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A new treefrog (Anura: Rhacophoridae: *Rhacophorus*) from Gunung Mulu, Borneo

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Abstract. A new treefrog of the genus *Rhacophorus* is described from a small montane stream on the southern slope of Gunung Mulu in eastern Sarawak, Malaysian Borneo. The new species is distinguishable from its Southeast Asian congeners by the combination of the following characters: small size; snout sharply pointed, forming a low swollen rostral tubercle at its anteriormost tip; supratympanic fold thick and conspicuous; tympanum diameter one-third of that of eye; canthus rostralis sharp; interorbital distance greater than upper eyelid width and internarial distance; vomerine teeth in two oblique series; dermal appendages on trunk and limbs absent; hands and feet not fully webbed; dorsum uniformly yellowish-green in life; iris ruby-coloured in life with a light grey margin; advertisement call consisting of three or four notes, with energy maximum at 4050-4380 Hz.

Key words. Amphibia, Anura, Rhacophoridae, *Rhacophorus penanorum* sp. n., taxonomy, natural history, advertisement call, Gunung Mulu National Park, Sarawak, Malaysia, Borneo.

Introduction

Gunung Mulu National Park (3°56'-4°16'N, 114°47'-115°00'E) is located in eastern Sarawak on Borneo, the largest of the Greater Sunda Islands. It is named after Gunung (= "Mount") Mulu, the second highest peak in Sarawak (2376 m elevation), and encompasses an area of 544 km² (Hazebroek & Kashim bin Abang Morshidi 2006). Situated within the borders of the national park are the type localities of fourteen frog species, eight of which have not been recorded elsewhere (Dring 1983a, 1983b, 1987, Kiew 1984, Dubois 1987, Inger et al. 1995). Nevertheless the herpetofauna of the park has hardly been explored. Most of the field work conducted so far took place during the joint expedition of the Sarawak Government and the Royal Geographic Society between 1977 and 1978, in the course of which 71 species of anurans were recorded (Dring 1978, Dring & Kiew 1982). In total 76 species of amphibians (Dring & Kiew 1982, Inger & Stuebing 1992, Sanchez-Herraiz et al. 1995, Malkmus 2002) and 91 species of reptiles (Das et al. 2008) have been reported from Gunung Mulu National Park so far.

During field work in the park I collected specimens of a species of *Rhacophorus* Kuhl & van Hasselt, 1822 that does not match any of the described species of the genus from Borneo and from any other part of Southeast Asia. I therefore describe it herein as new to science. The treefrog genus *Rhacophorus* is distributed from India to Japan and southwards to the Indo-Malayan archipelago and the Philippines and currently contains 76 species (Frost 2007, Bordoloi et al. 2007, Dehling & Grafe 2008). Sixteen species have been reported from Borneo (Inger & Tan 1996, Das & Haas 2005, Dehling & Grafe 2008).

Materials and methods

Type specimens were collected on 4 January 2008 between 1945 and 2000 h, kept alive for two days, euthanised using a chlorobutanol solution, fixed and preserved in 70% ethanol, and measured four weeks after collection. The following measurements were taken with a digital caliper (to the nearest 0.1 mm): snout-vent length (SVL, from tip of snout to vent); tibia-fibula length (TFL, measured

with both knee and tibio-tarsal articulation flexed); head width (HW, distance between angles of jaw); head length (HL, distance from angle of jaw to tip of snout); horizontal eye diameter (ED); horizontal tympanum diameter (TD); upper eyelid width (EW); interorbital distance (IO, shortest distance between upper eyelids); eye to nostril distance (EN, distance between anterior margin of eye and nostril); nostril to snout distance (NS, distance between nostril and tip of snout); internarial distance (NN, distance between nostrils); hand length (HND, distance from base of thenar tubercle to tip of third finger); foot length (FOT, distance from base of inner metatarsal tubercle to tip of fourth toe). The webbing formulae are given as proposed by Myers & Duellman (1982). Notes on the colouration in life were taken from digital photographs taken in the habitat and during two days after collection.

For comparisons I examined museum specimens of several species of *Rhacophorus* (see Appendix). Museum abbreviations are as follows: Field Museum of Natural History, Chicago, Illinois, USA (FMNH), Museum und Forschungsinstitut Senckenberg, Frankfurt am Main, Germany (SMF), Sabah Parks Zoological Museum, Kinabalu Park Headquarters, Ranau District, Sabah, Malaysia (SP), Zoological Museum of the Department of Biology, Universiti Brunei Darussalam, Bandar Seri Begawan, Brunei Darussalam (UBD), Zoologisches Museum der Humboldt-Universität zu Berlin, Berlin, Germany (ZMB). Additional information about characters used to compare Southeast Asian species of *Rhacophorus* were taken from: Boulenger (1882), Ahl (1927), Smith (1930), Wolf (1936), Inger (1954), Taylor (1962), Inger (1966), Brown & Alcala (1994), Manthey & Grossmann (1997), Manthey & Steiof (1998), Inger et al. (1999), Ohler et al. (2000), Ziegler & Köhler (2001), Orlov et al. (2001), Chanda (2002), Ziegler (2002), Harvey et al. (2002), Malkmus et al. (2002), Wilkinson & Rao (2004), Matsui (2005), Inger & Iskandar (2005), Inger & Stuebing (2005), Wilkinson et al. (2005), Das & Haas (2005), Matsui & Panha (2006), Ohler & Delorme (2006), and Bordoloi et al. (2007).

Advertisement calls from the type specimens were recorded in the habitat using a Sony WM-D6C stereo cassette recorder and a Sony ECM-S959C microphone. Call recordings were digitised at 16 bits and 44 kHz and analysed using Syrinx 2.6h sound analysis program (John Burt, www.syrinxpc.com) and Adobe Audition 1.5 software.

Systematics

Rhacophorus penanorum sp. n.

(Figs. 1-7)

Holotype: ZMB 70718, adult male, from a small stream, 45 minutes by foot below camp four on the southern flank of Gunung Mulu, approx. 1650 m elev., Gunung Mulu National Park, Miri Division, Sarawak, Malaysia, collected by J. M. Dehling, 4 January 2008.

Paratopotypes: ZMB 70719, 70720, two adult males, collected with the holotype.

Diagnosis: A species of the genus *Rhacophorus*, distinguishable from its congeners by the combination of the following characters:

Fig. 1. Holotype of *Rhacophorus penanorum* sp. n. (ZMB 70718) in life. Photograph taken in the habitat.

(1) small size (SVL of adult males 33.6-34.2 mm); (2) snout sharply pointed, projecting beyond mandible, sloping forward from nostrils then backward to mouth, forming a low swollen rostral tubercle at its anteriormost tip; (3) head wider than long and wider than body; (4) supratympanic fold thick and conspicuous; (5) tympanum diameter one-third of that of eye; (6) canthus rostralis sharp; (7) interorbital distance greater than upper eyelid width and internarial distance; (8) vomerine teeth in two oblique series; (9) dermal appendages on trunk and limbs absent; (10) hands and feet not fully webbed; (11) dorsum uniformly yellowish-green in life; (12) iris ruby-coloured in life with a light grey margin; (13) advertisement call consisting of three or four notes, with energy maximum at 4090-4380 Hz.

Description of the holotype: Body moderately slender with a narrow waist; head short (HL/SVL 0.31), slightly wider than trunk and wider than long (HW/HL 1.23); snout project-

Fig. 2. Ventral view of a paratype of *Rhacophorus penanorum* sp. n. (ZMB 70719) in life.

Fig. 3. Lateral view of the head of a paratype of *Rhacophorus penanorum* sp. n. (ZMB 70719). Note the brownish-green daytime-colouration of the dorsum.

Fig. 4. Type series of *Rhacophorus penanorum* sp. n. (top to bottom: ZMB 70719, 70718, 70720), showing the variation in daytime-colouration.

Fig. 5. Paratype of *Rhacophorus penanorum* sp. n. (ZMB 70720) in life. Note the greyish-green daytime-colouration.

ing beyond mandible, pointed in dorsal view, sloping forward from nostrils then back toward mouth in profile, forming a low swollen rostral tubercle at its anteriormost tip (cf. Fig. 3); canthus rostralis distinct, sharp, curved in profile, slightly concave in dorsal view; loreal region sloping, almost vertical; nostril about as close to eye as to tip of snout (EN/NS 0.99); internarial distance greater than eye to nostril distance (NN/EN 1.43); eyes directed anterolaterally, protruding, large (ED/HL 0.45); pupil horizontal; eye diameter greater than eye-to-nostril distance (ED/EN 1.63); interorbital distance wider than upper eyelid (IO/EW 1.30) and greater than internarial distance (IO/NN 1.08); tympanum visible, separated from eye by distance subequal to its horizontal diameter; tympanum diameter about one-third of eye diameter (TD/ED 0.32); tympanic annulus visible; skin not co-ossified to forehead; maxillary teeth present; choanae located far laterally, at margins of roof of the mouth; dentigerous processes of vomers low, located near anterior edges of choanae, directed posteromedially, bearing small teeth, separated from each other by distance equal to four-thirds their length; tongue broad, bifurcated at base and free for about two-thirds of its length; median lingual process absent; median subgular vocal sac present.

Dorsal surfaces, ventral side of limbs, chin, throat, and chest region smooth; abdomen coarsely granular; supratympanic fold thick and conspicuous, extending from posterior edge of upper eyelid to scapula region, overlapping tympanum for about one-fifth on upper edge; supracloacal region unornamented, without ridge, flap or fold; several small tubercles in infraanal region and on ventral side of thigh; small, indistinct white tubercles along postaxial edge of forearm.

Arms moderately slender; tips of fingers enlarged into broad oval disks, each with circummarginal groove; disk of third finger wider than tympanum diameter; relative length of fingers: I < II < IV < III; subarticular tubercles rounded, well developed, numbering one on Fingers I and II, two on Fingers III and IV; webbing formula of the hand **I**2.75-2.75**II**1.75-3**III**2-2^{-}**IV** (Fig. 6); thenar tubercle oval, almost as large as base of Finger I (length 2.4 mm); inner and outer palmar tubercles oval, low and indistinct, fused at their bases; narrow dermal ridge on postaxial edge of Finger IV between base of disk and outer palmar tubercle; metacarpals with several supernumerary small tubercles; nuptial pads or asperities absent.

Legs slender, moderately long (TFL/SVL 0.53); heels slightly overlap each other when legs are folded right angle to body; tibio-tarsal articulation reaching tip of snout; heel without dermal appendages; tarsus with several very small, indistinct white tubercles; relative length of toes: I < II < III < V < IV; disks of toes smaller than those of fingers; subarticular tubercles numbering one on Toes I and II, two on Toes III and V, and three on Toe IV; pedal webbing formula **I**1.5-2**II**1^{+}-2.5**III**1.5-2.5**IV**2-1^{+}**V** (Fig. 7); inner metatarsal tubercle oval, low and small (length 1.3 mm), no outer one; few supernumerary small tubercles on metatarsals; dermal ridge on postaxial edge of Toe V from disk to base of metatarsus.

Measurements (in mm; holotype, followed by paratypes [ZMB 70719, 70720, respectively]): SVL 33.6 (34.0, 34.2), TFL 17.7 (17.6, 17.1), HW 12.6 (12.5, 12.5), HL 10.2 (10.2, 10.3), ED 4.6 (4.9, 5.0), TD 1.5 (1.6, 1.7), EW 3.3 (3.3, 3.4), IO 4.3 (4.4, 4.5), EN 2.8 (2.9, 2.8), NS 2.8 (2.9, 3.0), NN 4.0 (4.0, 4.0), HND 10.8 (11.4, 10.9), FOT 14.1 (14.6, 14.1).

Colouration in life: Dorsum uniformly yellowish-green (Fig. 1). Sides of head below canthus rostralis and supratympanic fold, including annulus of tympanum, slightly lighter green. Dorsal colouration fading to white on flanks. Chin, throat, and chest completely white. Venter white, sparsely speckled with faint, reddish spots. Large black and dark brown spots present on flanks. Groin region, ventral sides of arm, thigh, tibia, hand and foot, preaxial side of tarsus and dorsal side of Fingers I and II and Toes I-III largely unpigmented, appearing greyish violet (cf. Fig.

2). Webbing between fingers translucent light brown with some greenish-white mottling. Webbing between toes darker with a conspicuous narrow green stripe between Toes IV and V. Iris ruby-coloured with a light grey margin.

Colouration in preservative: Dorsum colouration faded to greyish brown. Darker, narrow crosslines faintly visible on dorsal surfaces of thigh and tibia. Ventral side of arm, thigh, and tibia changed to white. Small light brown blotches present on margin of lower jaw, chest, lateral sides of arm, and ventral surface of thigh. Colour of iris faded to bluish-grey.

Variation: The paratypes are very similar to the holotype in measurements and proportions. They likewise have median subgular vocal sacs and lack nuptial pads and asperities. There is little variation in the extent of webbing. In one paratype (ZMB 70720), the webbing on the preaxial side of Finger IV reaches only to the middle of the distal subarticular tubercle (2**IV**), in the other one (ZMB 70719), the webbing on the preaxial sides of Toes III and IV reaches to just below the distal subarticular tubercles (2.25**III**1.5-2.25**IV**).
Colouration in life was also similar to that of the holotype. During the night, both specimens were yellowish-green dorsally like the holotype. However, one paratype turned brownish-green during the day, the other one greyish-green, whereas the holotype maintained its night colouration albeit somewhat paler (Fig. 4). In the greyish-green paratype even the iris turned completely grey during the day (Fig. 5). In preservative, the paratypes resemble the holotype in colouration.

Advertisement call: In total, twelve advertisement calls from the three type specimens were recorded prior to collection. The frogs called at irregular intervals between 30 secs and 1 min. The call is a very short trill. Measurements of the recorded calls are given in Tab. 1. Air temperature was 16.1 °C. There was no significant frequency modulation within the notes of a single call and there were no differences in energy maximum between three note and four note calls. Dominant frequency spectrum of the notes lay between 3900 and 4600 Hz (Fig. 8). The intervals between the amplitude maxima of the notes ranged between 34 and 43 ms (Fig. 9).

Apart from *R. gadingensis*, the call of which is unknown, all Bornean species of *Rhacophorus* can be distinguished from *R. penanorum* by their calls (Malkmus et al. 2002, own data).

Distribution and ecological notes: The new species is known only from the type locality, a small permanent headstream of Sungai Tapin on the southern flank of Gunung Mulu (approx. 1650 m elev.), 45 minutes by foot below camp four. The streambed consists of rock in steep, fast-flowing sections and gravel

Tab. 1. Characteristics of the advertisement call of *Rhacophorus penanorum* sp. n. Measurements are given as mean ± standard deviation.

	70718 Holotype	70719 Paratype	70720 Paratype
number of three note calls recorded	2	5	–
number of four note calls recorded	1	3	1
duration of three note call [ms] (range)	98 ± 1 (97-99)	105 ± 3 (101-110)	–
duration of four note call [ms] (range)	142	140 ± 10 (129-148)	131
energy maximum of notes [Hz] (range)	4140 ± 82 (4050-4260)	4190 ± 88 (4090-4380)	4220 (4180-4270)

Fig. 6. Ventral view of the right hand of the holotype of *Rhacophorus penanorum* sp. n. (ZMB 70718).

Fig. 7. Ventral view of the left foot of the holotype of *Rhacophorus penanorum* sp. n. (ZMB 70718).

in sections where the current is slower and the stream forms small, shallow pools. The site is also described in Dring (1983a, 1983b). All specimens were found calling from leaves overhanging the stream at heights between 1.5 and 2 m. The following species were found sympatric with the new species: *Ansonia hanitschi* Inger, 1960, *A. torrentis* Dring, 1983, *Leptobrachella brevicrus* Dring, 1983, *Xenophrys dringi* (Inger, Stuebing & Tan, 1995), *Limnonectes kuhlii* (Tschudi, 1838) - complex, *Meristogenys kinabaluensis* (Inger, 1966), *Staurois natator* (Günther, 1858), and *Philautus mjobergi* Smith, 1925. Dring (1983b) reported *Leptolalax* sp. (= *L. dringi* Dubois, 1987) from the site.

Etymology: The species epithet is a patronym honouring the Penan people who live in the Gunung Mulu area. The type locality of the new species is situated on one of their traditional hunting trails.

Comparisons: In the following Southeast Asian congeners the webbing reaches the disk on the postaxial side of the third finger (f), on preaxial and postaxial sides of the fourth toe (t) or both (f & t), thus readily distinguishing these species from *Rhacophorus penanorum*: *Rhacophorus annamensis* Smith, 1924 (f & t); *R. dennysi* Blanford, 1881 (t); *R. dulitensis* Boulenger, 1892 (t); *R. exechopygus* Inger, Orlov & Darevsky, 1999 (f & t); *R. fasciatus* Boulenger, 1895 (f & t); *R. feae* Boulenger, 1893 (f & t); *R. georgii* Roux, 1904 (f & t); *R. harrissoni* Inger & Haile, 1959 (f & t); *R. htunwini* Wilkinson, Thin, Lwin & Shein, 2005 (f & t); *R. jarujini* Matsui & Panha, 2006 (t); *R. kio* Ohler & Delorme, 2006 (f & t); *R. maximus* Günther, 1858 (f & t); *R.*

nigropalmatus Boulenger, 1895 (f & t); *R. pardalis* Günther, 1858 (f & t); *R. poecilonotus* Boulenger, 1920 (t); *R. prominanus* Smith, 1924 (t); *R. reinwardtii* (Schlegel, 1840) (f & t); *R. rhodopus* Liu & Hu, 1960 (f & t); *R. robinsonii* Boulenger, 1903 (f & t); *R. rufipes* Inger, 1966 (f & t). Webbing between the fingers is confined to the bases in *R. dugritei* (David, 1872), *R. everetti* Boulenger, 1894, *R. hungfuensis* Liu & Hu, 1961, and *R. kajau* Dring, 1983. The following Southeast Asian species of *Rhacophorus* differ from the new species in having dermal flaps or fringes along the postaxial edge of the forearm (F), the tarsus (T), or both (F & T): *Rhacophorus achantharrhena* Harvey, Pemberton & Smith, 2002 (F & T); *R. appendiculatus* (Günther, 1858) (F & T); *R. baluensis* Inger, 1954 (F & T); *R. barisani* Harvey, Pemberton & Smith, 2002 (F & T); *R. bipunctatus* Ahl, 1927 (F & T); *R. calcaneus* Smith, 1924 (T); *R. edentulus* Müller, 1894 (F & T); *R. hoanglienensis* Orlov, Lathrop, Murphy & Ho, 2001 (F); *R. margaritifer* (Schlegel, 1837) (F & T); *R. monticola* Boulenger, 1896 (F & T); *R. taronensis* Smith, 1940 (F & T); *R. turpes* Smith, 1940 (F & T). The remaining Southeast Asian *Rhacophorus* species differ in the following characters from the new species (characters given in parentheses). *Rhacophorus belalongensis* Dehling & Grafe, 2008, *R. bimaculatus* (Peters, 1867), *R. gadingensis* Das & Haas, 2005, and *R. gauni* (Inger, 1966) are somewhat smaller species and have brown or grey dorsal colouration (green), dorsal markings consisting of a brown interorbital band and crossbars on thigh, tibia, tarsus and forearm (markings absent), a more or less rounded, obtuse snout (pointed) and a large pointed tubercle at the tibio-tarsal articulation (absent). *Rhacophorus dorsoviridis* Bourret, 1937 has shorter legs with TFL/SVL 0.40-0.42 (0.50-0.53) and the tibio-tarsal articulation extending only to the posterior margin of the eye (extending to tip of snout), a larger tympanum with TD/ED 0.52 (0.32-0.34), and a rounded snout (pointed). *Rhacophorus duboisi* Ohler, Marquis,

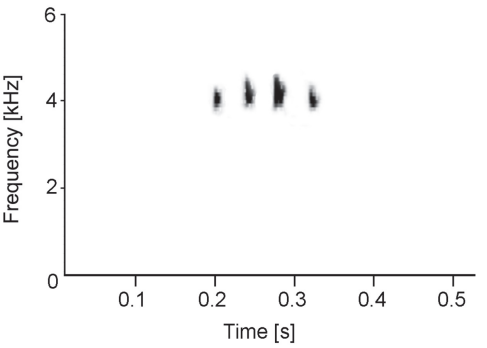

Fig. 8. Sound spectrogram of a four-note call of a paratype of *Rhacophorus penanorum* sp. n. (ZMB 70720) given at 16.1°C.

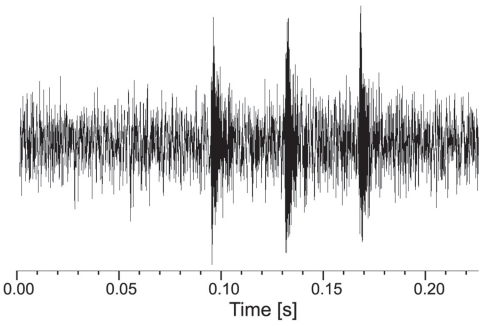

Fig. 9. Oscillogram of a three note call of the holotype of *Rhacophorus penanorum* sp. n. (ZMB 70718) given at 16.1°C.

Swan & Grosjean, 2000 is considerably larger, SVL of the male holotype being 61.5 mm (SVL of males 33.6-34.2 mm), has a tympanum diameter that is two-thirds of that of eye (one-third of eye diameter), and a golden iris (red with a grey margin). *Rhacophorus modestus* Boulenger, 1920, is brown dorsally (green), has a tympanum diameter wider than half the eye diameter (one-third of eye diameter) and the fingers only one-third webbed (webbing between fingers III and IV to distal subarticular tubercles). *Rhacophorus omeimontis* Stejneger, 1924 is larger, SVL of males up to 67.2 mm (up to 34.2 mm), has a rounded snout (pointed), and a large tympanum that is 70% of eye diameter (32-34%). *Rhacophorus cyanopunctatus* Manthey &

Steiof, 1998 and *R. orlovi* Ziegler & Köhler, 2001 are greyish to reddish brown dorsally in life, with darker blotches on the dorsum and crossbars on the limbs (dorsum uniformly yellowish-green without markings), have blue blotches on the flanks and lateral surfaces of the thighs (flanks white with brown or black blotches, thighs unblotched), and have more extensively webbed toes, formulae being **I**1-1.5**II**1-(1.5-2)**III**1-2**IV**1.5-1**V** and **I**1-1.5**II**1-1.5**III**1-2^{-}**IV**1.5-1**V**, respectively (versus **I**1.5-2**II**1^{+}-[2.25-2.5]**III**1.5-[2.25-2.5]**IV**2-1^{+}**V**). In addition, *R. orlovi* has more extensively webbed outer fingers, formula being **II**1^{+}-2**III**1.5-1.5**IV** (versus **II**1.75-3**III**2-2$^{(-)}$**IV**), and *R. cyanopunctatus* lacks vomerine processes and teeth (present).

In males of *Rhacophorus catamitus* Harvey, Pemberton & Smith, 2002, the dorsum is brown with irregular darker brown blotches on the back and darker bands on the limbs (dorsum uniformly yellowish-green), the groin and ventral surfaces of the thighs, hands, and feet are orange and the iris is dirty yellow with a tinge of green in life (groin and ventral surfaces unpigmented, iris red with a grey margin), webbing is less extensive with hand webbing formula being **II**(2^{+}-2.5)-3.5**III**2.75-(2^{+}-2.75)**IV** (versus **II**1.75-3**III**2-2$^{(-)}$**IV**), and pedal webbing formula being **I**1.75-(2^{+}-2.5)**II**(1.25-1.75)-(2.75-3)**III**(1.5-1.75)-(2.5-3.25)**IV**(2.25-2.75)-(1.25-1.75)**V** (versus **I**1.5-2**II**1^{+}-[2.25-2.5]**III**1.5-[2.25-2.5]**IV**2-1^{+}**V**), and a subtriangular tubercle is present at the tibio-tarsal articulation (absent).

Rhacophorus penanorum is similar to *R. angulirostris* Ahl, 1927, a species that has been collected at Gunung Kinabalu, Gunung Trusmadi, and the Crocker Range in Sabah/Borneo and at Padang on Sumatra (Inger 1966, Inger & Tan 1990, Inger et al. 2000, specimens listed in appendix). Both species differ strongly in colouration (colouration in life of *R. angulirostris* is described in Malkmus 1992, 1993, 1995, Hoffmann 1995, Inger et al. 1996, Malkmus et al. 2002, Inger & Stuebing 2005): Males of *R. angulirostris* possess a tan to sandy brown dorsum, usually with several large, darker brown blotches (green without blotches), and a dark brown interorbital band (absent). Forearm, thigh, tibia and tarsus are dark-banded (without pattern), flanks, lateral surfaces of thigh, tibia and tarsus are yellow with dark blotches (white, dark-blotched flanks, lateral surfaces of legs unpigmented), and the iris is red in the lower two-thirds and blue in its upper third (red with a light grey margin). In most specimens, one or several white infraocular spots are present (absent). Furthermore, the snout is pointed, but does not form a low swollen rostral tubercle at its anteriormost tip (forms a tubercle), and the eyelid diameter almost equals the interorbital width with IO/EW 1.03-1.12, mean 1.08 ± 0.04, n = 5 (IO/EW 1.30-1.33). Vomerine teeth are present, but the dentigerous processes of the vomers are shorter and separated from each other by a distance equal to about twice their length (longer, separated by four-thirds their length). The advertisement call is similar in frequency (maximum at 4050-4570 Hz), but typically consists of only two notes (Malkmus et al. 2002, own unpublished data). The average call duration is 192 ± 14 ms (n = 16 calls from 3 individuals, air temperature 18.4 °C; versus 103 ± 5/139 ± 8 ms for three note/four note calls, air temperature 16.1 °C); an exceptional call consisting of three notes had a duration of 253 ms (unpublished data).

Remarks: The classification of Asian rhacophorids is still unstable, and species are transferred from one genus to another frequently (e.g. Wilkinson et al. 2002, Delorme et al. 2005, Frost et al. 2006). The genus *Rhacophorus* might be paraphyletic with respect to *Polypedates* Tschudi, 1838 or even polyphyletic, and is in need of a comprehensive taxonomic revision (Wilkinson et al. 2002, Frost et al. 2006). The new species is allocated to *Rhacophorus* because it shows the following characters considered diagnostic for the genus (Brown & Alcala 1994, Manthey & Grossmann 1997, Wilkinson & Drewes 2000; see also Harvey et al. 2002):

fingers webbed, skin of head free from skull, and outer two metacarpals separated by a skin membrane. Disregarding these characters, the new species might be confused with a Bornean member of the genus *Philautus* Gistel, 1848, *P. erythrophthalmus* Stuebing & Wong, 2000. This species was described from 1550 m elev. at Mt. Muruk Mio in Sabah and resembles *R. penanorum* in having a light green dorsum, a "deep reddish orange" iris, dark reticulate markings on the flanks, a tympanum diameter that is one-third of the eye diameter, and in the absence of dermal appendages on the limbs (Stuebing & Wong 2000). Based on its small size, the absence of vomerine teeth, the absence of the *musculus cutaneus pectoris*, and the *m. geniohyoideus pars medials* being free, the species was assigned to the *vermiculatus* group of the genus *Philautus* by Stuebing & Wong (2000). Taking into consideration that the most recent diagnosis of *Philautus* characterises the genus only by "aerial direct development of eggs into froglets, without going through an aquatic tadpole stage" (Bossuyt & Dubois 2001) and that the reproductive mode of *P. erythrophthalmus*, which is known only from a single female, is unknown, the question is whether this species could possibly be conspecific with *R. penanorum*, irrespective of the generic affiliation. However, it differs from the new species (characters in parentheses) in the following characters: small size, the only specimen known, a mature female, having a SVL of only 26.2 mm (larger, SVL of adult males being 33.6-34.2 mm), snout blunt, abruptly truncate in profile (snout sharply pointed, projecting beyond mandible), nostrils situated near the end of the snout, above the symphysis (situated half-way between eye and tip of snout), vomerine teeth absent (present), Fingers **III** and **IV** webbed only at the base (webbed to distal subarticular tubercles), toes only half-webbed, formula being **I**2^{+}-2^{+}**II**2^{+}-3^{+}**III**2-3**IV**3-2**V** (versus **I**1.5-2**II**1^{+}-[2.25-2.5]**III**1.5-[2.25-2.5]**IV**2-1^{+}**V**), Toe III longer than Toe V (Toe V longer than Toe III), upper arm, anterior and posterior surfaces of thigh and groin golden yellow in life (dorsal side of upper arm green, ventral side of upper arm, lateral surfaces of thighs and groin unpigmented in life), undersides of thigh yellowish (unpigmented).

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Appendix
Comparative material examined

Rhacophorus angulirostris: Malaysia: Sabah: Gunung Trusmadi (SP 2859, 2869, 2884, 2896, 2904, 2913), Sungai Silau-Silau, Headquarters, Kinabalu National Park (ZMB 49022, 70073).

Rhacophorus appendiculatus: Malaysia: Sabah: Taman Bukit Tawau, Tawau District (SP 1098-1101, 2355, 26064); Linumunsut Lake, Maliau, (SP 2817); Lower Segama, Lahad Datu District (SP 20370-20372, 20374, 20375). Philippines: Culion, Calamian Group (SMF 6984); Northeast Mindanao (SMF 6985, 6986); no locality (ZMB 5464, 70071).

Rhacophorus baluensis: Malaysia: Sabah: Headquarters, Taman Kinabalu, Ranau District (SP 24, 1291); Restaurant Bayu, near Kinabalu Park, Ranau District (SP 2802).

Rhacophorus belalongensis: Brunei Darussalam: Kuala Belalong Field Studies Centre, Temburong District (ZMB 70377 [holotype], 70378, 70379 [paratypes]; UBD GK 06-22, 06-23, 06-24, 06-25, 06-26, 06-57, G07-1, 07-2, 07-3, 07-4, 07-5, 07-6, 07-7, 07-8, 07-9 [paratypes]).

Rhacophorus cf. bipunctatus: Myanmar: "Birma" (ZMB 11575, 70072). "Travancore" (ZMB 10131).

Rhacophorus bimaculatus: Philippines: Agusan River, Mindanao (ZMB 5681 [syntype]); Dapitan, Mindanao (SMF 7053).

Rhacophorus cyanopunctatus: Brunei Darussalam: Kuala Belalong Field Studies Centre, Temburong District (UBD GK06-13). Malaysia: Sarawak: Gunung Mulu National Park, Miri Division (ZMB 70707-70709). Thailand: Khao Sok National Park, Surat Thani (ZMB 57895 [holotype]).

Rhacophorus dulitensis: Brunei Darussalam: Batu Apoi, Temburong District (UBD 550). Malaysia: Sabah: Marak Parak, Kota Merudu District (SP 634-636, 842-844); Hutan Simpan, Mandamui, Pitas Kudat (SP 1165-1168, 20377); Taman Bukit-bukit Tawau, Tawau District (SP 637, 1264).

Rhacophorus edentulus: Indonesia: Northern Sulawesi (ZMB 34323).

Rhacophorus everetti: Malaysia: Sabah: Marai Parai (SP 362, 1123); Sayap, Kota Belud District (SP 1202, 1203, 1773, 1865, 2185); Headquarters, Kinabalu Park, Ranau District (SP 2700, 2701, 20020, 20322, 20325, 20327, 20362, 21412, 21451, 21452); Trusmadi (SP 2891, 2901).

Rhacophorus fasciatus: Malaysia: Sarawak: Gunung Mulu National Park, Miri Division (ZMB 70710).

Rhacophorus gadingensis: Malaysia: Sarawak: Gunung Gading National Park, Lundu Division (ID[Indraneil Das, field number]-7831, -7832 [holotype and paratype, respectively]; comparison based on detailed photographs provided by I. Das).

Rhacophorus gauni: Malaysia: Sarawak: Mengiong River, Nanga Tekalit, Third Division (FMNH 137981, 137983, 137985, 139343, 139344, 139346 [paratypes], FMNH 145542, 145545, 146269, 195359, 195445-195449); Nanga Tekalit, Seventh Division (FMNH 221743, 221744, 221746-221748); Gunung Mulu National Park, Miri Division (ZMB 70711-70717). Sabah: Sungai Kilampun, Purulon Camp, Crocker Range National Park (FMNH 239235; SP 2172, 2176); Mendolong Camp, Sipitang District (FMNH 235045, 239236, 239240, 242922, 242923, 242941, 242926; SP 2178, 2179); Poring Station, Mt. Kinabalu Park, Ranau District (FMNH 248308;

SP 1257, 1805); Tawau Hills Park, Tawau District (FMNH 248924, 248925, 249833-249836; SP 645, 646, 1072); Marak Parak, Kota Marudu District (FMNH 235747); Rangkam Kimanis, Pantod Besar, Tambunan District (FMNH 239233); Danum Valley Field Centre, Lahad Datu District (FMNH 231062, 231069, 231071, 231073, 231075, 234990, 234994, 241081, 241083, 241085, 241086, 241090, 245890, 245892, 245894, 245904, 245905, 245909, 245910, 245913, 245915, 245920); Sungai Agathis, Maliau Basin (SP 20244).

Rhacophorus georgii: Indonesia: Tanke Solokko, Mekongga Mountains, Southeast Sulawesi (ZMB 34322).

Rhacophorus harrissoni: Brunei Darussalam: Batu Apoi, Temburong District (UBD 214). Malaysia: Sabah: Lower Segama, Lahad Datu District (SP 20392-20394); Maliau Basin (SP 20279-20281).

Rhacophorus monticola: Indonesia: Southern Sulawesi (SMF 6829).

Rhacophorus nigropalmatus: Brunei Darussalam: Batu Apoi, Temburong District (UBD 366). Malaysia: Sabah: Sungai Stuebing, Trusmadi, Tambunan District (SP 223); Tawau Hills Park, Tawau District (SP 1286); "primary forest" (SP 20696).

Rhacophorus pardalis: Brunei Darussalam: Kuala Belalong Field Studies Centre, Temburong District (UBD GK06-07); without locality (UBD 17). Malaysia: Sabah: Taman Bukit Tawau, Tawau District (SP 2723, 26060); Danum Valley Field Centre, Lahad Datu District (SP 2082); Pulau Tiga National Park (SP 640-642, 644, 2778-2781); Kg. Tipasu, Napong 1, Ranau District (SP 2033); Mongkopo, Ranau District (SP 21986); Sungai Kokoguan, Marak Parak, Kota Marudu District (SP 353, 2083); Mendulong, Sipitang District (SP 1917-1919, 2084); Maliau Basin (SP 20255-20257); Sungai Rompon, Trusmadi (SP 671); Pulau Jembongan (SP 2190); Lower Segama, Lahad Datu District (SP 20378, 20381, 20382, 20384, 20389); Hutan Simpan, Mendamai, Pitas Kudat (SP 1169-1180); no locality (SP 1688, 1694, 1696); PDC Lembak Inbak, Telupid (SP 2660-2661); Malangkap Tomis, Kinabalu Park, Kota Belud District (SP 20768-20771); Sg. Kimanis, Kg. Kindosodon, Tambunan District (SP 21634). Philippines: Palawan (SMF 6994); Claveria, Northern Luzon (SMF 6995).

Rhacophorus reinwardtii: Borneo (SMF 76372 [two specimens]).

Rhacophorus rufipes: Brunei Darussalam: Kuala Belalong Field Studies Centre, Temburong District (UBD GK06-08).

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