

A NEW TREEFROG OF THE GENUS *RHACOPHORUS* (ANURA: RHACOPHORIDAE) FROM HAINAN ISLAND, CHINA

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ABSTRACT. – Faunal studies of Hainan, China, have recently been conducted to better understand the biodiversity of pristine montane rainforest on the island. A new green treefrog species, *Rhacophorus yinggelingsis*, is described. This new medium-sized species possesses the combination of characteristics: (1) snout rounded, without protruding process; (2) green dorsum with few fine white spots, dorsolateral folds absent; (3) skin on dorsum smooth, flanks and venter granulate; (4) metatarsal skinfolds faint; (5) fingers and toes webbed; (6) front of thigh yellow and red-tinged, rear of thigh and inner side of tibia red; (7) white-tipped tuberculous dermal ridges on cloaca present, not well developed; (8) iris silvery, partly light golden in upper half. Among the green *Rhacophorus* frogs from China, Taiwan, Vietnam and Laos, *R. yinggelingsis* can be distinguished from *R. omeimontis*, *R. pingbianensis*, *R. gongshanensis*, *R. duboisi*, *R. dugritei*, *R. puerensis* and *R. zhaojuensis* by lack of black or brown spots or patches on dorsum. The new species seems closely related to *R. arvalis*, *R. aurantiventris*, *R. chenfui*, *R. dorsovirens*, *R. hungfuensis*, *R. moltrechti*, *R. nigropunctatus*, *R. prasinatus*, *R. taipeianus*, and *R. yaoshanensis* on the basis of adult morphology. This species is currently known only from high-altitude (at or above 1,300 m) primary rainforest in the Yinggeling mountain range of Hainan Island.

KEY WORDS. – Amphibia, *Rhacophorus yinggelingsis*, new species, Hainan, China.

INTRODUCTION

Rhacophoridae is one of the most diverse anuran families in the Old World (Liem, 1970; Frost, 1985; Duellman & Trueb, 1986). In eastern Asia, there are six rhacophorid genera containing over 50 species documented in China, Taiwan, Korea, and Japan (Lue & Chen, 1986; Maeda & Matsui, 1990; Zhao & Adler, 1993; Fei, 1999; Lee et al., 2000; Fei et al., 2005). Zoogeographically, China is divided into seven major regions, of which the South China Region harbours a particularly rich rhacophorid fauna (Zhao & Adler, 1993). The island of Hainan, located almost wholly south of latitude 20°N, is the southernmost part of China and consequently, its herpetofauna belongs to a tropical subregion of South China. Studies of Hainan amphibians date back to Swinhoe (1870) who recorded three species. Pope's (1931) more comprehensive work reported 25 species from Hainan. Shi & Meng (2001), in a review of Hainan terrestrial vertebrates, listed 39 amphibians, including one salamander, one pelobatid (now megophryiid), three bufonid, one hylid, 18 ranid, nine rhacophorid, and six microhylid species. In recent years, faunal survey efforts in Hainan have greatly intensified (e.g., Kadoorie Farm & Botanic Garden, 2001a, 2001b, 2002a,

2002b, 2002c, 2003a, 2003b; Ng & Chan, 2004; Wang et al., 2004, 2005; Yang & Zhao, 2005), and additional study of the herpetofaunal diversity has revealed the presence of a new treefrog of the genus *Philautus* (see Liu et al., 2004). The rhacophorid fauna of Hainan, in general, agrees with Pope's (1931) observation that the lowland fauna has great affinities with the adjacent mainland, and that the mountain fauna is generally more distinctive. In contrast to the large number of endemic rhacophorid species of Taiwan (Liang & Wang, 1978; Mou et al., 1983; Kuramoto & Wang, 1987; Lue et al., 1990, 1994, 1995), a subtropical island located ca. 170 km off southeastern China, Hainan has relatively low endemism. Among the 10 species of Hainan treefrogs (Shi & Meng, 2001; Liu et al., 2004), *Buergeria oxycephala* and *Philautus hainanus* are endemic whilst *Chirixalus doriae*, *C. vittatus*, *P. ocellatus* (see Kadoorie Farm & Botanic Garden, 2004), *P. odontotarsus*, *Rhacophorus dennysi*, *R. megacephalus*, *R. mutus*, and *R. rhodopus*, mostly occurring in lowlands or hills, occur from the Fujian-Guangdong Coast and South Yunnan Mountains subregions to Southeast Asia. The large treefrog, *R. dennysi*, is the only green rhacophorid treefrog previously known from Hainan. Recently, a biodiversity survey in Mt. Yingge (known as Yinggeling; Fig. 1), jointly organized by

the Hainan Wildlife Conservation Centre of Hainan Provincial Forestry Department and Kadoorie Farm and Botanic Garden, resulted in the discovery of a green *Rhacophorus* frog. Comparison of this medium-sized green treefrog with others of southern China, Taiwan, Vietnam, and Laos indicated that it was previously undescribed. We therefore describe a new species herein.

At 1,811 m above sea level, Yinggeling is the second-highest peak in Hainan after Wuzhishan (1,867 m above sea level). Although much of the lower slopes up to 800 m above sea level in the area had been transformed to farmland or secondary forest, continuous cover of relatively pristine hillside rainforest could be found above 800 m. The satellite imagery suggests the continuous old-growth forest tract of Yinggeling covers over 300 km². Presently, the vegetation in the lowland (< 500 m above sea level) is dominated by farmland (most notably rubber *Hevea brasiliensis* plantation and shifting cultivation plots), tall shrubland, and young secondary forest about 6–15 m tall dominated by *Castanopsis* spp., *Macaranga denticulata*, *Cratoxylum cochinchinense* and *Schefflera heptaphylla*. At mid-elevation, between 500 and 1,000 m, the natural vegetation is mainly mature secondary forest dominated largely by pioneering species such as *Liquidambar formosana*, *Engelhardtia roxburghiana*, *Lithocarpus* spp., *Gironniera subaequalis* and *Xanthophyllum hainanense*, with trees varying from 10 m to 30 m in height and up to 180 cm dbh. At a similar altitude, primary forest dominated by *Castanopsis* spp., *Manglietia hainanensis*, *Elaeocarpus sphaericus*, *Phoebe hungmoensis*, *Nephelium topengii* and *Xanthophyllum hainanense* could be found in more inaccessible hillsides where trees grow up to 40 m in height. Between 1,000 and 1,600 m, the mountain is dominated by pristine montane rainforest dominated by

Dacrydium pectinatum, *Syzygium* spp., *Lithocarpus* spp., *Michelia mediocris* and *Phoebe hungmoensis*. The canopy of such forest averaged 20 to 30 m in height, with trees up to 180 cm dbh. Above 1,600 m up to the summit of Yinggeling, the primary mossy dwarf forest is dominated by *Rhododendron simiarum*, *Cyclobalanopsis* spp., *Castanopsis* spp., *Lithocarpus* spp. and *Cleyera obscurinervia*. Because of the harsh microclimate, this forest type has a lower canopy around 10 m tall, with branching tree trunks, although some individuals of *Pinus kwangtungensis* may reach 20 m. From the summit of Yinggeling, the forest extends west to Jiayi Nature Reserve in Ledong County and northwest to Bawangling National Nature Reserve in Changjiang County. Yinggeling Nature Reserve, established in 2004, is approximately 40 km long and 12 km wide, and has an area of ca. 500 km². Yinggeling mountain range is the major watershed of the two largest catchments in Hainan – the Nandu Jiang (*jiang* = river) and Changhua Jiang, and is an important refuge for endemic species. Its relative inaccessibility has formed a protective sheet covering the primary forest in this area. The discovery of the new frog implies a more complete understanding of the biodiversity in this area is necessary.

MATERIAL AND METHODS

Specimens were preserved in 75% ethanol. The following measurements were taken following Matsui (1984) with minor modifications: SVL (snout-vent length), HL (head length), HW (head width – maximum width of the head), EL (eye length; distance between front and rear canthi of left eye), TD (greatest tympanum diameter), ICD (intercanthal distance: distance between front canthi), IND (internarial distance: distance between inner edges of nostrils), IOD (interorbital distance: shortest distance between orbits), EW (eyelid width), ETD (shortest eye-tympanum distance); HLAL (hand and lower arm length), TFL (3rd finger length), TTL (thenar tubercle length), OPTL (outer palmar tubercle length); ThL (thigh length), TiL (tibia length), FL (foot length), TaL (tarsus length), FTL (4th toe length), and IMTL (inner metatarsal tubercle length). Measurements were taken with digital calipers and rounded to the nearest 0.1 mm. Drawings of the hand and foot of the new species were made using a Wild M3Z stereomicroscope and associated drawing tube. Appendix I lists comparative material of *Rhacophorus* species examined. Museum acronyms: BIZ for the Beijing Institute of Zoology, Chinese Academy of Sciences, Beijing, China; CIB for the Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu, China; KFBG for the Kadoorie Farm and Botanic Garden, Hong Kong SAR, China; and NMNS for the National Museum of Natural Science, Taichung, Taiwan.

Rhacophorus yinggelingensis, new species (Figs. 2–4)

Material examined. – Holotype: NMNS 4091, an adult male, SVL 43.4 mm; CHINA: Hainan Island: Yinggeling: Mahuoling:

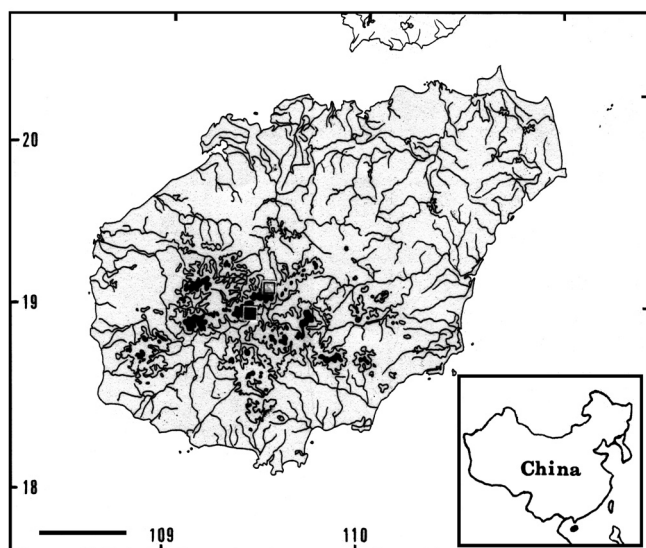


Fig. 1. Map of Hainan Island, China, showing the collection localities of *Rhacophorus yinggelingensis*, new species. **Solid square** (holotype locality): Yinggeling: Mahuoling; 1,300 m elevation; 18°57'23.4"N, 109°23'02.1"E. **Hollow square** (paratype locality): Yinggeling: Yinggezui; 1,550 m elevation; 19°03'55.6"N, 109°32'41.6"E. Black zone > 1,000 m above sea level. Scale bar = 50 km.

18°57'23.4"N 109°23'02.1"E, at an elevation of 1,300 m (Fig. 1). Coll. at 2000 hours on 21 Mar.2003 by Bosco Chan.

Paratype: KFBG 0004, an adult male, SVL 43.0 mm; CHINA: Hainan Island, Yinggeling, Yinggezui, 19°03'55.6"N 109°32'41.6"E, at an elevation of 1,550 m (Fig. 1). Coll. at 1230 hours on 31 May.2005 by Bosco Chan.

Diagnosis. – *Rhacophorus yinggelingensis* (Fig. 2) is a medium-sized treefrog possessing the following combination of characteristics: (1) snout rounded, without protruding process; (2) green dorsum with few fine white spots, dorsolateral folds absent; (3) skin on dorsum smooth, flanks and venter granulate; (4) metatarsal skinfolds faint; (5) fingers and toes webbed; (6) front of thigh yellow and red-tinged, rear of thigh and inner side of tibia red; (7) white-tipped tuberculous dermal ridge on cloaca present, not well developed; (8) iris silvery, partly light golden in upper half.

Description of holotype. – Body slender, snout-vent length (SVL) 43.4 mm (Fig. 3). Head medium, wider than long (head width 17.2 mm; head length 15.5 mm), concave above. Snout rounded in lateral profile, not protruding, its length (SL 7.8 mm) longer than horizontal diameter of eye (5.8 mm). Canthus rostralis rounded, loreal region concave. Interorbital space slightly convex, interorbital distance (5.2 mm) larger than upper eyelid width (3.6 mm), equal to internarial distance (5.2 mm). Intercanthal distance (9.1 mm) 0.65 times in distance between posterior ends of eyes (13.9 mm). Nostrils

oval, flap of skin not obvious, closer to eye (N-EL 2.9 mm) than to tip of snout (SNL 3.9 mm). Tympanum distinct, rounded, horizontal diameter (4.5 mm) 0.78 of eye diameter (5.8 mm); tympanum-eye distance (0.3 mm) 0.07 of tympanum diameter. Vomerine ridge present, bearing small teeth, between choanae, with an angle of ca. 30° relative to body axis, closer to choanae than to each other, length about the distance between them. Tongue somewhat elongate, width ca. half of length, not laterally emarginated, posteriorly 1/8 notched. Supratympanic fold distinct, from posterior canthus to above base of upper arm.

Arm short, moderately strong, forearm (8.8 mm) shorter than hand (13.3 mm), not distinctly enlarged. Relative length of fingers I < II < IV < III. Finger I (length 3.8 mm) thinnest; finger II length 4.6 mm; finger III length 7.1 mm (Fig. 4). Tip of fingers enlarged; discs present with distinct circum-marginal grooves. Fingers with thin dermal fringes; webbing present; web only a rudiment between I and II, beyond subarticular tubercle on postaxial side of II, to proximal subarticular tubercle for preaxial side of finger III, between proximal and distal subarticular tubercle for postaxial side of finger III, reaching disc as fringe of both sides of finger III, to level of distal subarticular tubercles on IV, reaching discs as a fringe on postaxial side of II, III, and preaxial side of IV, lateral fringes on preaxial side of I and postaxial side of IV to terminal phalanges. Subarticular tubercles prominent oval. Prepollex elongate, prominent; palmar tubercles not prominent.



Fig. 2. *Rhacophorus yinggelingensis*, new species, in life. Adult male (paratype) from Yinggezui, Yinggeling, Hainan Island, China. Tympanum diameter = 4.5 mm. Photograph by Lee Kwok Shing, KFBG.

Hind limbs long. Tibia (length 18.4 mm) almost as long as thigh (length 18.2 mm), longer than foot (length 17.8 mm). Toes long, toe IV (10.8 mm) longer than tarsus (9.6 mm)(Fig. 4). Relative length of toes: I < II < III < V < IV. Tips of toes enlarged; discs present on all toes with distinct circum-marginal grooves. Webbing present; web full to base of toe discs, except preaxial side of II, III and both sides of IV; webbing on preaxial side of II full to proximal edge of subarticular tubercle, continuing to disc as a fringe; web on preaxial side of III full to between proximal and distal subarticular tubercles, reaches close to disc as a fringe; web on IV full to level between proximal and distal subarticular

tubercles, reaching disc as a fringe; lateral fringes on preaxial side of I and postaxial side of V to disc. Subarticular tubercles prominent, rounded, simple; single tubercle: I(1)-II(1)-III(2)-IV(3)-V(2) (formula = digital numbers with tubercle counts in parentheses). Inner metatarsal tubercle distinct, elongate, length (2.7 mm) 0.7 times in length of toe I (3.5 mm). Tarsal fold or ridge weak. Outer metatarsal tubercle, supernumerary tubercles, and tarsal tubercle absent.

Skin on dorsum of body smooth; dorsolateral folds absent; belly grossly granulate. Dorsal surface of limbs smooth; ventral surface of forelimbs smooth, grossly granulate beneath

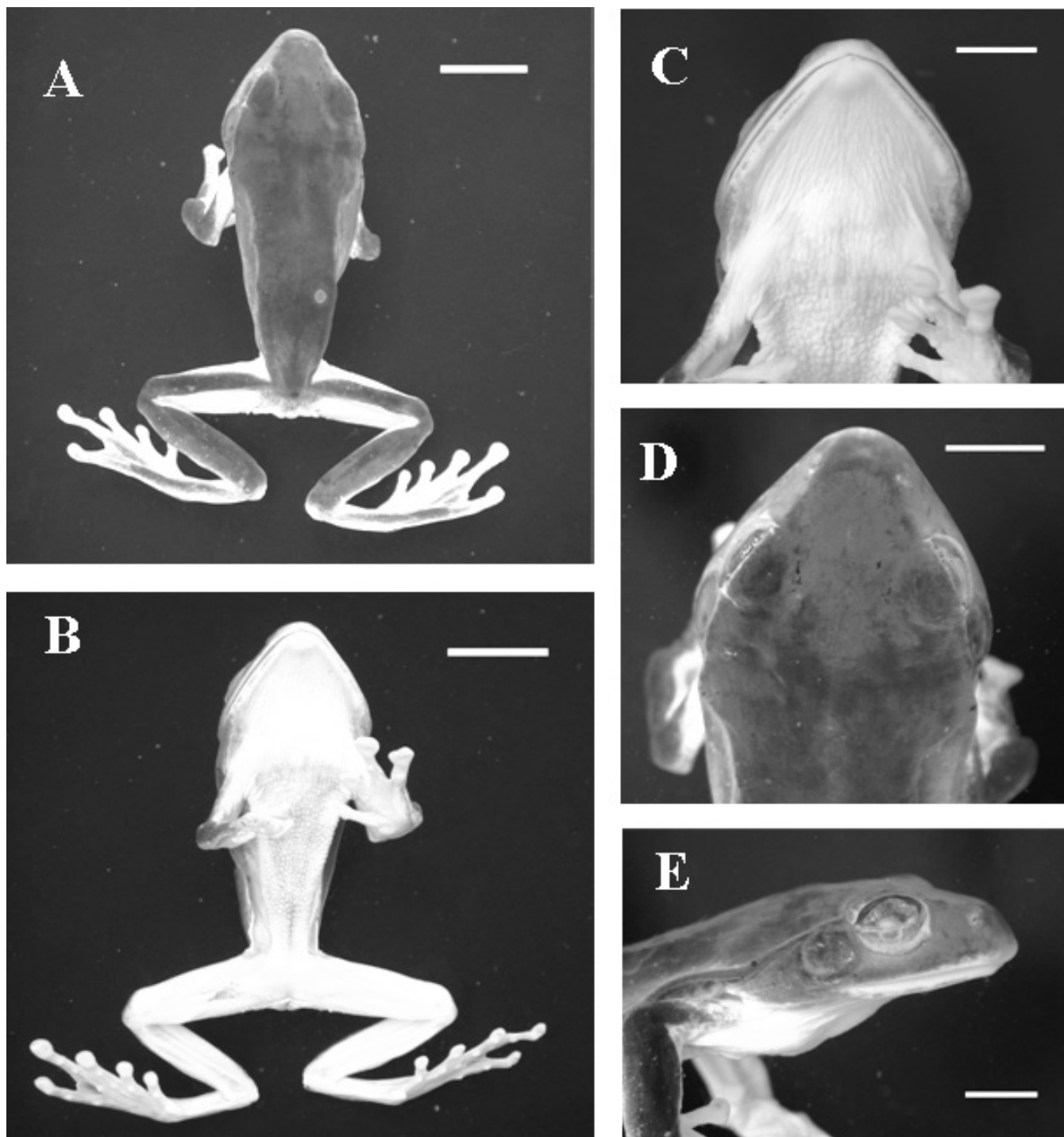


Fig. 3. *Rhacophorus yinggelingensis*, new species, NMNS 4091 (holotype): A, dorsal view; B, ventral view (Scale bar = 10 mm); C, ventral view; D, dorsal view; E, lateral view. Scale bars: A, B = 10 mm; C–E = 5 mm.

cloaca and posterior surface of thighs, smooth in the rest of hind limbs. Faint dermal fringe or fold running along outer edges of fourth finger, forearm, elbow, fifth toe, tarsus and ankle. White-tipped supraclacal ridge not well developed.

Colour in life of holotype. – Dorsal surfaces of head, body and limbs green with a small number of very fine white spots. Throat, chest, and ventral surfaces of body and limbs yellow. Flanks white, lacking clear white lines that divide dorsal and ventral portions. Axillary and inguinal regions yellow with some poorly defined black spots. White lines present on outer edges of fourth finger, forearm, and elbow. Front of thigh yellow and red-tinged; rear of thigh and inner side of tibia red. White lines on inner and outer sides of tibia forming clear border lines between the green dorsal surface and reddish or yellow underside. White lines present on outer edges of fifth toe, tarsus and ankle. Supraclacal region green, dermal ridge white. Fingers I, II, III and webbing yellow; discs of III and IV reddish yellow; finger IV light green dorsally. Toes I, II, III, and inner half of toe IV red; all toe discs yellow or reddish yellow; toe webbing red; a green, thickened dermal stripe present on web between toes IV and V. Iris silvery, light golden in upper half.

Colour in preservative of holotype. – Ground colour of dorsum becomes greyish-blue with white spots. Tympanum reddish brown. White lines along faint dermal fringe or fold

at outer edges of fourth finger, forearm, elbow, fifth toe, tarsus and ankle prominent. No clear flank white lines observed. Ventral region, webbing, concealed and non-green portions of limbs creamy white. Iris greyish-blue.

Measurements of holotype (mm). – SVL 43.4, HL 15.5, HW 17.2, EL 5.8, TD 4.5, ICD 9.1, IND 5.2, IOD 5.2, EW 3.6, ETD 0.3, HLAL 20.6, TFL 7.1, TTL 2.7, OPTL 1.6; ThL 18.2, TiL 18.4, FL 17.8, TaL 9.6, FTL 10.8, and IMTL 2.6.

Variation. – The throat and chest in the paratype is creamy in colour rather than yellow. Measurements of paratype (mm): SVL 43.0, HL 15.2, HW 17.1, EL 5.7, TD 4.5, ICD 9.0, IND 5.5, IOD 5.5, EW 3.4, ETD 0.4, HLAL 21.1, TFL 7.3, TTL 2.8, OPTL 1.5; ThL 18.5, TiL 18.5, FL 18.3, TaL 9.6, FTL 11.0, and IMTL 2.7.

Etymology. – The specific name is to mark the discovery of this distinctive treefrog from the Yinggeling mountain range of Hainan Island, emphasizing the importance of protecting primary forests in biodiversity conservation. The word “Yinggeling” means “mountain of parrots” in Chinese.

Eggs, Tadpoles, and Call. – Eggs and tadpoles unknown. At the site where the paratype was collected, a frog called at about 2045 hrs. on 1 June.2005. The call was a long series of repeated deep “Auuu” notes, each note lasted about 0.8 second

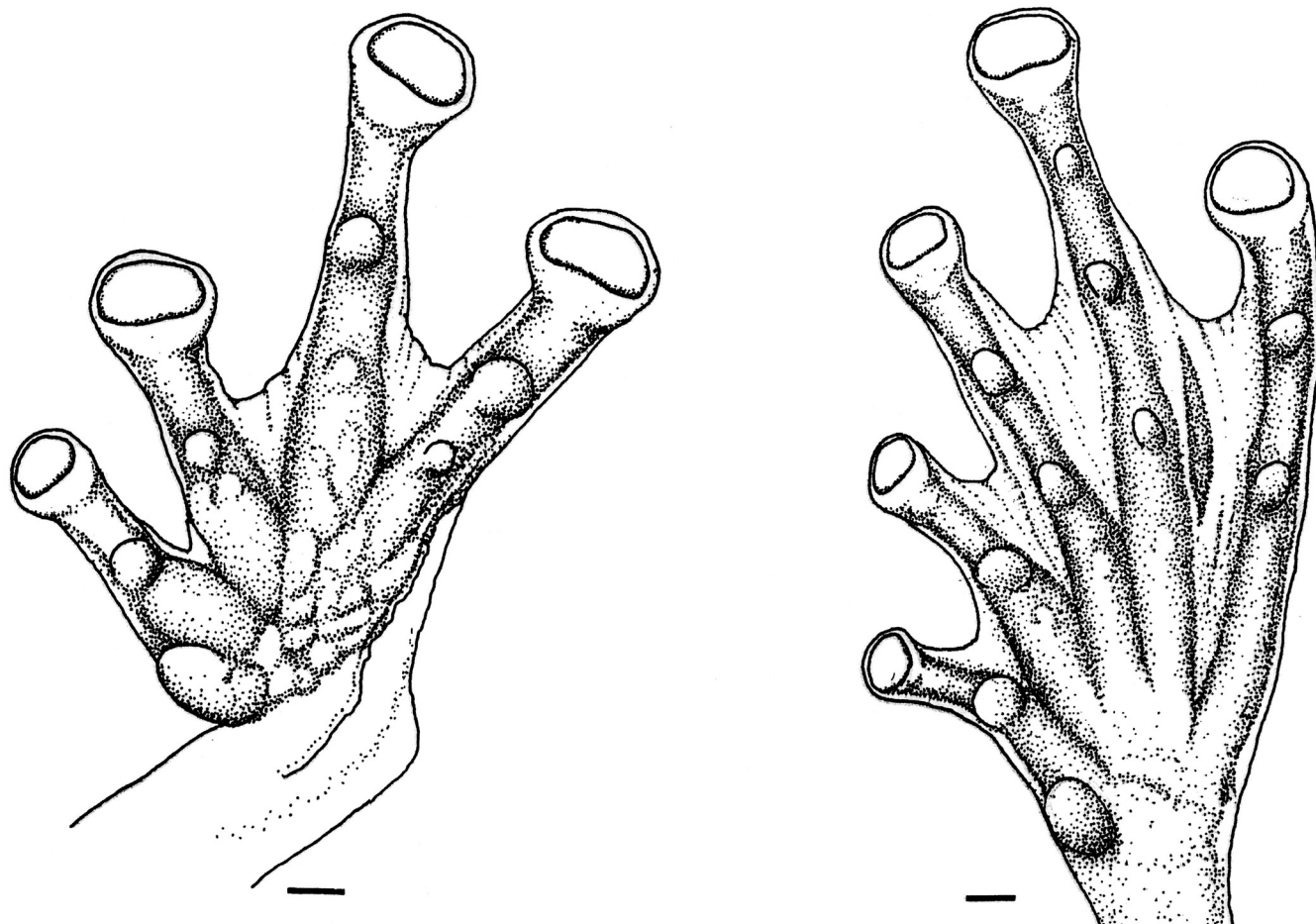


Fig. 4. Ventral views of hand (left) and foot (right) of *Rhacophorus yinggelingensis*, new species, NMNS 4091, holotype. Scale bar = 1 mm.

followed by 0.2 second inter-note duration. Two recorded calls lasted four seconds and 14 seconds, respectively. While being held captive in the base camp in the forest, the paratype emitted similar calls during the day and at night in rainy weather.

Distribution and Ecology. – This species is currently known only from high-altitude (at or above 1,300 m) primary rainforest in the Yinggeling mountain range which has the largest remaining primary tropical forest on Hainan Island. The type locality at Mahuoling is a small, flat, well-forested catchment basin at 1,300 m, bisected by a 2 m-wide low-gradient stream. The holotype was collected on leaves of a *Pinanga discolor* (Palmae) 30 cm above a dried rain pool by the stream. Another individual was also present approximately 15 m upstream from the holotype, also on a shrub with large leaves. Sympatric amphibians include *Leptobrachium hainanensis*, *Limnocytes fragilis*, *Huia nasuta*, *Sylvirana spinulosa*, *Amolops torrentis*, *Philautus odontotarsus* and *Microhyla heymonsi*.

At the time of the survey, in early spring 2003, the type locality had a daytime temperature of around 20–24°C, and a night time temperature of 14–16°C; the basin was always misty and humid. The paratype was found during the day hiding among sedges in a small, dried rain pool along a mountain ridge at 1,550 m. Its dorsum was dull green when collected but changed to bright green at night. The paratype was collected in late spring-early summer, when it rained almost daily; daytime temperature was around 28–32°C, and night time temperature ca. 24–26°C. Sympatric amphibians include *Philautus odontotarsus*, *Rhacophorus rodopus* and *Micryletta* sp.

Remarks. – The following treefrogs that have brown, reddish brown, orange red, or grayish brown background colour on dorsum (with additional distinguishing characters in parentheses), can be distinguished from the new species: *R. annamensis* (outer fingers fully webbed, webbing dark grayish brown dorsally, a pointed projection on heels, usually with two to three long tubercles at infra-cloacal region; Inger et al., 1999), *R. appendiculatus* (forearm and tarsus with crenulated dermal ridge, white-tipped infra-cloacal fringe present; Inger, 1954), *R. baliogaster* (ventral surfaces of head and body with conspicuous black spots, females with a rostral cone; Inger et al., 1999), *R. bimaculatus* (two round black spots at axillary region; outer fingers webbed reaching distal subarticular tubercles; Inger, 1954; Fei, 1999), *R. bipunctatus* (a pointed projection on heels, axillary spots present; Wilkinson et al., 2005), *R. bisacculus* (fingers with web remnants, a row of tubercles on underside of arm and another on tarsus; Taylor, 1962; Das & Haas, 2005); *R. calcaneus* (snout sloping and sharply pointed, heels with a pointed projection, a glandular supratympanic fold; Inger et al., 1999; Das & Haas, 2005), *R. colletti* (fingers not webbed; Taylor, 1962), *R. exechopygus* (outer fingers fully webbed, forearm and tarsus with crenulated dermal ridge; Inger et al., 1999), *R. hoanglienensis* (loreal region dark brown, a pointed projection on heels, dorsum with irregular black and brown spotting, brown line running between the eyes, white lines

running from the supratympanic fold to tip of snout through eyelid and canthal ridge; Orlov et al., 2001; Bain & Truong, 2004), *R. leucomystax* (fingers not webbed), *R. megacephalus* (fingers not webbed), *R. mutus* (fingers not webbed), *R. naso* (a pointed knob at snout, forearm and tarsus with crenulated dermal ridge; Fei, 1999), *R. orlovi* (dark brown bar between eyes, loreal region and supratympanic fold dark brown with irregular yellow patches; Ziegler & Köhler, 2001), *R. rhodopus* (a round black spot at axillary region, a squarish supra-cloacal flap and a squarish dermal projection on heels; Fei, 1999), *R. translineatus* (a pointed knob at snout, outer fingers fully webbed, a pointed projection on heels; Fei, 1999), *R. tuberculatus* (head and back with large, irregular grey markings; toe webs black; Fei, 1999), *R. verrucopus* (forearm and tarsus with tuberculous crenulated dermal ridge, a pointed projection on heels, basally fused tubercles transversally arrayed above cloacal opening; Fei et al., 2005), *R. verrucosus* (forearm and tarsus with crenulated dermal ridge, two to six long whitish tubercles at infra-cloacal region; Inger et al., 1999; Orlov et al., 2001; Ziegler & Köhler, 2001; Fei et al., 2005). Among the other *Rhacophorus* frogs that have green ground colour on dorsum, the reduced webbing between the outer fingers (Fig. 4) distinguishes the medium-sized *R. yinggelingensis* (SVLs 43.0–43.4 mm) from the large-sized *R. dennysi*, *R. feae*, *R. kio* (Ohler & Delorme, 2006), *R. maximus*, and *R. reinwardtii* (SVLs of these species 68–116 mm; Fei, 1999) that have fully webbed outer fingers. The new species is distinguished from *R. omeimontis*, *R. pingbianensis* (Kou et al., 2001; probably a synonym of *P. duboisi* according to Orlov et al. [2002]), *R. gongshanensis*, *R. duboisi* (Ohler et al., 2000) and *R. dugritei* (probably a complex containing *R. puerensis* [He, 1999] and *R. zhaojuensis* [Wu & Zheng, 1994]; see Orlov et al., 2001; Fei et al., 2005) by lack of black or brown spots or patches on dorsum.

The new species seems closely related to *R. arvalis*, *R. aurantiventris*, *R. chenfui*, *R. dorsovireidis*, *R. hungfuensis*, *R. moltrechti*, *R. nigropunctatus* (probably a synonym of *R. dorsovireidis*; Orlov et al., 2001), *R. prasinatus*, *R. taipeianus*, and *R. yaoshanensis* on the basis of adult morphology. Male *R. yinggelingensis* has the relatively largest tympanum of which the diameter is 0.78–0.79 of the eye (vs. 0.41–0.58 in males of listed species based on examined specimens). Orlov et al. (2001), however, found sexual tympanum size dimorphism present in several Vietnamese frogs. A male *R. cf. hungfuensis* has a large tympanum (about 79% of eye diameter). *Rhacophorus arvalis*, *R. aurantiventris*, and *R. chenfui* have white flank lines that clearly divide dorsal and ventral portions [note: this character is stable in these species according to WHC's observation but is variable in *R. dugritei* noted by Bain & Truong (2004)]. In addition, *R. arvalis* has slightly granulate dorsum and pale purple belly in life; *R. aurantiventris* has golden yellow iris and orange red belly in life; *R. chenfui* has purple flanks in life (Liu & Hu, 1961; Fei, 1999) and creamy white belly with brown flecks in preservative, dorsum with fine granules; *R. prasinatus* has shagreened dorsum and a golden brown stripe extending from midway of canthal ridge to margin of eyelid and supratympanic folds; *R. hungfuensis* has dark brown iris

(Orlov et al., 2001), yellow flanks, ventral surfaces of limbs and venter in life (Liu & Hu, 1961; Fei, 1999), more granulate dorsal skin, and lacks supra-cloacal white line; *R. taipeianus* has more granulate skin, relatively indistinct tympanum that is obscured by a layer of skin, and yellow colouration on anterior and posterior margins of thigh; *R. nigropunctatus* and *R. yaoshanensis* have weak tuberculous dermal ridge along outer sides of forearm and tarsus; *R. dorsovirens* has weak tuberculous dermal ridge along outer sides of forearm and tarsus, variable black spotting at flanks, and orange or reddish brown iris in life (Orlov et al., 2001); *R. moltrechti* has red or reddish brown iris and black spots or patches posterior flanks, anterior and posterior margins of thigh, and in some cases, variable spotting on belly, tibia, tarsus, foot and webbing.

DISCUSSION

Taxonomy of rhacophorid frogs with respect to *Rhacophorus* and *Polypedates* is unstable (e.g., Bourret, 1942; Inger et al., 1990; Zhao & Adler, 1993; Orlov et al., 2001, 2002; Fei et al., 2005; Sang et al., 2005). Both Liem (1970) and Jian et al. (1987), considered *Polypedates* and *Rhacophorus* to be closely related, and proposed a number of characters to distinguish between them. Their genus *Polypedates* has the following features: dermal fold along outer edges of forearm and above cloaca absent or forming only a dermal fringe; M. extensor radialis accessories lateralis moderately large, originating along lateral side of humerus; M. extensor brevis superficialis of the first digit present in most species; vomerine teeth always present; parieto-squamosal arch of the fronto-parietal bone present in most species and usually short; vertebral column diplasiocoelous; M. cutaneous pectoris thick and muscular. Their genus *Rhacophorus*, however, has extensive dermal fold along outer edges of forearm and above cloaca in many species; M. extensor radialis accessories lateralis usually narrow, originating near crista ventralis of the humerus; M. extensor brevis superficialis of the first digit absent in most species; vomerine teeth usually present; parieto-squamosal arch of the fronto-parietal bone absent; procoelous vertebral column; thin M. cutaneous pectoris, with only a few layers of muscle fibers. Dubois (1987) did not consider species within *Polypedates* distinct enough from those of *Rhacophorus*, and he along with other workers (e.g., Duellman 1993; Fei, 1999), reassigned species of *Polypedates* to *Rhacophorus*. Re-evaluation of the phylogeny, either morphologically (Channing, 1989) or by molecular means (Meegaskumbura et al., 2002; Wilkinson et al., 2002), revealed that *Rhacophorus* and *Polypedates* are distinct clades and not sister groups. Fei et al. (2005), nevertheless, followed Dubois (1987), treating both genera as *Rhacophorus*, and further divided rhacophorid frogs from China and Taiwan into species groups using the following key:

- 1. Finger webbing absent *R. megacephalus* group (*R. leucomystax*, *R. megacephalus* and *R. mutus*)
- Finger webbing present 2

- 2. Supra-cloacal or heel dermal fold present
R. reinwardtii group (*R. bipunctatus*, *R. reinwardtii*, *R. rodopus*, *R. translineatus* and *R. verrucopus*)
- Supra-cloacal or heel dermal fold absent 3
- 3. Snout pointed, dorsolateral fold present, tuberculous metatarsal skinfolds present *R. naso* group (*R. naso*)
- Snout rounded or slightly pointed, dorsolateral fold absent, tuberculous metatarsal skinfolds absent 4
- 4. Fingers, or at least outer fingers, fully-webbed*R. maximus* group (*R. dennysii*, *R. feae*, *R. maximus*, and *R. tuberculatus*)
- Fingers at most half-webbed 5
- 5. Toes less than half-webbed
R. dugritei group (*R. chenfui*, *R. dugritei*, *R. hungfuensis*, *R. nigropunctatus* and *R. yaoshanensis*)
- Toes with full or nearly full webbing 6
- 6. Dorsum green with brown spots *R. omeimontis* group (*R. omeimontis* and *R. gongshanensis*)
- Dorsum bright green, spots, if present, not brown
R. moltrechti group (*R. arvalis*, *R. aurantiventris*, *R. moltrechti*, *R. prasinatus* and *R. taipeianus*)

Our examination of Chinese green treefrogs belonging to *R. dugritei* group, *R. omeimontis* group, and *R. moltrechti* group of Fei et al. (2005) revealed that these species could not be properly classified into respective groups by toe webbing, i.e., full or nearly full-webbing (*R. omeimontis* and *R. moltrechti* groups) versus less than “half-webbing” (*R. dugritei* group). The *R. omeimontis* group (*R. omeimontis* and *R. gongshanensis*), that have full toe webbing and dorsum usually shagreened with fine white granules, could be separated from the remaining species. However, we found that *R. arvalis*, *R. aurantiventris*, *R. dugritei*, *R. moltrechti*, *R. prasinatus*, *R. taipeianus*, *R. nigropunctatus*, *R. yaoshanensis*, *R. chenfui*, and *R. hungfuensis* have almost identical toe webbings but are classified in different groups by Fei et al. (2005). The new Hainan treefrog, *R. yinggelingensis*, that also has identical toe webbing, could not be confidently placed in either *R. dugritei* or *R. moltrechti* species groups. We suggest that the *R. dugritei* group and *R. moltrechti* group be merged to form a single group.

Taxonomic treatments of rhacophorid frogs by Fei et al., (2005) are not congruent with those of Zhao & Adler (1993), who assigned Chinese and Taiwanese *R. chenfui*, *R. dugritei*, *R. feae*, *R. hungfuensis*, *R. megacephalus*, *R. mutus*, *R. nigropunctatus*, and *R. omeimontis* to the genus *Polypedates* and the remaining species to the genus *Rhacophorus*. Wilkinson & Drewes (2000) suggested that a green dorsal pattern might be a useful character to distinguish *Rhacophorus* from *Polypedates*, as was provisionally supported by base characters of DNA, e.g. in *R. moltrechti*, *R. dennysi*, and *R. reinwardtii* (Wilkinson et al., 2002). This seems unlikely, however, as not all *Rhacophorus* species have a green dorsal pattern [e.g., *R. rhodopus*, *R. bipunctatus*, and *R. annamensis*, which were sampled in Wilkinson et al., (2002)]. Our placement of the new green treefrog from Hainan Island in the genus *Rhacophorus* is a conservative approach, and that may or may not hold, pending further investigation of *Rhacophorus* and *Polypedates* which is beyond the scope of this work.

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APPENDIX

List of comparative specimens examined.

- Rhacophorus arvalis*. - NMNS 2469 (N = 1), 2474 (N = 3) (from Taiwan: Chiayi Co.: Minhsiung). *Rhacophorus aurantiventris*. - NMNS 2683 (from Taiwan: Taitung Co.: Peinan, Chiban. N = 3). *Rhacophorus chenfui*. - CIB 595043(paratype), 79II0147-158 (from China: Sichuan: Xiushan); CIB79II0210-220 (from China: Sichuan: Pangjiawan). *Rhacophorus dennysi*. - CIB 585139 (from China: Guangdong), 58541; BIZ 901-907 (from China: Fujian); CIB 585184-185, BIZ 01226 (from China: Zhejiang). *Rhacophorus dugretei*. - CIB 65II0084, 65II0086, 65II0403, 65II0408, 65II0431, 65II0462, 65II0515-516 (from China: Sichuan: Yuexi); CIB 65II288 (from China: Sichuan: Zhaojue). *Rhacophorus gongshanensis*. - CIB 820553, 820723, 820833 (from China: Yunnan: Baoshan). *Rhacophorus hungfuensis*. - CIB 660389-391, 660404, 660415, 660423-426, 660426 (from China: Guangxi: Dayaoshan). *Rhacophorus maximum*. - CIB 74III0079 (from China: Tibet: Medog); CIB 571149 (from China: Yunnan: Jinghong). *Rhacophorus moltrechti*. - NMNS 2028 (from Taiwan: Nantou Co.: Hsitou. N = 4); NMNS 2429 (from Taiwan: Nantou Co.: Yuchih, Lienhwachih. N = 2); NMNS 2611 (from Taiwan: Kaohsiung Co.: Liokuei, Sanpin. N = 2); NMNS 2682 (from Taiwan: Taitung Co.: Peinan, Chiban. N = 5). *Rhacophorus nigropunctatus*. - CIB 590405 (holotype), and 590404 (from China: Guizhou: Weining: Longting); CIB 63II0454, 63II0559 (from China: Guizhou: Leishan: Fangxianggetou). *Rhacophorus omeimontis*. - CIB 62W539, 62W552, 62W578-579, 62W706-708 (from China: Sichuan: Erlangshan); CIB 62W718-719, 62W864-865 (from China: Sichuan: Zhishi). *Rhacophorus prasinatus*. - NMNS 1455, 1456 (from Taiwan: Taipei Co.: Hsintien. N = 11). *Rhacophorus taipeianus*. - NMNS 2571 (from Taiwan: Nantou Co.: Yuchih, Lienhwachih. N = 5); NMNS 2815 (from Taiwan: Taipei Co.: Wulai, Hsinhsien. N = 1). *Rhacophorus yaoshanensis*. - CIB 620016 (holotype) and 620015 (from China: Guangxi: Yaoshan; Jinxiuling).