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A New Species of *Rhacophorus* (Anura: Rhacophoridae) from Myanmar (Burma)

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A new species of the genus *Rhacophorus* is described from Myanmar. The new species is most similar to *R. bipunctatus* but differs in the male having a larger body size, a bright green dorsal coloration, yellow in the outer portion of the iris, fainter crossbands on the limbs, a more extensive dermal fringe along the arm, more extensive projection on the heel, more extensive webbing on the hand, and typically two large equal-sized black spots, one in the axillary region and one on the middle of the flank.

Ten species of *Rhacophorus* are thought to occur in Myanmar (*R. appendiculatus* (Günther), *R. bipunctatus* Ahl, *R. bisacculus* Taylor, *R. dennysi* Blanford, *R. feae* Boulenger, *R. maximus* Günther, *R. reinwardtii* (Schlegel), *R. taronensis* Smith, *R. turpes* Smith, and *R. verrucosus* Boulenger). Here, we report on an additional species of *Rhacophorus* collected during expeditions in 2001 and 2002 to Rakhine State in western Myanmar near the Bay of Bengal and to Kachin State in northeastern Myanmar near the Chinese border (Fig. 4).

METHODS AND MATERIALS

Specimens were collected by hand, euthanized, tissue samples removed, then fixed in 10% buffered formalin before preserving in 70% ethanol. Latitude and longitude were recorded with a Garmin 12 GPS, datum WGS84. Specimens are housed in the Department of Herpetology, California Academy of Sciences (CAS) and the Division of Amphibians and Reptiles, National Museum of Natural History, Smithsonian Institution (USNM).

The preserved specimens were examined, measured, and compared with available specimens (see material examined; museum acronyms follow Leviton et al. [1985]) and published descriptions of currently recognized (Frost 2004) species of *Rhacophorus* and *Polypedates* from Myanmar and neighboring countries (Boulenger 1920; Smith 1924; Smith 1940; Bourret 1942; Liu and Hu 1961; Taylor 1962; Inger 1966; Berry 1975; Dring 1983; Inger et al. 1985; Sarkar and Sanyal 1985; Inger and Dutta 1986; Kiew 1987; Daniel and Sekar 1989; Yang et al. 1991; Brown and Alcalá 1994; Manthey and Grossman 1997; Inger and Stuebing 1997; Iskandar 1998; Chan-ard et al. 1999; Fei 1999; Inger et al. 1999; Das 2000; Ohler et al. 2000; Vasudevan and Dutta 2000; Orlov et al. 2001; Ziegler and Köhler 2001; Chanda 2002; Harvey et al. 2002; Malkmus et al. 2002). Measurements were taken using dial calipers to the nearest 0.1 mm as follows: snout-vent length (SVL, from tip of snout to vent); head length (HL, from tip of snout to hind border of angle of jaw);

head width (HW, width of head at its widest point); internarial distance (IND, distance between nares); interorbital distance (IOD, minimum distance between upper eyelids); snout length (SL, from anterior border of eye to tip of snout); distance from nostril to eye (DNE, from nostril to anterior border of eye); forelimb length (FLL, from elbow to tip of third finger); hand length (HAL, from base of outer palmer tubercle to tip of third finger); thigh length (THL, from vent to knee); tibia length (TIL, from knee to foot); foot length (FL, from proximal end of metatarsal tubercle to tip of fourth toe); width of disk of third finger (3FDW, greatest horizontal width); and width of disk of fourth toe (4TDW, greatest horizontal width).

SPECIES DESCRIPTION

Rhacophorus htunwini Wilkinson, Thin Thin, Kyi Soe Lwin, and Awan Khwi Shein, sp. nov.

Figs. 1-3.

Htun Win's treefrog

DIAGNOSIS.—*Rhacophorus htunwini* can be distinguished from all other species of *Rhacophorus* and *Polypedates* by the following combination of characters: intermediate body size in the male (SVL 37.8-50.4 mm); extensive yellow webbing between fingers; thick dermal fringe on forearm and foot, dermal projection (calcar) on heel; squared-off supraclacal fold, snout pointed; bright green dorsal color (slate blue in alcohol); yellow in the outer portion of the iris; very faint crossbands on the limbs; reddish-orange foot webbing; two large black spots on each side of body, one in the axillary region and one at the middle of the flank.

HOLOTYPE.—CAS 229893 (Fig. 1), an adult male, collected from Nagmung Township, Au Yin Ga Camp (27°17'36.9"N, 97°51'45.3"E), Putao District, Kachin State, Myanmar, elevation approximately 878 m, collected on 2 May 2002 by Htun Win, Young Ngai Thi Na, Ram Sar, and Hpe Ram.

DESCRIPTION OF HOLOTYPE.—An adult male with slender habitus and head slightly longer than wide, 36% of SVL; snout pointed in dorsal view, gently slopes in lateral view to nostrils, then becomes slightly spatulate extending beyond mandible (Figs. 1a, c); nostrils closer to eye than tip of snout and anteriorly protuberant; canthus distinct, rounded, and inwardly curved; medial rostral areas between eyes and nostrils and between nostrils and tip of snout slightly concave; lores concave to nostril; eye directed anterolaterally with horizontal pupil. Tympanum distinct and circular; weak supratympanic fold, curving ventrally from dorso-posterior edge of tympanum to posterior edge of axilla.

Vomerine processes with 8/6 rounded teeth respectively and approximately equal to transverse plane, separated medially by a space equal to two times their width, and laterally in contact with anteromedial edge of choanae; choanae small, ovoid to a medial point, and wholly visible at edge of lingual shelves of maxillae when viewed ventrally; tongue deeply bifurcates posteriorly; paired vocal slits oval and lateral to tongue.

Dorsal body surface smooth; ventral abdominal surface and region below thighs areolate; pectoral and gular regions much less areolate. Vent protrudes posteriorly, squared supraclacal fold medially notched.

Arms short and slender; hand 73% as long as foot; when adpressed, relative length of fingers is $3 > 4 > 2 > 1$; tips of fingers rounded; digital pads on hands and feet well developed and oval, with circummarginal grooves; distal phalanges bifurcate (as seen from dorsal aspect of digital tips). Hands extensively webbed, webbing formula for digits is **I2-2III1-1IIII1-1IV** following Myers and Duellman (1982); narrow dermal fringe extends along lateral margin of fourth finger to base of hand. Subarticular tubercles between penultimate and adjoining proximal phalange round and well developed; proximal subarticular tubercles on finger 3 smallest; right hand with one, three, and two

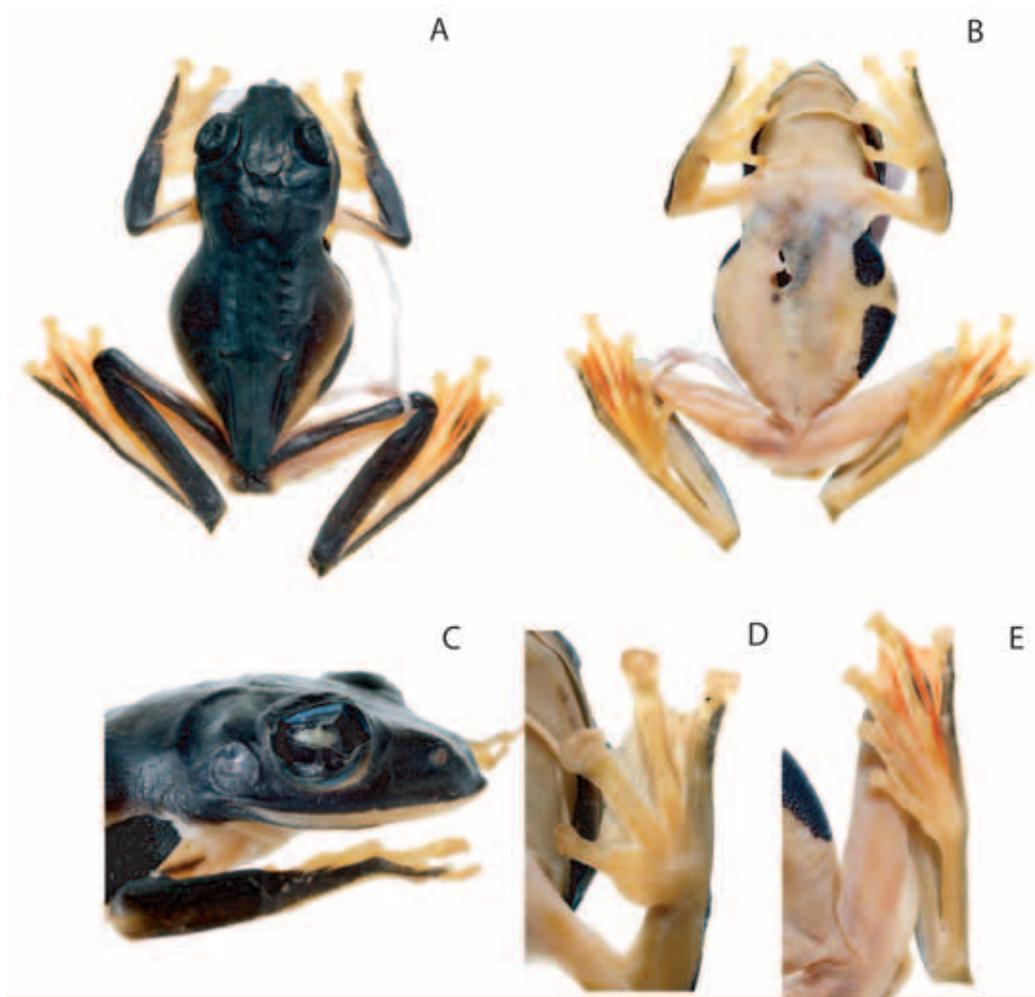


FIGURE 1. (A) Dorsal and (B) ventral views of the body, (C) lateral view of the head, and ventral views of the (D) left hand and (E) left foot of the holotype of *Rhacophorus htunwini* sp. nov. (CAS 229893).

small supernumerary tubercles in a row between proximal tubercle and base of hand on fingers two, three, and four, respectively; left hand with less obvious supernumerary tubercles; thenar tubercle low, extends medially at base of first finger, palmar tubercle absent. Thick dermal flange extends from lateral base of fourth finger to elbow, at widest approximately 18% of width of forearm.

Hind limbs moderately long and slender; when adpressed to body, tibiotarsal articulation reaches beyond anterior edge of eye; webbing on foot reaches to base of pads on all toes; when adpressed, relative length of toes is $4 > 5 = 3 > 2 > 1$; thick dermal fringe from base of pad of toe 5 extends along lateral edge of tarsus to heel where it develops into broad flange with laterally projecting calcar on lateral edge of heel. A single subarticular tubercle on toes 1 and 2, two subarticular tubercles on toes 3, 4, and 5; proximal tubercle on toe 5 approximately same size as distal tubercle; supernumerary tubercles and an outer metatarsal tubercle absent; inner metatarsal tubercle flat, oval, and pointed medially.

Coloration in preservative (Fig. 1). Dorsal color of body slate blue, extending laterally and ventrally $\frac{1}{3}$ of flanks and limbs, from elbow to halfway up middorsal aspect of hindarm, and along dorsal aspect of forearm, lateral fringe, and lateral half of fourth finger to base of pad, and from vent to knee along middorsal aspect of thigh, entire dorsal aspect of tibia, and lateral half of foot, lateral fringe, and fifth toe to just short of base of pad. Lateral margins of tarsal and supracloacal fringes light cream; first to third fingers and webbing, medial side of forearm, and all but middorsal distal half of hindarm cream yellow; similarly, all but middorsal aspect of thigh, lateral and medial sides of tibia, medial half of foot, and first through fourth toes cream yellow. Webbing between toes two through five with streaks of orange, giving an orange appearance, but cream yellow between toes one and two; small, elongated patch of slate blue on lateral side of second phalange of fourth toe and within webbing at same position between fourth and fifth toes; venter and flanks cream yellow. Posterolateral fringe of lower jaw and midventral aspect of fifth toe with some slate blue pigmentation; cream yellow margin on upper lip. Two large black oval spots on sides in axillary and mid-flank; axillary spot smaller, 8.7 mm horizontal diameter, mid-flank spot larger, 10.8 mm horizontal diameter.

Color in life based on a color transparency (Fig. 2a). Dorsum bright green with sparsely scattered black and white pin-sized spots. Dorsal surface of fingers one through three, toes one through four, all digital pads, webbing on hand, lateral margin of fringe from foot to heel, ventrum, and sides yellow to yellowish orange. Two large jet black spots, with clusters of light blue spots on the dorsal margins, on axillary and mid-flank. Faint crossbands present on dorsal aspect of thigh and tibia.

Pupil surrounded by light grayish brown horizontally rectangular iris, with yellow above and below, more so above. Yellow color extends posterior onto interior of orbit. Black thin line surrounds eye at margin with eyelid.

VARIATION.— The holotype, paratypes, and referred specimens of *R. htunwini* are male, sexual dimorphism could not be determined. The paratypes and referred specimens are similar to the holotype except for the following. CAS 222065 and 222136 have smaller calcars than holotype. CAS 222065 is much smaller (SVL 37.8 mm), and specimen CAS 222136 has one large black spot in axillary region, without posterior spot on flank. Supratympanic fold of CAS 221351 strong on both sides of head and covers dorsoposterior edge of tympanum, but does so only on left side of CAS 222065, in all other specimens supratympanic fold similar to holotype. The dorsum of CAS 221351 is lighter in coloration than other specimens in alcohol, although color pattern is same, however darker bluish green in life. CAS 221351 has scattered black pin-size spotting on head, dorsum, and dorsal aspect of thighs. Snout of this specimen rounded instead of pointed as in all other specimens, and tips of pads more squared off than other specimens.

ETYMOLOGY.— The name *htunwini* is given in honor of the late U Htun Win, who devoted the last eight years of his life to the pursuit of knowledge of the diversity and natural history of the reptiles and amphibians within his country. As team leader of the Myanmar Herpetological Survey Team, he first recognized this frog as potentially new to science.

COMPARISONS.— Because *R. htunwini* is a medium size tree frog that possesses expanded discs on the fingers and toes, an intercalary element between the penultimate and terminal phalanges, a narrow bony metasternum, a flange on the distal end of the third metacarpal, Y-shaped terminal phalanges, and extensive webbing between the fingers and toes, it has been placed within *Rhacophorus* (Wilkinson and Drewes 2000). *Rhacophorus* is a relatively large genus of approximately 60 species from Asia (Frost 2004), and members of this genus closely resemble the approximately 28 species of the genus *Polypedates* (Liem 1970). Because of this close resemblance, several species have been moved back and forth between the two genera, or *Polypedates* has not been

recognized as a genus separate from *Rhacophorus* (Dubios 1986; Fei 1999). Recently, Wilkinson et al. (2002) provided molecular evidence to separate the genera *Polypedates* and *Rhacophorus*, and to move two species in *Polypedates* (*P. dennysi* and *P. prasinatus*) back into *Rhacophorus*. We believe that generic level reversals are still required in order to ensure the correct taxonomic placement of many species within these two genera and therefore have included members of both genera in the comparisons below.

Following the taxonomic designations in Frost (2004), *R. htunwini* can be distinguished from other species of the following *Rhacophorus* and *Polypedates* from Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Thailand, and Vietnam as follows: from members of *Polypedates* in the *P. leucomystax* species group (*P. colleti*, *P. cruciger*, *P. eques*, *P. leucomystax*, *P. macrotis*, *P. maculatus*, *P. mutus*, *P. otlophus*, and *P. zed*), *P. insularis*, *P. megacephalus*, *P. naso*, *P. pseudocruciger*, members of *Rhacophorus* in the subgenus *Rhacophorus* in the *R. appendiculatus* species group (*R. appendicu-*

latus, *R. bisacculus*, *R. verrucopus*), *R. baliogaster*, *R. baluensis*, *R. barisani*, *R. bimaculatus*, *R. calcaneus*, *R. catamitus*, *R. cyanopunctatus*, *R. exechopygus*, *R. margaritifera*, *R. modestus*, *R. namdaphaensis*, *R. orlovi*, *R. poecilonotus*, *R. translineatus*, *R. tuberculatus*, and *R. verrucosus* by a bright green dorsal color; from members of *Polypedates* in the *P. chenfui* species group (*P. chenfui*, *P. hungfuensis*, and *P. yaoshanensis*), the *P. dugritei* species group (*P. dugritei*, and *P. omeimontis*), *P. dorsovirens*, *P. duboisi*, *P. nigropunctatus*, *P. pingbianensis*, *P. puerensis*, *P. zhaojuensis*, members of *Rhacophorus* in the subgenus *Rhacophorus* and the *R. dennysii* species group (*R. dennysi* and *R. feae*), the *R. pardalis* species group (*R. annamensis*, *R. notator*, *R. pardalis*, and *R. robinsonii*), *R. achantharrhena*, *R. angulirostris*, *R. taronensis*, and *R. variabilis* by the presence of a sharp dermal calcar at the heel; from members of *Rhacophorus* in the subgenus *Rhacophorus* and

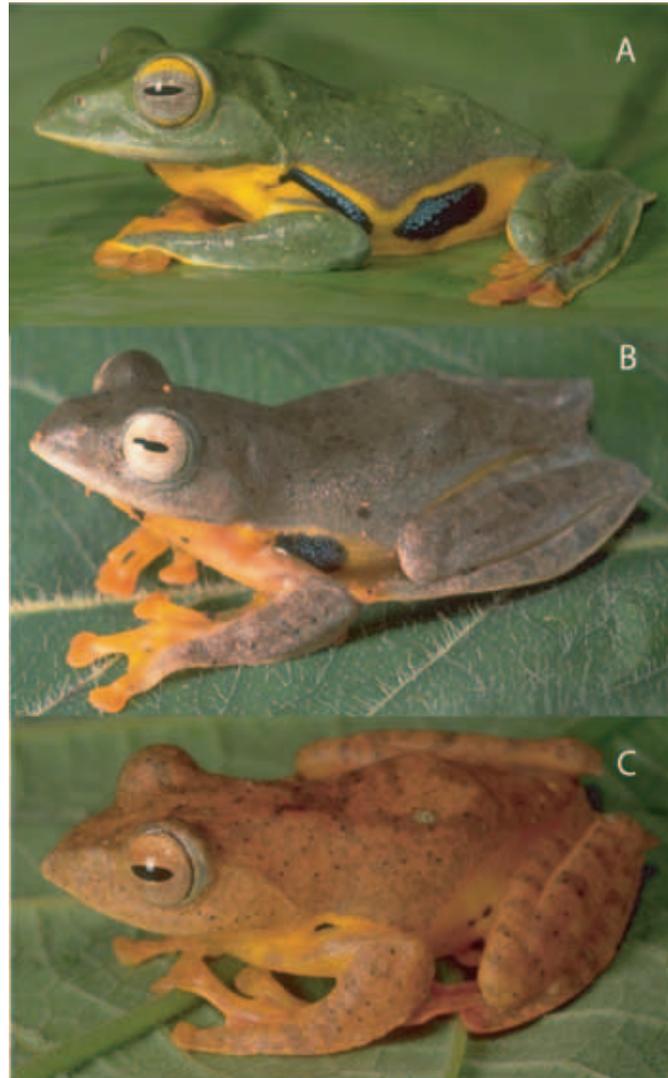


FIGURE 2. Photos in life of (A) a male *Rhacophorus htunwini* sp. nov. (CAS 229893), (B) a female *R. bipunctatus* (CAS 229902), and (C) a male *R. bipunctatus* (CAS 224676).



FIGURE 3. Dorsal view of representative specimens of *Rhacophorus htunwini* sp. nov. (top row), representative specimens of female *R. bipunctatus* (middle row), and representative specimens of male *R. bipunctatus* (bottom row).

the *R. malabaricus* species group (*R. calcadensis* and *R. malabaricus*), *R. lateralis*, *R. pseudomalabaricus*, and *R. turpes* by axillary spots.

Rhacophorus htunwini closely resembles members of the *R. reinwardtii* species group in the subgenus *Rhacophorus* (*R. bipunctatus*, *R. dulitensis*, *R. maximus*, *R. nigropalmatus*, *R. prominanus*, *R. reinwardtii*) and *R. hoangliensis*, but can be distinguished from all but *R. bipunctatus* and *R. reinwardtii* by the presence of axillary spots. It can be distinguished from *R. reinwardtii* (SVL male 68 mm) by its smaller size and yellow hand webbing (black hand webbing in *R. reinwardtii*).

Rhacophorus htunwini most closely resembles *R. bipunctatus*, which also has axillary spots, dermal calcars at the heels, a pointed snout, and sometimes a green dorsal color (Fig. 2b). However, it can be distinguished from *R. bipunctatus* by size (Table 1, Fig. 3); the males of *R. htunwini* are larger (average SVL = 45.7 mm) than the males of *R. bipunctatus* (average SVL = 34.9 mm). *Rhacophorus htunwini* also has a bright green dorsal color in life that becomes slate blue when preserved, whereas some members of *R. bipunctatus* have an olive green dorsal color in life that becomes light bluish gray or brown when preserved and others are orange to tan in life with a darker brown pattern (blotching or an X mark) on the dorsum, which become brown when preserved (Figs. 2–3). The eye of *R. htunwini* contains yellow at the upper and lower portion of the iris, which is absent in *R. bipunctatus* (Fig. 2). *Rhacophorus bipunctatus* has distinct crossbands on the fore and hindlimbs (Figs. 2b–c), whereas *R. htunwini* has faint crossbands that disappear in alcohol (Fig. 2a). *Rhacophorus htunwini* has a more extensive dermal fringe on the forearm, a more extensive dermal calcar at the heel, and more extensive webbing on the hand than the male of *R. bipunctatus*. In all but one specimen, *R. htunwini* has two large black equal size spots on the sides, one in

the axillary region and one on the flank, whereas, the majority of male specimens of *R. bipunctatus* examined had only one spot in the axillary region, and in specimens that had two spots the posterior spot was much smaller than the anterior spot.

DISTRIBUTION AND NATURAL HISTORY.— At present *Rhacophorus htunwini* is known from Nagmung and Machanbaw Townships, Putao District, Kachin State, and from much further south in Rakhine State in the southwestern foothills of Rakhine Yoma, Gwa Township, and Kyauktaw Township, Sittawe District (Fig. 4). This distributional pattern indicates that this species may be restricted to the Indo-Burman Mountain Range that arcs from southwestern Myanmar along the border with India, and the Eastern Himalayas in northern Myanmar. The absence of specimens from the Chin Hills of western Myanmar is probably due solely to a lack of surveys in the region.

The type specimens including the holotype (CAS 229913, USNM 561869) were found approximately 2 m off the ground in bamboo. Referred specimens were found in undisturbed habitat near a spring (CAS 222136) or seasonal (CAS 221351) and permanent (CAS 222065) streams. Other species of *Polypedates* and *Rhacophorus* found in the vicinity of the type locality were *P. leucomystax*, *R. bipunctatus*, and *R. dennysi*.



FIGURE 4. Distribution of *Rhacophorus htunwini* sp. nov. in Myanmar with type locality indicated by a star (at tip of arrow).

MATERIAL EXAMINED

Rhacophorus htunwini (paratypes): CAS 229913, USNM 561869 adult males collected at the same locality and date as the holotype.

Rhacophorus htunwini (referred specimens): CAS 221351, an adult male, collected between Ahtan Ga and Au Rin Ga (27°15'27.2"N, 97°50'32.4"E), Ma Chan Baw Township, Putao District, Kachin State, Myanmar, collected on 4 September 2001 by Htun Win and Ran Shaung; CAS 222136, an adult male, collected from Yea Pu Camp (17°56'02.6"N, 94°38'02.9"E), Gwa Township, Rakhine State, Myanmar, collected on 8 June 2001 by Hla Tun, Kyi Soe Lwin, and Awan Khwi Shein; CAS 222065, an adult male, collected from Pin Lone Camp, Pe Chaung, near Saba Sate Village (21°00'54.9"N, 92°52'06.6"E), Kyaut Taw Township, Sittawe District, Rakhine State, Myanmar, collected on 4 July 2001 by Htun Win, Kyi Soe Lwin, and Awan Khwi Shein.

Polypedates chenfui: FMNH 232963, 232964 (China).

Polypedates colletti: FMNH 234773, 235631 (Malaysia).

Polypedates cruciger: CAS 85280 (Sri Lanka).

Polypedates dugritei: CAS 64273 (China).

Polypedates eques: CAS 85281, 85282 (Sri Lanka).

Polypedates leucomystax: FMNH 239159 (Malaysia); FMNH 254649 (Lao PDR); CAS-SU 15163 (India); CAS 14943 (China); CAS 94573 (Bangladesh); CAS 103624 (Indonesia); CAS 105003 (Vietnam); CAS 105972 (Malaysia); CAS 111336 (Cambodia); CAS 172691 (Thailand); CAS 221962, 224461 (Myanmar).

Polypedates macrotis: FMNH 239107, 239119 (Malaysia); CAS 60630, 60631, 60684, 60804, 62138 (Philippines); CAS 62581 (Malaysia); CAS 64074 (Philippines); CAS 64077 (Indonesia); CAS 64089–64092 (Philippines); CAS 105974, 105975 (Malaysia).

Polypedates maculates: CAS 16922–16924 (Sri Lanka); CAS 94571, 94572, 104152, 125365–125370 (India).

- Polypedates megacephalus*: ROM (field numbers) 18038, 18045 (Vietnam).
Polypedates otitophus: FMNH 230836, 239147 (Malaysia).
Rhacophorus angulirostris: FMNH 235035 (Malaysia).
Rhacophorus annamensis: FMNH 253933, 253940 (Vietnam); ROM 29889, 29890, 29891, 29892, 29897, 29901, 29904 (Vietnam).
Rhacophorus appendiculatus: CAS 60169–60174, 62261, 64078–64086 (Philippines).
Rhacophorus bimaculatus: CAS 61840, 133178–133180, 133251 (Philippines).
Rhacophorus bipunctatus: FMNH 253122, 253124 (Vietnam); NMNS 3220 (China); CAS 224676, 228808, 229887, 229889, 229890, 229898, 229899, 229901–229907, 229910 (Myanmar).
Rhacophorus calcaneus: FMNH 256456, 257933 (Lao PDR); ROM 29849, 29850, 29854, 29855, 29875, 29877, 29879, 29880 (Vietnam).
Rhacophorus dennysi: FMNH 256449, 256450 (Lao PDR); ROM 29839, 29840, 29841, 29842, 29843, 29846, 30245 (Vietnam); CAS 64224 (China); CAS 221535, 224496, 224659 (Myanmar).
Rhacophorus dulitensis: FMNH 235741 (Malaysia).
Rhacophorus feae: FMNH 257910 (Lao PDR); CAS-SU 6387, 6388 (Vietnam).
Rhacophorus gauni: FMNH 235044, 239238 (Malaysia).
Rhacophorus maximus: CAS 221516, 221517 (Myanmar).
Rhacophorus microtypanum: CAS 85283 (Sri Lanka).
Rhacophorus nigropalmatus: FMNH 230901, 230902 (Malaysia).
Rhacophorus pardalis: FMNH 235750 (Malaysia); FMNH 259530 (Philippines); CAS 60472–60476, 61386, 128725, 129267–126270 (Philippines).
Rhacophorus reinwardtii: FMNH 235034 (Malaysia), FMNH 255305 (Lao PDR); NMNS 3213 (China).
Rhacophorus rufipes: FMNH 231377 (Malaysia).
Rhacophorus taronensis: BMNH 1947.2.8.17 (Myanmar).
Rhacophorus turpes: BMNH 1947.2.8.69, 1947.2.8.70 (Myanmar).
Rhacophorus verrucosus: CAS 224441, 224442, 224469, 224737, 224754, (Myanmar).

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Appendix

TABLE 1. Measurements of the type series and referred specimens of *Rhacophorus htunwini* and comparative material of *R. bipunctatus*. Mean (in mm) followed by range (in parenthesis) and ratio of SVL (below). See text for abbreviations.

	<i>Rhacophorus htunwini</i>	<i>Rhacophorus bipunctatus</i>	<i>Rhacophorus bipunctatus</i>
	Male	Female	Male
	N = 6	N = 3	N = 16
SVL	45.7 (37.8-50.4)	55.9 (51.2-60.2)	34.9 (32.0-37.7)
HL	16.4 (13.5-17.7)	18.3 (17.2-19.8)	12.5 (11.5-14.0)
	35.9	32.7	35.9
HW	16.5 (14.9-17.5)	17.9 (16.9-19.3)	12.6 (11.4-14.1)
	36	32.1	36
IND	4.4 (4.3-4.9)	4.5 (4.4-4.7)	3.4 (2.7-4.2)
	9.6	8.1	9.8
IOD	5.2 (4.8-5.9)	6.6 (5.4-7.5)	3.8 (2.9-4.5)
	11.4	11.8	10.9
SN	7.3 (6.1-8.1)	8.0 (7.7-8.4)	5.4 (4.6-6.0)
	16	14.2	15.6
DNE	3.7 (3.1-4.2)	3.6 (3.2-4.0)	2.6 (2.1-2.9)
	8	6.4	7.4
FLL	22.0 (18.6-25.1)	27.9 (26.8-29.2)	17.9 (16.1-19.7)
	48.1	49.8	51.2
HL	13.8 (11.2-15.5)	17.6 (16.5-19.0)	11.2 (10.0-12.5)
	30.3	31.4	32
THL	22.5 (17.6-26.1)	27.0 (26.7-27.4)	17.6 (14.3-19.7)
	49.3	48.2	50.5
TIL	23.0 (19.4-25.1)	26.2 (25.0-27.9)	17.5 (15.6-18.7)
	50.3	46.9	50.3
FL	20.0 (16.2-22.3)	25.9 (24.8-27.9)	15.6 (13.9-16.9)
	43.7	46.3	44.7
3FDW	2.5 (2.2-2.7)	3.2 (3.1-3.4)	1.9 (1.5-2.4)
	5.4	5.8	5.4
4TDW	1.9 (1.6-2.2)	2.4 (2.0-2.7)	1.5 (1.2-1.9)
	4.2	4.3	4.2