Zootaxa 2727: 45–55 (2010)
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

A new tree frog of the genus *Rhacophorus* (Anura: Rhacophoridae) from southern Vietnam

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Abstract

We describe a new species of rhacophorid frog from the Langbian Plateau in southern Vietnam. *Rhacophorus vampyrus* **sp. nov.** is distinguished from its congeners by a combination of: a pale tan to brick red dorsum; white throat, chest and belly; black flanks and anterior and posterior surface of thighs; grey to black webbing between fingers and toes; reduced finger webbing; and pointed projection at tibiotarsal articulation. At present, the new species is known from montane evergreen forest between 1470–2004 m elevation. *Rhacophorus vampyrus* **sp. nov.** is a phytotelm breeder, depositing eggs in foam nests in small tree-holes.

Key words: Anura, Rhacophoridae, Southeast Asia, Vietnam

Introduction

The family Rhacophoridae contains approximately 320 species of frog, distributed throughout subsaharan Africa, China, Southeast Asia, Japan, Taiwan, the Philippines, and the Greater Sunda Islands (Frost 2010). Most species within the family are arboreal, adapted for life in the trees by having intercalary elements between the terminal and penultimate phalanges, expanded digit disks, and, often, extensive webbing on the hands and feet (Duellman & Trueb 1986).

The genus *Rhacophorus* (Kuhl & Van Hasselt 1822) contains approximately 80 species distributed throughout Asia (Frost 2010). The true diversity of the genus remains unknown, with over a quarter of *Rhacophorus* species described in the last decade (Frost 2010). This continued species discovery is a result of both the taxonomic partitioning of species previously hidden within more widespread species complexes (eg. Ohler & Delorme 2006; Chan & Grismer 2010), and the discovery of novel species as a result of recent herpetological surveys (eg. Dehling & Grafe 2008; Matsui & Panha 2006; Orlov *et al*. 2010).

To date, 24 species of *Rhacophorus* have been recorded from mainland Southeast Asia, over one-third of which were described in the last decade (Frost 2010). During recent field work in the Langbian Plateau, in southern Vietnam, we discovered a medium-sized species of *Rhacophorus* that differs morphologically from all mainland Southeast Asian members of the genus. We describe this species as new.

Material and methods

Specimens were deposited at the Australian Museum (AMS), the North Carolina Museum of Natural Sciences (NCSM), the University of Science, Ho Chi Minh City (UNS) and the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK). Some specimens currently at the AMS will be deposited at the UNS and have been cross-cat-

Accepted by M. Vences: 3 Dec. 2010; published: 21 Dec. 2010

aloged at both institutions. In these instances, voucher numbers are reported as UNS/AMS. We recorded morphological data from specimens fixed in 10% formalin and then stored in 70% ethanol (AMS, NCSM, and UNS/AMS) or fixed in 90% ethanol and stored in 70% ethanol (UNS and ZFMK). Morphometric data were taken (to the nearest 0.1 mm) with digital calipers. Measurements include snout-vent length (SVL); head length from tip of snout to rear of jaws (HDL); head width at the commisure of the jaws (HDW); snout length from tip of snout to the anterior corner of eye (SNT); diameter of the exposed portion of the eyeball (EYE); interorbital distance (IOD); horizontal diameter of tympanum (TMP); distance from anterior edge of tympanum to posterior corner of the eye (TEY); internarial space (IN); distance from nostril to tip of snout (NS); distance from front of eye to nostril (EN); tibia length with the hindlimb flexed (TIB); manus length from tip of third digit to base of tubercle on prepollex (ML); pes length from tip of fourth toe to base of the inner metatarsal tubercle (PL); and length of inner metatarsal tubercle (IML). We use a traditional formula for finger numbering rather than one based on homology (eg. Alberch & Gale 1985). Sex was determined by the presence of vocal sacs and/or gonadal inspection. Mass was recorded in life (to the nearest 0.1 g), using Pesola scales. Radiographs of the holotype were also prepared to examine osteological features including the presence of intercalary discs and the shape of the distal end of the terminal phalanges. Vocal sac terminology follows Liu (1935). Terminology for describing eye colouration in life follows Glaw and Vences (1997). Webbing formula follows that proposed by Savage and Heyer (1967), and modified by Myers and Duellman (1982) and Savage and Heyer (1997). For comparisons between *Rhacophorus* species in mainland Southeast Asia, webbing on the hands was considered complete if webbing reached the subarticular tubercle on Finger I, and the disks between Fingers II–IV. We obtained comparative morphological data from museum specimens of *Rhacophorus* and photographs of these specimens in life (Appendix 1), and from the literature (Table 2). We analyzed 548 base pairs (bp) of mitochondrial 16S ribosomal RNA from four adults of the new species and one tadpole. DNA was extracted using DNeasy tissue extraction kits (Qiagen). We used the primers 16SAR and 16SBR of Palumbi *et al.* (1991) to amplify the 16S rRNA gene. Standard PCR protocols were used and PCR products were purified using ExoSap-IT (USB Corporation, OH, USA). Purified templates were sequenced directly by Macrogen (Seoul, Korea). Sequences were validated using Sequencher 4.10 (Gene Codes, Ann Arbor, MI), aligned using the Clustal option in MEGA 4 and refined by eye. Kimuara 2-parameter mtDNA pairwise sequence divergence was calculated using MEGA 4. DNA sequences for the new species were deposited in GenBank under the accession numbers HQ656815– HQ656819.

Rhacophorus vampyrus sp. nov.

Holotype. AMS R 173127, adult male, on a tree branch in montane evergreen forest in Bidoup-Nui Ba National Park, Lac Duong District, Lam Dong Province, Vietnam (12.1865° N, 108.7151° E, 1625 m). Collected at 21:00 h on 26 July 2010 by Le T. T. D.

Paratypes. AMS R 173126, female, on a tree branch approximately 2 m above ground in montane evergreen forest (12.1865° N, 108.7150° E, 1625 m), collected at 22:30 h on 26 July 2010 by Le T. T. D. UNS 00103/AMS R 173128 male, on a leaf approximately 2 m above ground in montane evergreen forest (12.1736° N, 108.6987° E, 1470 m) collected at 22:05 h on 31 March 2009 by Le T. T. D. UNS 00104/AMS R 173129, male, on a leaf approximately 1.5 m above ground, 0.5 m from rocky stream in montane evergreen forest (12.1865° N, 108.7151° E, 1625 m) collected at 20:30 h on 30 March 2009 by Le T. T. D. AMS R 173507, female, on a leaf approximately 1 m above ground in montane evergreen forest (12.1736° N, 108.6987° E, 1470 m), collected at 21:50 h on 18 August 2009 by Le T. T. D. NCSM 77318, adult male, on a trunk of tree away from water, 1 m above ground in montane evergreen forest (12.1864° N, 108.7149° E, 1627 m), collected at 21:00 h on 6 March 2008 by B. L. Stuart, J. J. L. Rowley, Le T. T. D., Tran T. A. D., and Hoang D. H. UNS 00105, adult female, in montane evergreen forest (12.1736° N, 108.6987° E, 1470 m), collected on 18 March 2010 by Tran T. A. D. ZFMK 91076, adult male, on a tree 1 m above ground near 1–2 m wide, dry stream in montane evergreen forest (12.0096° N, 108.6607° E, 2004 m), collected on 23 March 2010 by Tran T. A. D. All specimens were collected in Bidoup-Nui Ba National Park, Lac Duong District, Lam Dong Province, Vietnam.

Other material. AMS R 173132, six tadpoles, inside small pool of water in an approximately 10 cm diameter tree-hole, approximately 1 m above the ground in montane evergreen forest in Bidoup-Nui Ba National Park, Lac Duong District, Lam Dong Province, Vietnam (12.1736° N, 108.6987° E, 1470 m). Collected at 10:30 h on 28 July 2010 by Le T. T. D.

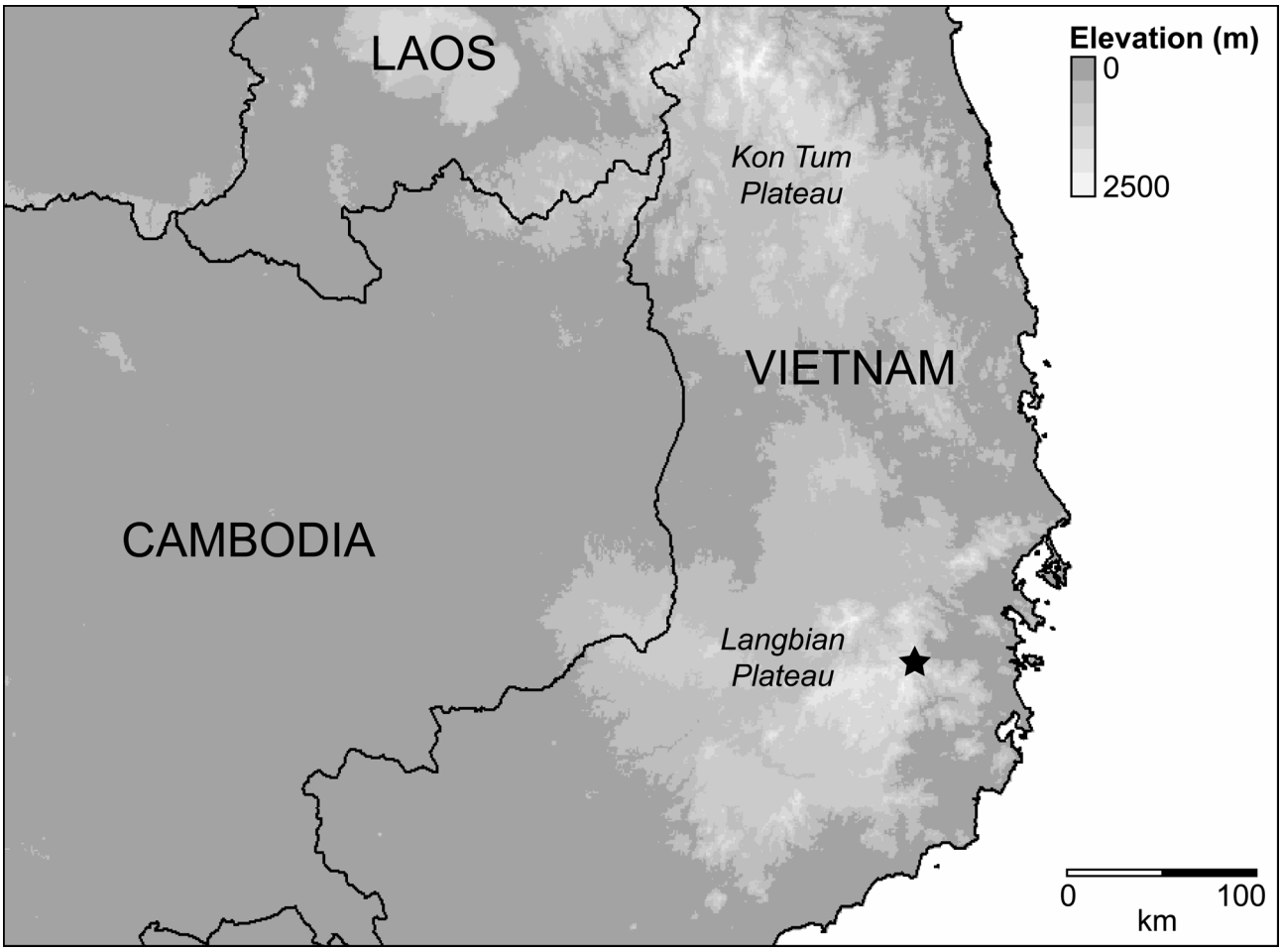

FIGURE 1. Collection site of *Rhacophorus vampyrus* **sp. nov.**

Etymology. Specific epithet in reference to the unusual tadpole of the new species (see below), applied as a noun in apposition.

Suggested common name. Vampire tree frog (English). Ếch cây ma cà rông (Vietnamese).

Diagnosis. The new species is assigned to the genus *Rhacophorus* by the presence of intercalary cartilage between the terminal and penultimate phalanges of digits, Y-shaped distal end of terminal phalanx, tips of digits expanded into large disks bearing circummarginal grooves, webbed fingers, a supracloacal dermal ridge, vomerine teeth, and horizontal pupil (Brown & Alcala 1994; Duellman & Trueb 1986; Liem 1970). *Rhacophorus vampyrus* is distinguished from all other *Rhacophorus* in mainland Southeast Asia by a combination of (1) pale tan to brick red dorsum, (2) white throat, chest and belly, (3) mostly black flanks and anterior and posterior surface of thighs, (4) grey to black webbing between fingers and toes, (5) reduced finger webbing, and (6) pointed projection at tibio-otarsal articulation.

Description of holotype. Body dorsoventrally compressed; head length 90% of head width; snout truncate in dorsal view, bluntly truncate in profile, projecting slightly beyond margin of the lower jaw, with slight point on tip of snout visible in ventral view; canthus rostralis distinct, bluntly angular; loreal region sloping, slightly concave; lips slightly flared; interorbital region slightly convex; nostrils oval, slightly protuberant, without flap of skin laterally, much closer to tip of snout than eye; pupil horizontal, tympanum barely visible externally, tympanic rim slightly elevated relative to skin of temporal region, 41% of eye diameter; pineal ocellus absent; skin not co-ossified to forehead; vomerine teeth present in oblique groups, separated by a distance about as long as each group, closer to choanae than wide; choanae oval, at margins of roof of mouth; tongue attached anteriorly, deeply notched posteriorly; tooth-like projections on lower jaw absent; pair of distinct, oval vocal sac openings at base of jaw; external paired subgular vocal sacs; weak supratympanic fold extending to just beyond level of axilla. Forelimbs relatively robust, relative length of fingers I < II < IV < III; tips of all fingers with well-developed disks with dis-

tinct circummarginal grooves, disks relatively wide compared to finger width (third finger disk 170% third finger width), third finger disk width greater (163%) than tympanum diameter; webbing formula I 2 – 2^{+} II 1^{+} – 2^{+} III 2^{-} – 1 IV; subarticular tubercles prominent, rounded, formula 1, 1, 2, 2; palmar tubercle absent; accessory palmar tubercles indistinct; thenar tubercle absent; prepollex enlarged, with low, relatively indistinct tubercle; nuptial pads or nuptial excrescences absent. Relative length of toes I < II < III < V < IV; tips of toes with well-developed disks with distinct circummarginal grooves; disks smaller than those of fingers; webbing formula I 1 – 2 II 1 – 2 III 1 – 2^{+} IV 2 – 1 V; subarticular tubercles rounded, distal subarticular tubercles distinct, inner less distinct, formula 1, 1, 2, 3, 2; inner metatarsal tubercle low, oval; outer metatarsal tubercle and supernumary tubercles absent. Dorsal skin smooth, ventral surface of thighs and belly coarsely granular, chest and throat smooth. Loose skin on either side of the throat over vocal sacs. Tarsal fold absent. Outer margin of forearm and foot with low dermal ridges; low supracloacal dermal ridge; pointed projection at tibiotarsal articulation present, approximately 1 mm long.

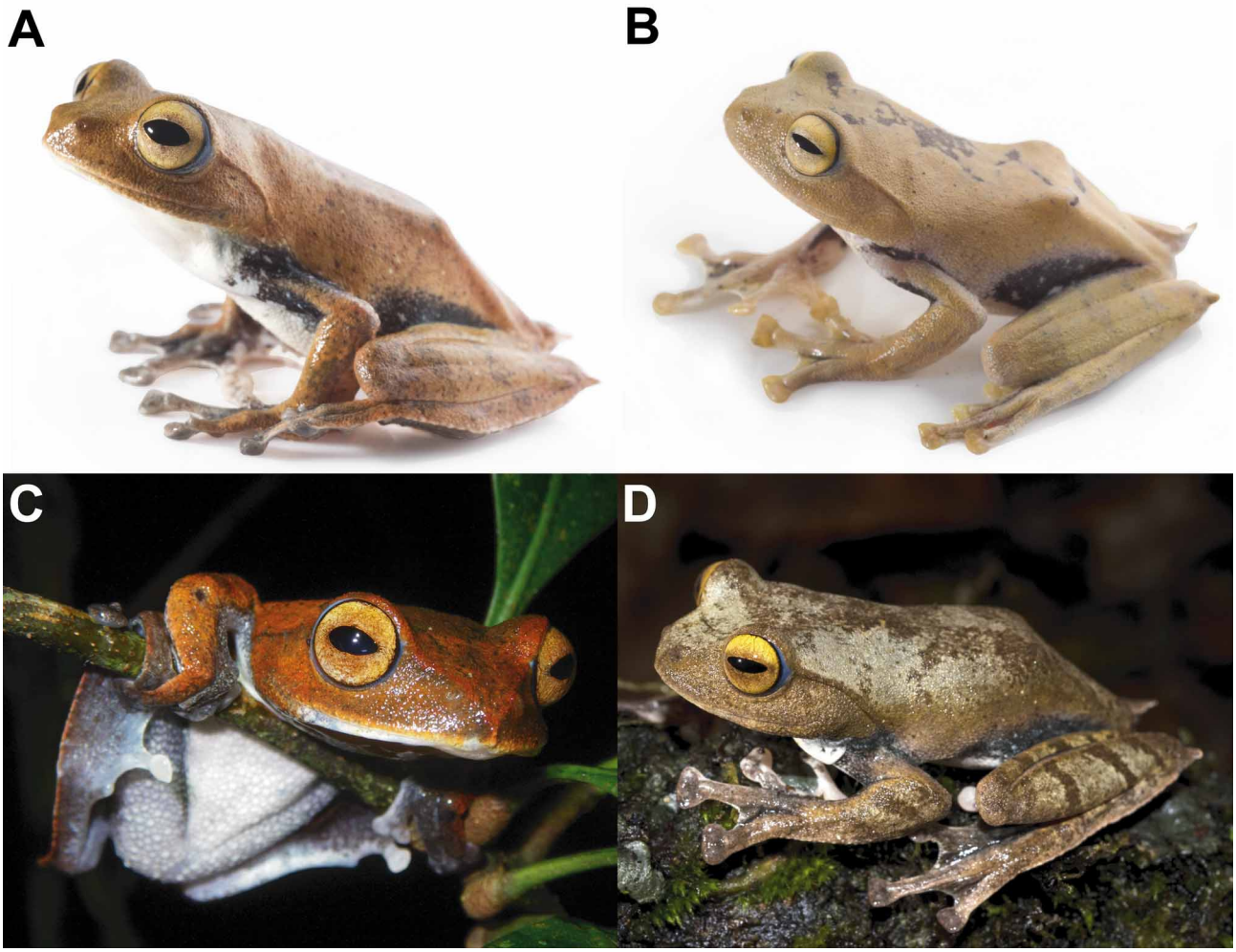

FIGURE 2. Dorsolateral view of *Rhacophorus vampyrus* **sp. nov.** in life (A) adult male holotype (AMS R 173127), diurnal colouration, (B) female paratype (AMS R 173126), diurnal colouration, (C) adult male, non-vouchered specimen, *in situ* with nocturnal colouration, and (D) adult male paratype NCSM 77318, diurnal colouration (note modified skin under angles of jaw over paired subgular vocal sac).

Colour of holotype in life. Dorsal surface pale copper-brown with faint darker brown mottling along back; dorsolateral surfaces with very small, sparse, white and darker brown flecks; dorsal surface of lower arms, thigh and tibiotarsus copper-brown with diffuse darker brown barring; dorsal surface of hands and feet copper-brown proximally, fading distally to pinkish-cream on fingers and toes I–II, and grey on fingers III–IV and toes III–V; dark grey to black webbing dorsally. Black flanks, upper arms, ventral surface of lower arms, anterior and posterior surface of thighs, and ventral surface of crus, with small, irregular white spots within the black on the flanks and upper arms. Ventral surface of throat, chest and belly immaculate except for black mottling extending slightly onto

lateral margins of chest at axilla; ventral surfaces of toes and fingers pale grey; ventral surface of webbing grey with dark grey/black margins. Iris pale yellowish gold with a network of fine dark gold reticulations concentrated around the pupil; iris periphery black; posterior periphery of eye blue. Dorsal colouration varied from pale tan (diurnally) to brick red (nocturnally).

Colour of holotype in preservative. As in life, but with dorsum fading to pale tan.

Measurements. Holotype: SVL 43.6, HDL 14.6, HDW 16.3, SNT 5.5, EYE 4.6, IOD 4.8, TMP 1.9, TEY 1.6, IN 3.8, NS 1.2, EN 3.6, TIB 20.7, ML 13.2, PL 19.1, IML 2.4.

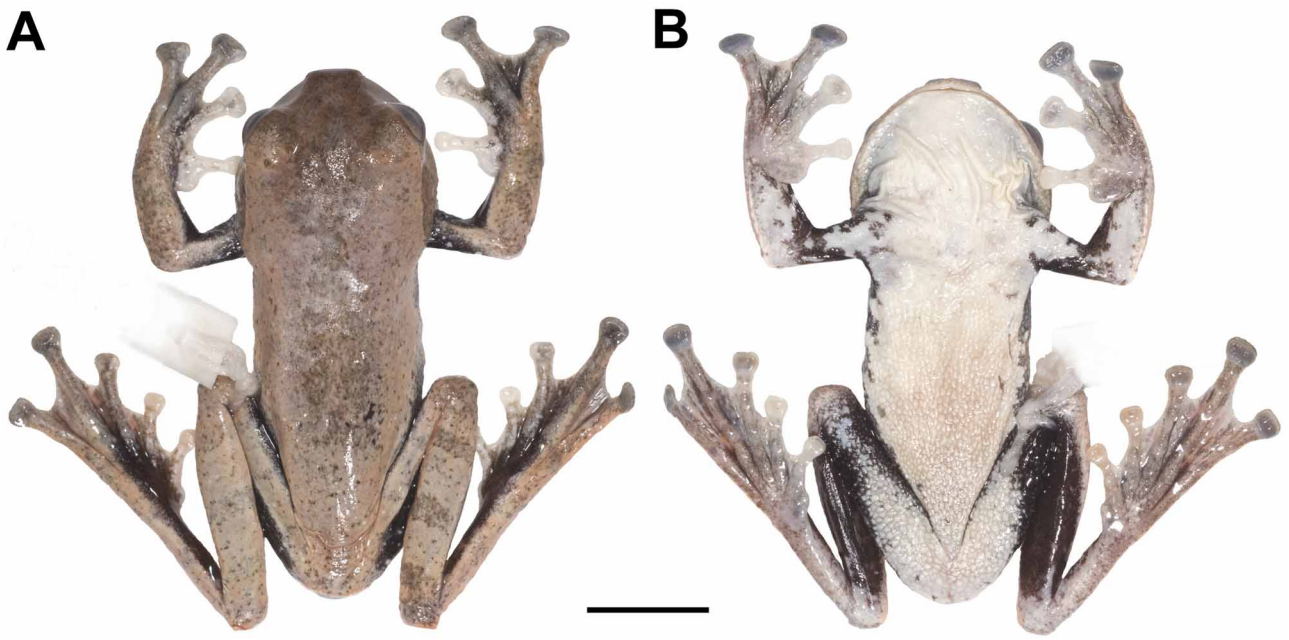

FIGURE 3. Dorsal (A) and ventral (B) views of preserved male holotype of *Rhacophorus vampyrus* **sp. nov.** (AMS R 173127). Scale bar = 10 mm.

Variation. Measurements of the type series are shown in Table 1. AMS R 173126 has dark brownish-grey marbling on the dorsal surface running from the interorbital region down the back; pinkish coloured webbing, particularly ventrally, between toes III–IV; more distinct barring on limbs in preserve; and less dense black colouration on the ventral surfaces of the thighs. AMS R 173507 has a uniformly coloured dorsum, with no black or white spotting or dark patterns; indistinct barring on dorsal surface of tibiotarsus; and grey webbing on hands and fingers. AMS R 173129 has an indistinct, slightly darker brown, irregular pattern running along dorsum; two, 1 mm diameter white spots on the back posteriorly; and completely black posterior and anterior surfaces of thighs, without white spotting. AMS R 173128 is strongly patterned with a darker brown, irregular pattern and scattered darker brown specks on the entire dorsum; very distinct barring on limbs; and less black colouration on ventral surfaces of thighs. NCSM 77318 has pale brown or cream mottling on the dorsal surface of head, back and limbs in life; and a dark brown dorsum with pale dusting only visible in between barring on the dorsal surface of the legs in preserve. ZFMK 91076 is almost uniformly pale tan in life and in preserve; has faint barring on arms and legs; slightly darker blotches in the interorbital region and along back; less extensive black colouration marbled with white on flanks, anterior and posterior surfaces of upper arms, anterior surface of lower arms, and anterior and posterior surface of thighs; and only faint black speckling on ventral surfaces of fingers II–IV and finger webbing, ventral surface of crus, and anterior half of pes, including ventral surface of toes I–III and toe-webbing. UNS 00105 has an almost uniformly pale tan dorsum in life and in preserve; has faint barring on arms and legs; and the most extensive black colouration, without white spotting on flanks, anterior and posterior surfaces of upper arms, anterior surface of lower arms, ventral surfaces of fingers I–IV and finger-webbing, anterior and posterior surface of thighs, ventral surface of crus, and anterior half of pes, including ventral surface of toes I–III and toe-webbing. UNS 00105 also has fine black specks concentrated on ventral surface of chest, but also sparsely distributed on the belly and outer margins of the throat. Males vary in the extent and colouration of loose skin in the gular region; UNS 00103/AMS R 173128 has only slightly loose skin in the gular region, only weakly coloured grey; UNS00104/AMS R 173129 has loose skin in the gular region, coloured greyish black; NCSM 77318 and ZFMK 91076 have the most pro-

nounced loose skin in the gular region, with dark grey colouration also extending ventrally along margins of throat. All males lack nuptial pads or asperities.

TABLE 1. Measurements (mm) of *Rhacophorus vampyrus* **sp. nov**. Abbreviations defined in text.

	AMS R 173127*	UNS 00103/ AMS R 173128	UNS 00104/ AMS R 173129	NCSM 77318	ZFMK 91076	AMS R 173126	AMS R 173507	UNS 00105
Sex	Male	Male	Male	Male	Male	Female	Female	Female
SVL	43.6	42.5	44.8	44.2	43.3	38.9	41.4	53.4
HDL	14.6	14.9	15.2	15.3	14.4	15.0	15.3	18.0
HDW	16.3	17.0	17.3	17.0	17.1	16.8	16.6	20.8
SNT	5.5	5.8	6.2	6.3	5.8	5.5	6.1	7.3
EYE	4.6	4.6	4.5	4.7	4.5	4.2	4.7	5.3
IOD	4.8	6.1	5.6	4.7	5.5	4.9	5.2	5.1
TMP	1.9	2.4	2.0	2.2	2.7	2.6	2.5	2.7
TEY	1.6	1.2	1.6	1.6	1.3	1.5	2.0	2.0
IN	3.8	4.1	3.6	4.2	4.5	3.8	3.9	4.8
NS	1.2	2.1	2.4	2.7	2.3	1.7	2.0	3.0
EN	3.6	3.9	3.9	3.6	3.5	3.6	3.7	4.4
TIB	20.7	20.7	21.3	20.7	20.5	20.1	21.1	26.4
ML	13.2	12.5	13.1	14.4	13.8	12.2	13.8	16.8
PL	19.1	17.4	17.4	19.3	18.0	17.6	18.2	23.1
IML	2.4	1.9	1.9	2.1	1.6	2.0	1.6	2.4
HW:HL	1.12	1.14	1.14	1.11	1.19	1.12	1.08	1.16
HL:HW	0.9	0.88	0.87	0.9	0.84	0.89	0.92	0.87
TIB:SVL	0.47	0.49	0.47	0.47	0.47	0.52	0.51	0.49
HDL:SVL	0.33	0.35	0.34	0.35	0.33	0.38	0.37	0.34
TMP:EYE	0.41	0.53	0.45	0.47	0.60	0.61	0.54	0.51
Weight (g)	3.9	-	-	-	-	3.5	4.0	-

*holotype

Tadpole. Tadpoles were assigned to the new species based upon the extremely low sequence divergences between the tadpole and adults frogs (0.0–0.6% at the 16S rRNA gene). The tadpole is elongate, with a tail length about 3 times body length, and the tail is about as tall as the body. The tadpole has a greatly reduced oral disc, only an upper jaw sheath, and most notably, a pair of keratinized hooks on the edge of the lower labium that face away from the mouth. Colour in life dark brownish grey, slightly paler in preservative. A detailed description of the new tadpole will be published separately.

Ecology. The species is a phytotelm breeder, depositing foam nests in small tree-holes, away from streams or ponds. Between May-July 2010, we observed eight foam nests and/or groups of tadpoles consistent with the new species, all in water-filled tree-holes, 0.3–1.2 m above the ground. Adults of the new species were also adjacent to these tree-holes on several occasions. The advertisement call of the species is unknown.

Conservation status. *Rhacophorus vampyrus* is known only from Bidoup-Nui Ba National Park. The actual distribution of the new species is unknown but probably extends into montane evergreen forest in the Langbian Plateau, including Chu Yang Sin National Park in Dak Lak Province, and Phuoc Binh National Park in Ninh Thuan Province, which are continuous with Bidoup-Nui Ba National Park. Given the available information, we suggest the species should be considered Data Deficient following IUCN's Red List categories (IUCN 2001).

Comparisons. The pale tan to brick red dorsum, white venter, and mostly black flanks, ventral surface of upper arms and crus, and anterior and posterior surface of thighs distinguishes the new species from all mainland Southeast Asian congeners (Table 2).

TABLE 2. *Rhacophorus* species known from mainland Southeast Asia. Fields that differ to those of the new species are highlighted in grey.

Species	Dorsum colour	Ventral colour	Pattern on sides of body	Dorsal colour of webbing	Finger webbing	Pointed projection on heel	Source
annamensis	brown with dark markings	white	variable, white and/or yellow; scattered black/grey/brown spots	variable; dark greyish brown/black	complete	absent	Smith 1924; Inger *et al.* 1999; JR pers. obs.
appendiculatus	greyish brown with dark obscure mottling	cream coloured; no spots	–	–	reduced	absent (narrow flap only)	Günther 1858; Brown & Alcala 1994
bipunctatus	green	yellow	1–3 black spots	red	reduced	present	Ahl, 1927; Bordoloi *et al.* 2007
burmanus	green	chocolate brown with white markings anteriorly, whitish posteriorly*	–	–	reduced	absent	Andersson 1939; Ohler 2009
calcaneus	olive/pale green; small pale yellow dots	pale yellow	yellow, 2 black spots (one side only)	yellow/olive, dark spots	reduced	present	Smith 1924
chuyangsinensis	dark green or brown; small pale spots	bright yellow	bright yellow with 2 black spots	bright yellow	reduced	present	Orlov *et al.* 2008
cyanopunctatus	sand-coloured with cinnamon coloured cross bars	throat and chest white with brown speckles; belly light yellow to dark down the flanks	posterior dark brown to blackish with iridescent blue spots	–	reduced	absent	Manthey & Seiof 1998
dennysi	green	dirty white, mottled with dusky	none	whitish	reduced	absent	Blanford 1881; Bordoloi *et al.* 2007
dorsoviridis	green	white	white with variable black spotting	–	reduced	absent	Bourret 1937
duboisi	dark olive green	fleshy with brown spots	lower flanks blackish with white spots	marbled black and white	reduced	absent	Ohler *et al.* 2000
dugritei	green, with round spots of a golden metallic ash	cream yellow, spotted with dark grey	marbled with cream yellow	–	reduced	absent	David 1872 "1871; Liu 1950
exechopygus	mottled grey, brown, and olive green	white anteriorly; yellow posteriorly	marbled back and white/pale blue	as dorsum	complete	absent (large tubercle only)	Inger *et al.* 1999; JR pers. obs.

TABLE 2. (continued)

Species	Dorsum colour	Ventral colour	Pattern on sides of body	Dorsal colour of webbing	Finger webbing	Pointed projection on heel	Source
feae	green with small golden spots	anteriorly white; posteriorly pinkish; pale green throat	none	brownish grey	reduced	absent	Boulenger, 1893; JR pers obs.
hoanglienensis	brown with diffuse darker brown pattern	creamy white, covered by small dark spots	grey, diffuse mottling in axilla, groin white with black mottling	–	reduced	present	Orlov *et al.* 2001
hungfuensis	green	light yellow/white	none	greenish	reduced	absent	Liu & Hu, 1961; Fei *et al.* 2009
jarujini	light brown with darker brown patterns	anteriorly cream, posteriorly yellow	none	reddish orange with a light brown streak	reduced	absent	Matsui & Panha 2006
kio	green	lemon yellow	1 black spot, lower flanks dark brown with yellow spots	orange/black	complete	present	Ohler & Delorme 2006
marmoridorsum	flesh coloured with marble chocolate pattern	light cream colour without spots	irregular spots and lines of chocolate colour on cream coloured background	greyish with brown lining	reduced	present	Orlov 2008
maximus	green	light brown/white	spotted purple-brown	greyish	complete	absent	Günther 1858; Ahl 1931; Bordoloi *et al.* 2007
omeimontis	green with brown interweaved patterns	cream; throat stippled dark	dark brown mottling	–	reduced	absent	Stejneger 1924; Liu 1950
orlovi	reddish brown with dark brown markings	white to light brown with a few indistinct small dark flecks	flanks light brown with dark brown reticulation and yellow spots	brownish	reduced	weak	Ziegler & Köhler 2001; JR pers. obs.
rhodopus	brown	yellow	1 black spot	red	reduced	present	Bordoloi *et al.* 2007
spelaeus	greyish brown with dark irregular spots	light grey with dark specks, throat lilac	light grey	grey-brown with dark speckles	reduced	present	Orlov *et al.*, 2010 "2009"
vampyrus **sp. nov.**	pale tan to brick red	white; black margins (single specimen with fine black specks).	black, with or without sparse white spots	grey/black	reduced	present	Present paper

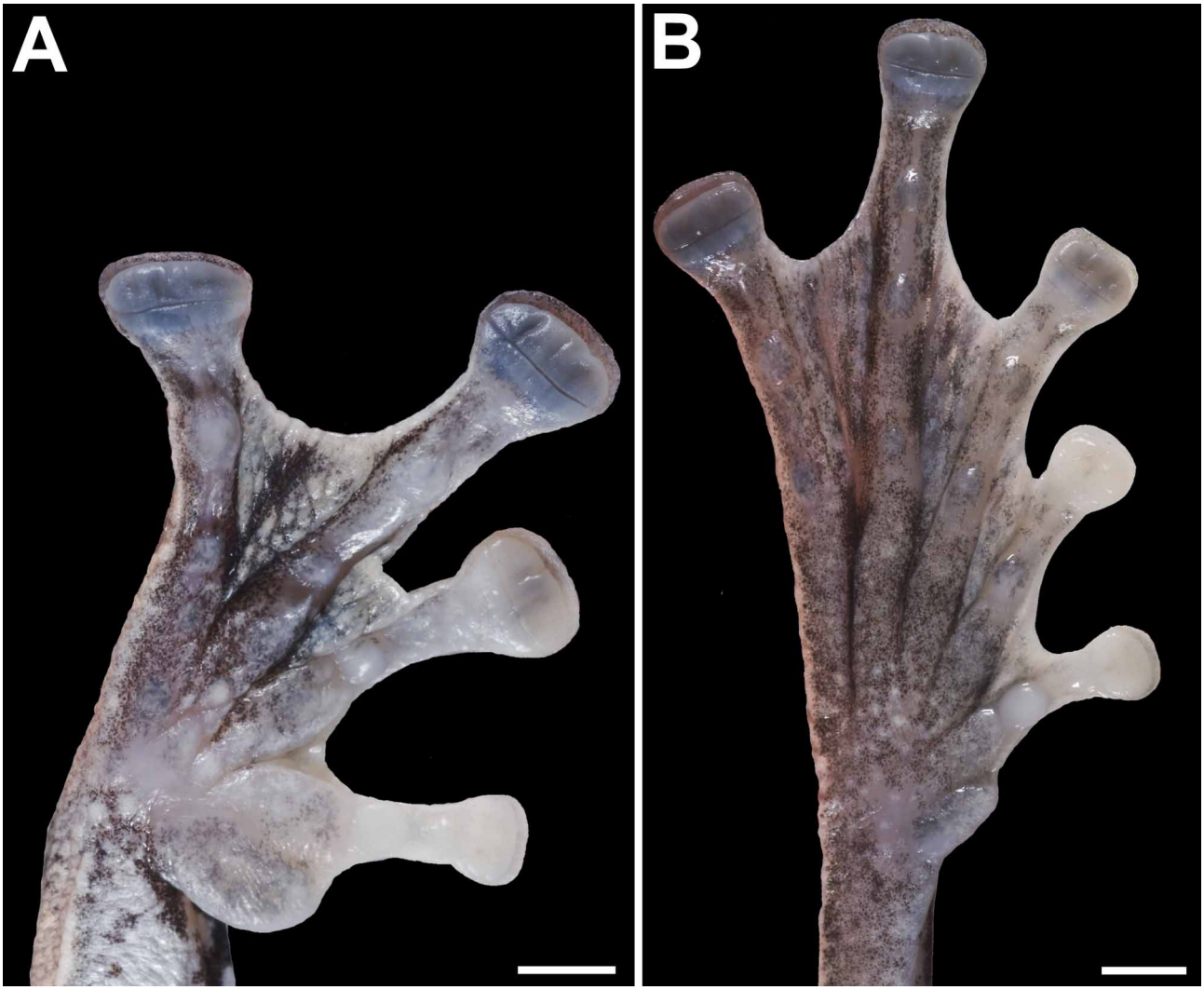

FIGURE 4. Ventral surfaces of (A) right hand and (B) right foot of the male holotype of *Rhacophorus vampyrus* **sp. nov.** (AMS R 173127). Scale bars = 2 mm.

The presence of a distinct pointed projection at the tibiotarsal articulation further distinguishes the new species from all mainland Southeast Asian congeners with the exception of *Rhacophorus bipunctatus, R. calcaneus, R. chuyangsinensis, R. hoanglienensis, R. kio, R. marmoridorsum, R. rhodopus,* and *R. spelaeus* (Table 2). From these species, *R. vampyrus* can be distinguished further on the basis of colouration and extent of hand webbing. *Rhacophorus vampyrus* differs from: *R. bipunctatus* in having a pale tan to brick red dorsum (versus green), white ventral surface with black margins (versus yellow), black flanks (versus 1–3 black spots), and grey/black webbing on dorsal surface (versus red); from *R. calcaneus* in having a pale tan to brick red dorsum (versus olive/pale green), white ventral surface with black margins (versus pale yellow), black flanks (versus yellow with black spots), and grey/black webbing on dorsal surface (versus yellow/olive with dark spots); from *R. chuyangsinensis* in having a pale tan to brick red dorsum (versus dark green or brown with small pale spots), white ventral surface with black margins (versus bright yellow), black flanks (versus bright yellow with black spots), and grey/black webbing on dorsal surface (versus bright yellow); from *R. kio* in having incomplete finger webbing (versus complete), a pale tan to brick red dorsum (versus green), white ventral surface with black margins (versus lemon yellow), black flanks (versus with one black spot), and grey/black webbing on dorsal surface (versus orange and black); from *R. marmoridorsum* in having a pale cream to brick red dorsum (versus flesh coloured with marble chocolate pattern), white ventral surface with black margins (versus light cream), and black flanks (versus irregular spots and lines of chocolate colour on cream background); from *R. rhodopus* in having a white ventral surface with black margins (versus yellow), black flanks (versus 1 black spot), and grey/black webbing on dorsal surface (versus red); and from *R. spelaeus* in having a pale tan to brick red dorsum (versus greyish brown with dark, irregular spots), white

ventral surface with black margins (versus light grey with dark specks), black flanks (versus light grey), and grey/black webbing on dorsal surface (versus grey-brown with dark speckles).

Acknowledgements

The Vietnamese Ministry of Agriculture and Rural Development and staff at Bidoup-Nui Ba National Park kindly facilitated surveys and issued permission to collect (Permit numbers 3023/GT-BNN-KL & 1430/GT-BNN-KL). Eleanor Appleby, Da Du Ha Tien, Vu Hanh Dung, Nguyen Thi Xuan Phuong, Ly Tri, Nguyen Le Xuan Bach, Dinh Binh Phuong, Ta Van Thuc and Nguyen Dinh Hien assisted with fieldwork. The research was supported by funding from the National Geographic Conservation Trust, ADM Capital Foundation, Conservation International, The John D. and Catherine T. MacArthur Foundation, Ocean Park Conservation Foundation Hong Kong, the Alexander-Koenig-Gesellschaft (AKG) and Idea Wild. Wolfgang Böhme kindly loaned specimens in his care. Ross Sadlier, Cecilie Beatson, Glenn Shea, Ronald Altig, Rebecca Johnson, Wolfgang Böhme and Thomas Ziegler provided much valuable assistance and support. For all this assistance we are most grateful.

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APPENDIX. Comparative material examined.

Rhacophorus annamensis: Vietnam, Quang Nam Province, Song Thanh Proposed Nature Reserve (AMS R171793– R171800)
Rhacophorus exechopygus: Vietnam, Quang Nam Province, Song Thanh Proposed Nature Reserve (AMS R171788–171792)
Rhacophorus feae: Vietnam, Kon Tum Province, Ngoc Linh Nature Reserve (AMS R173809)
Rhacophorus orlovi: Vietnam, Nghe An Province, Pu Mat National Park (AMS R171731–171735)