticular tubercle, or from between the subarticular tubercle and the toe disc. Some males exhibit white spinules along the upper lip to posterior lip glandule, loreal region, tympanic region (not on tympanum), upper eyelid, side of head, dorsolaterally (but not as a fold), sacrum, and calf to metatarsus continuing to postaxial side of toe V as a line to the toe tip. Spinules are not densely packed, except in FMNH 258240 (male). Spinules are also present in about one-half of the female specimens examined. Spinules in the females are fewer in number, smaller, and lower in density than those of the males, except in the largest female specimens (e.g. FMNH 258581, 258582) where they can be seen clearly with the naked eye. Spinules are not found on ventral surfaces of males or females.

In preservative the upper lip varies from dull grey to red-brown, usually with grey mottling; dorsum varies from dark green-grey to red-brown; flanks with grey and tan marbling or red-brown with white spots; flash marbling on thighs vary from brown on yellow to red-brown on white; dorsal limbs dark grey with brown banding; posterior surface of thighs marbled brown on white; webbing grey with dark grey spots; venter varies from immaculate white or yellow to deeply mottled brown from throat to upper third of belly (network of light brown on creamy white). See Table 3 for geographic variation of *R. morafkai*.

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Appendix 1: Material Examined

Rana banaorum.—**VIETNAM, Gia Lai Province**, An Khe District, Tram LapVillage: ROM 39944 (holotype female); ROM 39912, 39913, 39915, 39916 (paratype males); ROM 39899–39901, 39928, 39929, 39931, 39936, 39941 (paratype females); Krong Pa: ROM 39700, 39702–39705 (paratype males); Buon Luoi Village, 14°20'N, 108°36'E, 20 km to the northwest from Kannack, 700–750 m, on vertical surfaces of rocks and trunks of large trees around waterfalls, 20:00–22:00 h: ROM 25084–25086, 25100, 25102, 25103 (paratype males); FMNH 253684; Cha River, on big stones in fast water and on tree branches 1.5–2 m from the water, 11:00–1:00 h: ROM 39716 –39720, 39920 –39922, 39924–39926 (paratype males); FMNH 253694, 253699, 253701, 253706, 253713, 253715, 253719, 253721); on rocks projecting 10 m on a waterfall, 17:00–19:00 h: FMNH 253726, 253731, 253732; bushes on stony area of bank of river, 900 m, 19:00–21:00 h: FMNH 253734, 253736; stony ford (shallow crossing) of river, 900 m, 21:00–23:00 h: FMNH 253739;.

Rana chloronota.—**INDIA, Darjeeling**: BMNH 1947.2.28.10, 1947.2.28.12, male syntypes; BMNH 1947.2.28.6 female syntype (note: BMNH catalog number correction from Bain et al., 2003, as per B. Clarke, pers. comm.), ROM 14057, 14058,; **Assam**: FMNH 72416, 74158, males; **MYANMAR, Shan State**: CAS 221771–72, males; **Rakhine State**: CAS 220261, male; CAS 216574, 220186–87, 220260, 222907, females; **Kachin State**: CAS 221315, female; **Bago State**: CAS 211719, 211671, females.

Rana livida.—**MYANMAR**, Dawna Mountains, Thagata Juwa: BMNH 1889.3.25.48, female neotype; BMNH 1889.3.25.47, female; THAILAND, Prachuap Khirikhan Province: FMNH 263415.

Rana cf. ***livida***.—**THAILAND, Loei Province**, Phu Kading: 172380 (Taylor's field number 34958); on summit: FMNH 172378 (Taylor's field number 34956); in pool FMNH 172379 (Taylor's field number 34957; illustrated in TAYLOR, 1962: fig. 67.

Rana morafkai.—**VIETNAM, Gia Lai Province**, An Khe District, Kannack Town, Tram Lap Village: ROM 39932, holotype female; ROM 39930, 39934, 39947, 39949 paratype females; ROM 39904–39911, 39937, paratype males; Buon Luoi Village, 14°20'N, 108°36'E, 20 km to the northwest from Kannack, Annam Mountains, 700–750 m, on the vertical surfaces of rocks and trunks of large trees around waterfalls, 20:00–22:00 h: ROM 25094–25097, 25099, 25101, 25104–25106, 25108–25111, paratype males; FMNH 253677, 253678, 253680, 253681; Cha River, on big stones in the rapid stream and on tree branches 1.5–2 m from the water, 11:00–1:00 h: FMNH 253700, 253702, 253703, 253709, 253720; on rocks projecting 10 m on a waterfall, 17:00–19:00 h: FMNH 253727; **Quang Nam Province**, Ngoc Linh Mountain, Tra Don Commune, Tra My Region, 15°12'N 108°2'E, 820–950 m: IEBR 56, NQT 14903, AMNH Field Series-14855, AMNH 163724–163727; **Ha Tinh Province**, Huong Son Reserve, Rao An Region, 18°22'N 105°13'E, 200 m: AMNH 161235, 161236. **LAOS, Xe Kong Province**, Kaleum District, Xe Sap National Biodiversity Conservation Area, along Houay Batay Stream 16°01'30"N, 106°55'40"E, 780–900 m: FMNH 258171, 258222, 258581–258584; on stream near 16°04'10"N, 106°58'45"E, 1100–1280 m: FMNH 258228, 258586; above stream near 16°04'10"N, 106°58'45"E, 1280–1500 m: FMNH 258585; along Houay Alung Stream 16°00'32"N, 106°55'31"E, 920–1000 m: FMNH 258223; **Champasak Province**, Pakxong District, Boloven Plateau, Dong Hua Sao National Biodiversity Conservation Area, near 15°02'48"N, 106°10'45"E, 400 m: FMNH 258238–40, 258592–258594.