

TAXONOMIC NOTES ON RHACOPHORID FROGS (RHACOPHORINAE: RHACOPHORIDAE: ANURA) OF SOUTHERN PART OF ANNAMITE MOUNTAINS (TRUONG SON, VIETNAM), WITH DESCRIPTION OF THREE NEW SPECIES

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We present a review of taxonomic status and distribution of rhacophorid frog species (Anura, Rhacophoridae, subfamily Rhacophorinae) found in isolated mountain systems of southern Vietnam (Annamite Mountains) and neighboring regions. On the basis of morphological and molecular evidences we reconsider taxonomy of Vietnamese rhacophorids with special focus on genera *Theloderma* sensu lato, *Philautus* sensu lato, *Raorchestes*, *Feihyla*, *Kurixalus*, *Chiromantis*, and *Rhacophorus*. Two new species of rhacophorid frogs of the genus *Theloderma* are described from high-elevation montane forest in Chu Yang Sin Mt. (Dak Lak Province) and lowland monsoon tropical forest in Annamite foothills in Binh Phuok, Lam Dong and Dong Nai provinces of Vietnam; we discuss taxonomy of other small *Theloderma* species and provide two new combinations. These new species are different from the other members of *Theloderma* in their appearance, morphological details and coloration. We provide a redescription of *Raorchestes gryllus* (Smith, 1924), reconsider taxonomy of *Rhacophorus calcaneus* group and give a description of one new *Rhacophorus* species. The new species is different from other *Rhacophorus* species on the basis of strongly expressed pointed projection at tibiotarsal articulation and coloration. Ecology and natural history of newly described taxa are discussed. We also give a present-day list of rhacophorid frogs found in Vietnam.

Keywords: Rhacophoridae; taxonomy; *Rhacophorus*; *Philautus*; *Raorchestes*; *Theloderma*; *Chiromantis*; *Feihyla*; *Kurixalus*; southern Vietnam; Dak Lak; Lam Dong; Binh Phuok.

INTRODUCTION

Rhacophorid frogs (Anura: Rhacophoridae) is a large group of arboreal frogs containing over 320 species and distributed throughout subsaharan Africa, China, South-east Asia, Japan, Taiwan, the Philippines, and the Greater Sunda Islands (Frost, 2011). 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 and Trueb, 1986). Due to their high level of diversification and high species diversity, limited number of morphological synapomorphies within groups and unresolved molecular phylogenies, generic allocation within the family is often difficult. Their phylogenetic placement presently remains unresolved (Delorme et al., 2005, Li et al., 2008, 2009, Wilkinson et al., 2002; Yu et al., 2008, 2009, 2010).

The subfamily Rhacophorinae (Anura: Rhacophoridae: Rhacophorinae) is the most speciose anuran group in Vietnam with almost 50 species of 10 genera recorded for the country (Orlov and Ananjeva, 2007). According to recent reviews on rhacophorid taxonomy (summarized in “Amphibian Species of the World: an on-line reference. Version 5.5”; Frost, 2011) all Vietnamese rhacophorid frogs belong to the following ten genera: *Chiromantis* Peters, 1854; *Feihyla* Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan,

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Raxworthy, Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green et Wheeler, 2006; *Gracixalus* Delorme, Dubois, Grosjean et Ohler, 2005; *Kurixalus* Ye, Fei et Dubois, 1999; *Nyctixalus* Boulenger, 1882; *Philautus* Gistel, 1848; *Polypedates* Tschudi, 1838; *Raorchestes* Biju, Shouche, Dubois, Dutta et Bossuyt, 2010; *Rhacophorus* Kuhl et Van Hasselt, 1822 and *Theloderma* Tschudi, 1838 (all above-mentioned taxa belong to the subfamily Rhacophorinae).

Vietnamese rhacophorids occupy different ecological niches and are most diverse in monsoon tropical forests and mountain tropical rainforests on various altitudes from the sea level to more than 2500 m a.s.l. (Orlov and Ananjeva, 2007). Intensive fieldwork during last two decades led to numerous new records and descriptions of new rhacophorid species (Orlov, 1997, 2005, 2008; Inger et al., 1999; Orlov and Ho, 2000a, 2000b, 2005; Orlov et al., 2001, 2002, 2004, 2006, 2008; Matsui and Orlov, 2004; Ziegler and Köhler, 2001; Stuart and Heatwole, 2004; Ohler et al., 2000; Frost et al., 2006; Orlov and Ananjeva, 2007; Ohler and Delorme, 2006; Nguyen et al., 2005, 2008a, 2008b; Bain et al, 2009; Orlov et al., 2010; Rowley et al., 2010b, 2011b). Compared to better studied provinces of northern and central Vietnam, many areas in mountainous regions of Annamite Mountains (Truong Son) in the southern half of the country remain insufficiently surveyed. This is true for the mountain massive of Lang Bian plateau — the southernmost part of the Annamites, occupying parts of Dak Lak, Lam Dong and Khanh Hoa provinces and adjacent territories. Recent progress in herpetological research in this area led to description of several new amphibian and reptilian species (Nazarov et al., 2008, 2012; Poyarkov, Vasilieva, 2012; Rowley et al., 2010a, 2011a, 2011b; Stuart et al., 2011; etc.).

During our recent field surveys on the Lang Bian Plateau (Southern Annamite Mountains, Vietnam) in 2009 – 2011, we have encountered several species of small sized rhacophorids of unclear generic attribution. Two of them we herewith describe as new species putatively allocated to the genus *Theloderma* (Tschudi 1838). Due to the recent progress in studies on phylogeny of the Rhacophoridae the generic-level taxonomy of the family is quite unstable (Delorme et al., 2005, Frost et al., 2006, Li et al., 2008, 2009, Wilkinson et al., 2002; Yu et al., 2008, 2009, 2010). Many of recently revealed clades still lack described morphological synapomorphies. The genus *Theloderma* (Tschudi 1838), as currently understood, can not be considered as a monophyletic genus. The species assigned to the genus *Nyctixalus* Boulenger 1882 cluster within one monophyletic lineage with the majority of *Theloderma* species, except *T. moloch*, which is supposed to represent a quite distinct lineage within the Rha-

cophoridae (Li et al., 2008, 2009; Wilkinson et al., 2002; Yu et al., 2008, 2009, 2010; Rowley et al., 2011). Since no morphological synapomorphy is known for the genus *Theloderma*, and its monophyly is not supported by molecular data (Liem, 1970; Li et al., 2009), we consider the proposed generic allocation of the two new species described herein as preliminary. Future phylogenetic data have to show whether this allocation can be sustained.

In the present paper we will discuss taxonomy of rhacophorids found in southern Vietnam, provide descriptions of two new small species of the genus *Theloderma* sensu Rowley et al., 2011, reconsider taxonomy and provide new combinations for two other small *Theloderma* species, give redescription of *Philautus* (*Raorchestes*) *gryllus* Smith, 1924, discuss taxonomy of *Rhacophorus calcaneus* group and provide a description of one new *Rhacophorus* species. We also give a present-day list of rhacophorid frogs found in Vietnam.

MATERIAL AND METHODS

The present review of rhacophorid fauna of Vietnam, descriptions of new *Theloderma* Tschudi, 1838 and *Rhacophorus* Kuhl et van Hasselt, 1822 species, taxonomic notes on members of genera *Raorchestes* Biju, Shouche, Dubois, Dutta et Bossuyt, 2010; *Feihyla* Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan, Raxworthy, Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green et Wheeler, 2006; *Chiromantis* Peters, 1854; and *Philautus* Gistel, 1848 found in southern Vietnam are based on specimens collected by the authors in 1993 – 2011 during field surveys in southern Vietnam (Thua Thien-Hue, Quang Nam, Danang, Kon Tum, Gia Lai, Dak Lak, Dak Nong, Lam Dong, Khanh Hoa, Dong Nai, Binh Phuok provinces), museum collections and literature review.

Specimens were caught in the field mostly during night excursions by hand, initially fixated in 70% ethanol and subsequently preserved in 70% ethanol or 4% formalin. Specimens used for description are deposited in the Zoological Museum of Moscow University (ZMMU, Moscow, Russia); Zoological Institute Russian Academy of Science of St. Petersburg (ZISP, St. Petersburg, Russia) and the Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK). Comparative material was examined from the collections of Royal Ontario Museum (ROM, Toronto, Canada); Chengdu Institute of Biology (CIB, Chengdu, China); Kunming Institute of Zoology (KIZ, Kunming, China); Field Museum of Natural History (FMNH, Chicago, IL, USA); National Museum of Natural History, Smithsonian (NMNH, Washington, D.C., USA); Museum of Vertebrate Zoology, California

University (MVZ, Berkeley, CA, USA); California Academy of Sciences (CAS, San Francisco, CA, USA); Museum für Naturkunde, Humboldt University (ZMB, Berlin, Germany); Institute of Ecology and Biological Resources (IEBR, Hanoi, Vietnam); British Museum of Natural History (BMNH, London, Great Britain). Specimens examined are listed in *Appendix 2*.

All measurements were taken with digital calipers to the nearest 0.01 mm. The following abbreviations are used. **Body and head:** SVL, snout-vent length; A-G, axilla to groin, distance from posterior base of forelimb at its emergence from body to anterior base of hind limb at its emergence from body; HW, head width at the greatest cranial width; HL, head length from the rear of the lower jaw to the tip of the snout; HD, head depth, greatest transverse depth of head, taken beyond interorbital region; UEW, upper eyelid width: greatest width of upper eyelids; IOD, interorbital distance; ED, horizontal diameter of eye; TD, horizontal diameter of tympanum; ESL, tip of snout-eye distance; TED, tympanum-eye distance from anterior edge of tympanum to posterior corner of the eye; IND, internarial distance: distance between nostrils; END, eye to nostril distance: distance from anterior corner of eye to nostril. Terminology for description of frog's eyes was taken from Glaw and Vences (1994). **Forelimbs:** FLL, length of forelimb from tip of disk of finger III to axilla; FFL, first finger length; TFL, third finger length; FTD, maximal diameter of disc of finger III; NPL, nuptial pad length; MKT, length of metacarpal tubercles (MKTi, length of inner metacarpal tubercles; MKTe, length of exterior metacarpal tubercles). **Hindlimbs:** HLL, length of hindlimb from tip of disk of toe IV to groin; FL, femur length; TL, tibia length; FOT, length of hindlimb from tip of disk of toe IV to posterior edge of tibia; FTL, first toe length; FFTL, fourth toe length; HTD, diameter of fourth toe tip, greatest diameter of disc on fourth toe; MTT, length of metatarsal tubercles (MTTi, length of inner metatarsal tubercle; MTTe, length of exterior metatarsal tubercle). Roman numerals refer to the fingers and toes, and the Arabic numerals refer to the number of subarticular tubercles and phalanges. Formula of webbing by Glaw and Vences, 1994; Orlov et al., 2006, where: i, inner side; e, exterior side of phalanges. **Tadpole measurements:** Development stages of tadpoles were evaluated according to Gosner's tables (Gosner, 1960). The following measurements were taken (following Grosjean, 2001; Altig, 2007): TL, total length; BL, body length; TaL, tail length; BW, body width; BH, body height; TH, tail height (maximal); SVL, snout-vent length; SSp, snout-spiraculum length; UF, upper fin height (maximal); LF, lower fin height (maximal); IN, inter-narial distance; IP, inter-pupilar distance; NR, nairo-rostral distance; NP, nairo-pupilar distance; ED, eye



Fig. 1. Holotype (ZISP 10541) from *Theloderma chuyangsinense* sp. nov., general view.

diameter; ND, narial aperture diameter; ODW, oral disk width.

DESCRIPTION OF NEW SPECIES OF *Theloderma*

Theloderma chuyangsinense sp. nov.

Holotype. ZISP 10541 (Fn TAO 491) an adult female from the Chu Yang Sin Mountain, Chu Yang Sin National Park, Lak District, Dak Lak Province, Vietnam (12°24'28.9" N 108°23'19.8" E, 1800 m elevation), collected on April 22, 2009, by Nguyen Quang Tao, Nguyen Ngoc Sang, Daniel A. Melnikov and Nikolai L. Orlov (Figs. 1 and 2).

Etymology. The species name “*chuyangsinense*” is a Latinized toponymic adjective in neutral gender derived from the name of the Chu Yang Sin Mountain and the Chu Yang Sin National Park in Dak Lak Province, Vietnam, where the only known specimen was collected.

Suggested common name. Chu Yang Sin moss frog (English); Ếch cây sần Chu Yang Sin (Vietnamese).

Diagnosis. The new species is assigned to the genus *Theloderma* by the presence of tuberculate skin on the dorsum, a distinct tympanum, terminal phalanx with a Y-shaped distal end, intercalary cartilage between the terminal and penultimate phalanges of digits, tips of digits expanded into large disks bearing circummarginal grooves, and the absence of co-ossification of the head skin to the skull (Liem, 1970). *Theloderma chuyangsinense* sp. nov. is characterized by a combination of the following characters: body dorsoventrally compressed; head relatively large and broad; pupil horizontal; choanae trapeziform; vomerine teeth absent; nostril round, cut in lateral direction inside the high tubercle; tympanum big, round, distinctly visible, approximately 96.6% of eye

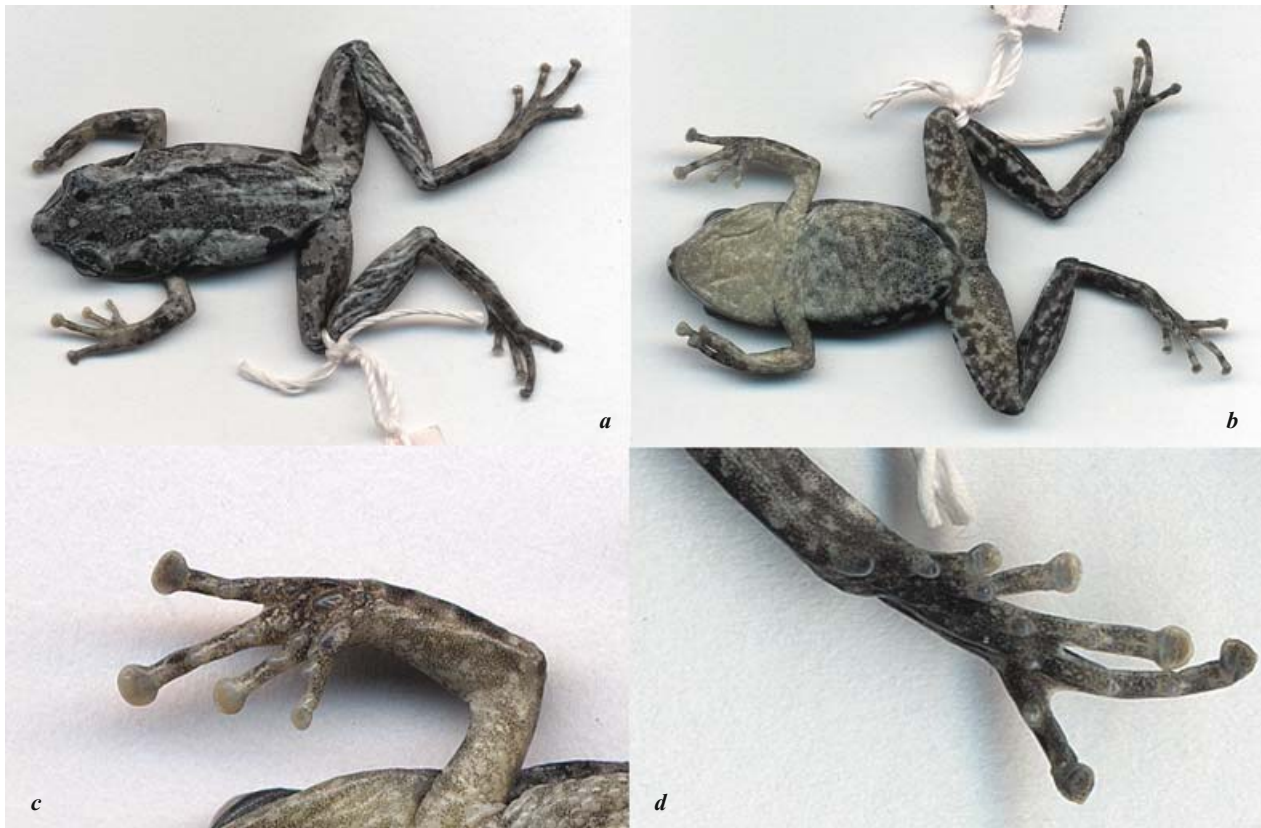


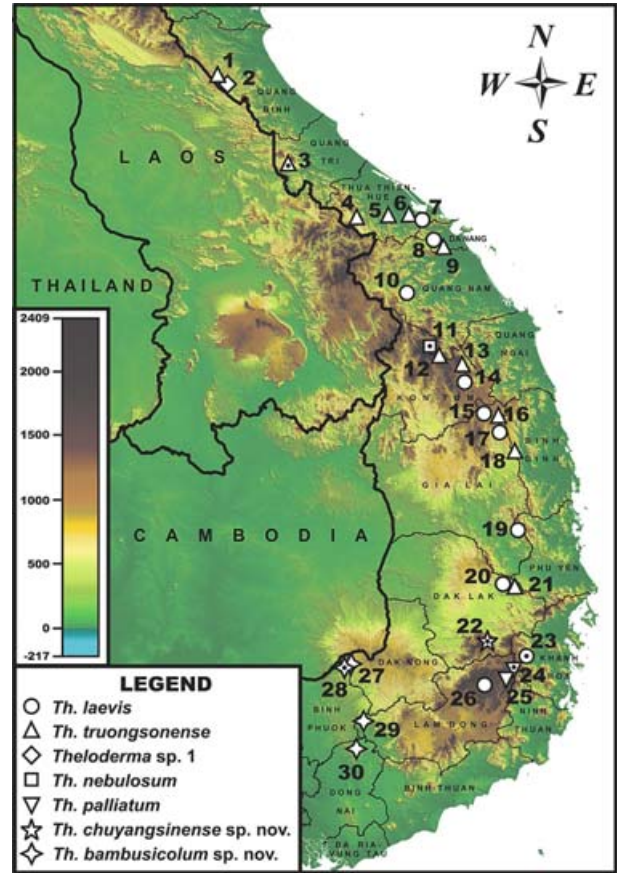
Fig. 2. Holotype (ZISP 10541) from *Theloderma chuyangsinense* sp. nov.: a, dorsal view; b, ventral view.

length; dorsal skin slightly tuberculous, ventral skin granular; strongly developed tubercles in supraorbital area; strongly tuberculous skin around cloaca and on the outer surface of fore and hind limbs; webs between fingers not developed. Upper surface of body is pale-yellow to light straw-brown with dark-brown blotches of irregular size and shape, forming a X-shaped figure on the back. On the flanks the pale-yellow background color of dorsal surface is edged with black stripe; its borders get indistinct at lateral sides of belly; belly is grayish with light bluish and dark spots and blotches, forming stellate pattern; iris bicolored.

Description of holotype. Adult male, SVL 28.24 mm, body dorsoventrally compressed; head relatively large and broad (HL 9.77 mm, HW 9.62); snout pointed (ESL 20.60% of SVL); eye large (ED 3.82 mm); pupil horizontal; tympanum large (TD 3.69 mm), round, distinctly visible, approximately 96.59% of eye length, separated from eye by distance less than 1/3 of tympanum length; supratympanum fold slightly developed; choanae trapeziform; tongue attached anteriorly, deeply notched posteriorly; vomerine teeth absent; vocal sacs absent; strongly developed tubercles in supraorbital

area — 12 big tubercles forming two rows; small tubercles also dispersed along the dorsal surface of the body, ventral skin granular, especially in posterior part of body; strongly tuberculous skin around cloaca and on the outer surface of fore and hind limbs; webs between toes not developed; nostril round, cut in lateral direction inside the high tubercle. Dermal flaps along the external edge of the forelimbs and hindlimbs are absent. Webbing between toes moderately developed, webbing between fingers are absent. Forelimbs: FLL 19.97 mm; relative length of fingers: $I < II < IV < III$; tips of fingers dilated into large expanded disks; fingers with round discs having circum-marginal grooves; subarticular tubercles large, formula of subarticular tubercles: 1, 1, 2, 2; inner palmar tubercles well developed, roundish; very good developed white nuptial pad on the thumb; webbing on hands absent (Fig. 2c). Hindlimbs: HLL (46.89 mm) about 2.24 times length of forelimb (20.92). Tibia length 50.77% of SVL; FTL 13.24% of SVL; FFTL 22.02% of SVL; relative toes length $I < II < III < V < IV$; discs of toes smaller than those of fingers; toes with rounded disks; subarticular tubercles distinct, roundish: 1, 1, 2, 3, 2; inner tarsal fold present; inner metatarsal tubercles roundish; webs

Fig. 3. Distribution of small *Theloderma* species in Vietnam and localities studied. Icon information is given in the legend, icons with dots in the middle denote species' type localities: 1, *T. truongsongense* — Phong Nha — Ke Bang National Park, Quang Binh Province, Vietnam, 350 m a.s.l.; 2, *Theloderma* sp. — Phong Nha — Ke Bang National Park, Quang Binh Province, Vietnam, 350 m a.s.l.; 3, *T. truongsongense* — Ban Cup village, Huong Hoa District, Quang Tri Province, central Vietnam (16°55'09" N 106°35'04" E, 400 m elevation) — type locality; 4, *T. truongsongense* — A Luoi, Thua Thien — Hue Province, Vietnam; 5, *T. truongsongense* — Huong Thuy, Thua Thien — Hue Province, Vietnam; 6, *T. truongsongense* — Bach Ma, Thua Thien — Hue Province, Vietnam; 7, *T. laevis* — Bach Ma National Park, Thua Thien-Hue Province, Vietnam; 1400 m a.s.l.; 8, *T. laevis* — Ba Na, Da Nang (Nguyen et al., 2009); 9, *T. truongsongense* — Ba Na, Da Nang Province, Vietnam; 10, *T. laevis* — Song Thanh, Quang Nam Province, Vietnam; 11, *T. nebulosum* — Ngoc Linh Nature Reserve, Dak Glei District, Kon Tum Province, Vietnam (15°06' N, 107°86' E, ~2000 m) — type locality (Rowley et al., 2011); 12, *T. truongsongense* — Ngoc Linh, Kon Tum Province, Vietnam; 13, *T. truongsongense* — Kon Plong, Kon Tum Province, Vietnam; 14, *T. laevis* — Mang Canh Village, Kon Plong District, Kon Tum Province, Vietnam; 1250 m a.s.l.; 15, *T. laevis* — K Bang, Gia Lai Province, Vietnam; 16, *T. truongsongense* — Kon Cha Rang, 60 km northwest of the town Kannack (14°20' N 108°36' E), An Khe district, Gia Lai Province, Vietnam; 1000 m a.s.l.; 17, *T. laevis* — Kon Cha Rang Nature Reserve, An Khe District, Gia Lai Province, Vietnam; 950 m a.s.l.; 18, *T. truongsongense* — Buon Luoi, 20 km northwest of the town Kannack (14°20' N 108°36' E), An Khe district, Gia Lai Province, Vietnam; 750 m a.s.l.; 19, *T. laevis* — Krong Pa, Gia Lai Province, Vietnam; 20, *T. laevis* — Ea So Nature Reserve, Ea Kar District, Dak Lak Province, Vietnam; 900 m a.s.l. (108°37' E 12°56' N); 21, *T. truongsongense* — Ea So Nature Reserve, Ea Kar District, Dak Lak Province, Vietnam; 900 m a.s.l. (108°37' E 12°56' N); 22, *T. chuyangsinense* sp. nov. — Chu Yang Sin Mountain, Chu Yang Sin National Park, Lak District, Dak Lak Province, Vietnam (12°24'28.9" N 108°23'19.8" E, 1800 m elevation) — type locality; 23, *T. laevis* — "Sui Kat, alt. 1000 m., Langbian Plateau, S. An-nam" (Smith, 1924) — type locality [= Sui Cat (Lam Dong), Khanh Hoa Province]; 24, *T. palliatum* — Giang Ly environs and Hon Giao, Bidoup-Nui Ba National Park, Lac Duong District, Lam Dong Province, Vietnam (12°11.2' N 108°42.9' E, 1625 m) — type locality (Rowley et al., 2011); 25, *T. palliatum* — Bidoup Mount, summit, 1850–1950 m a.s.l., Bidoup — Nui Ba National park, Lam Dong Province, Vietnam; 26, *T. laevis* — Lang Bian (Nui Ba), Lam Dong Province, Vietnam; 27, *T. bambusicolum* sp. nov. — Binh Phuok/Dak Nong border, Vietnam; 28, *T. bambusicolum* sp. nov. — Phuok Hoa environs, Bu Gia Map National Park, Dak Ka River valley Bu Gia Map commune, Bu Gia Map District, Binh Phuoc Province, 5 km W from the border with Dak Nong Province, southern Vietnam (12°19.6' N 107°25.2' E, 400 m a.s.l. — type locality; 29, *T. bambusicolum* sp. nov. — Cat Loc, Lam Dong Province, Vietnam; 30, *T. bambusicolum* sp. nov. — Cat Tien, Dong Nai Province, Vietnam.



between toes moderately developed, formula of webbing I(1)II(1)e(1)III(2)e(1.5)IV(2)e(2)V(2). Dermal fringes and pointed projection at tibiotarsal articulation absent (Fig. 2d).

Coloration of holotype in life. Dorsal body surface pale-yellow to light straw-brown with dark-brown blotches and spots of different size and shape, they form a distinct figure in the shape of "X" lasting from the snout tip to cloaca. On the body flanks the pale dorsal coloration is margined with black lateral stripe with irregular borders, lasting from the lateral sides of snout along the canthus rostralis across the eye to supratympanic fold and further to body flanks and groin. Lateral stripe edges are sharp at the dorsal side and get indistinct at ventral side towards belly flanks. At the groin area the lateral black

stripe ends with two large black blotches divided with narrow blue stripe, in front of the black spots the lateral stripe is almost interrupted with blue stripe, forming a loop. Dorsal surface of arms (including elbow area) warm brown to beige; hands and feet light warm reddish-brown with faint speckling. Tarsus with six light oblique stripes. Ventral surfaces dark warm brown with pale bluish white marbling on chest, inguinal region, anterior surface of thighs and tibiotarsus. Faint white speckling on the throat and ventral surfaces of arms, extending laterally onto upper lip and flanks. Belly is grayish with light bluish and dark blackish spots and small blotches forming a stellate pattern. The pattern is not uniform and gets denser towards the posterior part of belly and inner surface of tibiotarsus. Iris bicolored, upper part pale gold-

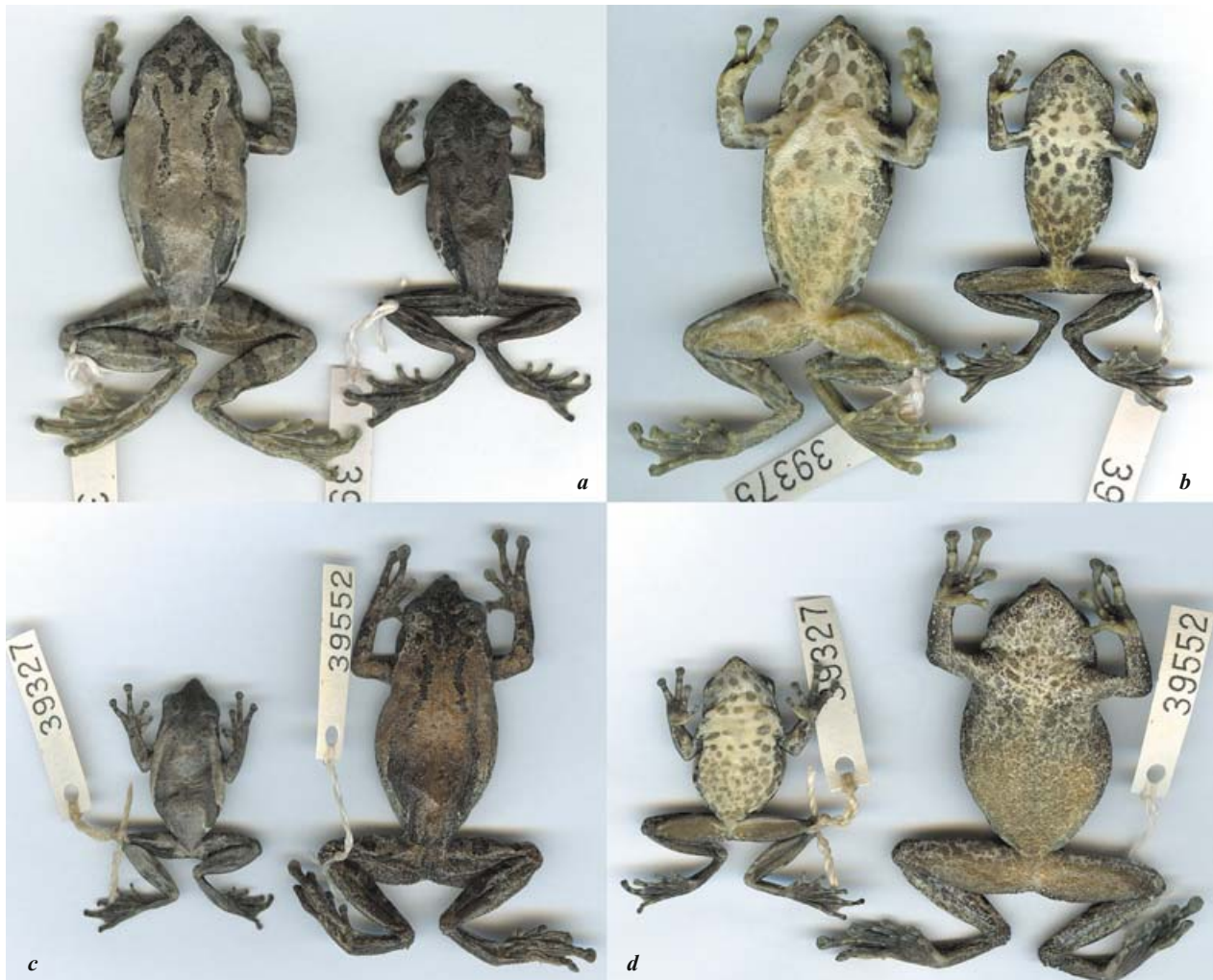


Fig. 4. *Kurixalus baliogaster* from Kon Plong, Kon Tum Province, Vietnam.

en (approximately a third), dark reddish brown in lower two-thirds; division of eye color matches skin coloration adjacent to eye; pupil horizontal, black.

Coloration of holotype in preservative. Color patterns correspond to those in life, but base color of dorsal surface fades to creamy white, and dark brown is slightly less warm in tone turning grayish-brown (Fig. 2a–b). The white marbling and speckling on ventral surface is also more distinct.

Measurements of holotype (in mm). Body and head: SVL 28.24; A-G 14.44; HW 9.62; HL 9.77; HD 4.91; UEW 3.63; IOD 4.84; ED 3.82; TD 3.69; ESL 5.82; TED 1.05; IND 3.54; END 3.57. Forelimbs: FLL 20.92; FFL 3.41; TFL 6.23; FTD 1.68; NPL 2.38; MKTi 1.43; MKTe 1.56. Hindlimbs: HLL 46.89; FL 14.33; TL 14.34; FOT 18.22; FTL 3.74; FFTL 6.22; HTD 1.08; MTTi 1.15; MTTe 1.18.

Tadpole. So far any data on reproductive biology, eggs, tadpole morphology and development of *T. chuyangsinense* sp. nov. are absent.

Distribution. The new species is known only from the type locality (Fig. 3) from montane evergreen forest above 1800 m a.s.l. at the type locality of Chu Yang Sin Mountain, Chu Yang Sin National Park, Lak District, Dak Lak Province, Vietnam (Fig. 3). During field surveys at the Park, only one specimens of *T. chuyangsinense* sp. nov. was found. Due to the small size and arboreal nature of these frogs, the apparent rarity of the species may be due simply to poor detectability.

Habitat and natural history. Adult female collected on April 22 at altitude of 1800 m a.s.l. in a polydominant primary mountain forest, consisting of both coniferous (local pine species *Pinus kesiya*, *Pinus dalatensis*, *Du-campopinus krempfii*) and deciduous (mostly Lauraceae,



Fig. 5. *Kurixalus banaensis* (a) and *K. carinensis* (c) from Kon Plong, Kon Tum Province, Vietnam; *K. effingeri* (b) of Yaeyama islands, Ryu Kyu archipelago, Japan; *K. odontotarsus* (d) of Quang Ninh Province, Vietnam.

Fagaceae, Magnoliaceae, Theaceae) tree species. Breeding biology and larvae of this species are unknown. The collection site is quite far from nearest waterbodies, the calling male was recorded at night under drizzling rain. Most probably, *T. chuyangsinense* sp. nov. does not use large waterbodies for reproduction but breeds in small secretive waterbodies, as do many other species of small rhacophorids, belonging to the genera *Theلودerma* and *Philautus* sensu stricto. However so far we do not have evidences that *T. chuyangsinense* sp. nov. uses any special types of waterbody like tree holes, small caves and rock caverns filled with water as other *Theلودerma* species (Orlov et al., 2010).

Comparison. *Theلودerma chuyangsinense* sp. nov. (SVL 28.24 mm) can be easily distinguished from large congeners *T. bicolor* (Bourret, 1937), *T. corticale* (Boulenger, 1903), *T. gordonii* Taylor, 1962, *T. horridum* (Boulenger, 1903), *T. kwangsiense* Liu et Hu, 1962, *T. leporosum* Tschudi, 1838, *T. moloch* (Annandale, 1912), *T. naganlandense* Orlov, Dutta, Ghate et Kent, 2006, *T. phrynoderma* (Ahl, 1927), and *T. ryabovi* Orlov, Dutta, Ghate et Kent, 2006 by its much smaller size (SVL = 28.2 mm vs.

adult males SVL over 40 mm in large species); moreover all large congeners possess heavily warty skin on dorsal surfaces with well developed dorsal asperities forming conspicuous ridges. *Theلودerma chuyangsinense* sp. nov. differs from all species of small rhacophorids known from Indochina and southern China in its appearance and morphological details. *T. chuyangsinense* differs from the majority of species of *Philautus*, *Kurixalus*, *Raorchestes*, and *Liuxalus* [*Philautus maosonensis* Bourret, 1937; *Philautus abditus* Inger, Orlov et Darevsky, 1999; *Philautus petilus* Stuart et Heatwole, 2004; *Philautus aurifasciatus* (Schlegel, 1837); *Philautus cardamonius* Ohler, Swan et Daltry, 2002; *Philautus cinerascens* (Stoliczka, 1870); *Philautus garo* (Boulenger, 1919); *Philautus kempii* (Annandale, 1912); *Philautus tythius* Smith, 1940 (Figs. 7–9); *Kurixalus ananjevae* (Matsui et Orlov, 2004); *Kurixalus baliogaster* (Inger, Orlov et Darevsky, 1999); *Kurixalus banaensis* (Bourret, 1939); *Kurixalus carinensis* (Boulenger, 1893); *Kurixalus eiffingeri* (Boettger, 1895); *Kurixalus odontotarsus* (Ye et Fei, 1993); *Kurixalus verrucosus* (Boulenger, 1893) (Figs. 4 and 5); *Raorchestes gryllus* (Smith, 1924); *Raorchestes longchua-*

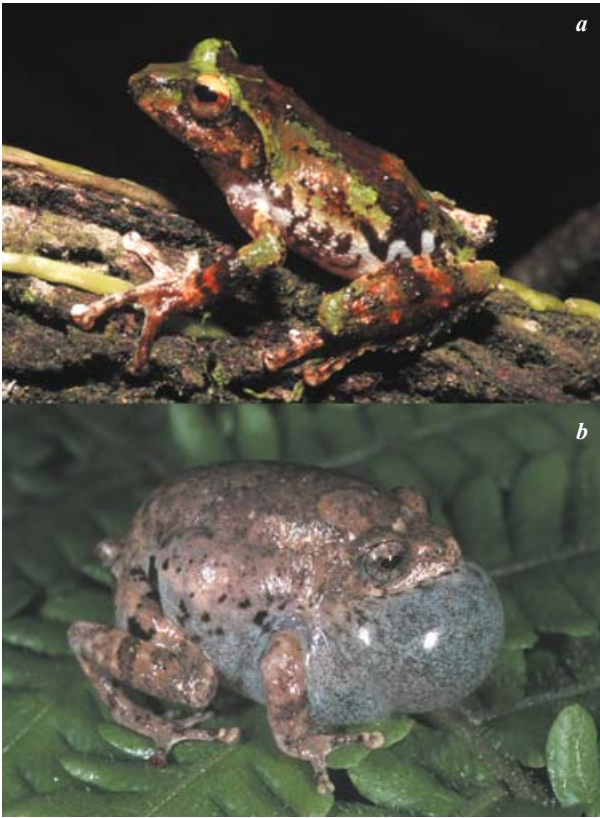


Fig. 6. *Raorchestes gryllus* from Chu Yang Sin National Park, Dak Lak Province (a) and *R. parvulus* from Tam Dao National Park, Vinh Phuc Province (b), Vietnam.



Fig. 7. *Liuixalus romeri* from Hong Kong, China (FMNH 224294).

nensis (Yang et Li, 1978); *Raorchestes parvulus* (Boulenger, 1893); *Raorchestes menglaensis* (Kou, 1990); *Raorchestes shillongensis* (Pillai et Chanda, 1973); *Liuixalus romeri* (Smith, 1953)] (Figs. 6 and 7) of Indochina by relatively slender and flat body, pale-yellow dorsal coloration and black/white stellate patterns on ventral sur-



Fig. 8. *Gracixalus gracilipes* from Mau Son, Lang Son Province (a) and *G. supercornutus* of Ba Na National Park, Da Nang Province (b), Vietnam.

faces. Moreover from majority of *Kurixalus* species the new species differs in absence of vomerine teeth (present in the genus *Kurixalus*). From *Gracixalus ananjevae* the new species is different in its dorsal and ventral coloration. From green *Gracixalus* species [*Gracixalus gracilipes* (Bourret, 1937); *G. supercornutus* Orlov, Ho et Truong, 2004; *Gracixalus guyeti* Nguyen, Hendrix, Böhme, Vu et Ziegler, 2008; *Gracixalus jingxiuensis* (Hu, 1978); and *Gracixalus quangi* Rowley, Dau, Nguyen, Cao et Nguyen, 2011] *T. chuyangsinense* further also differs by pale-yellow coloration of dorsal surface of the body and black-white stellated pattern on belly (green or greenish color of the back, transparent skin and belly without dark spots in green *Gracixalus*) (Fig. 8). From *Feihyla palpebralis* (Smith, 1924); *Chiromantis doriae* (Boulenger, 1893); *Chiromantis nongkhorensis* (Cochran, 1927); and *Chiromantis vittatus* (Boulenger, 1887) (Fig. 9) the new species is different by the presence of tuberculate skin on the dorsum, not transparent skin cover and spotted belly (smooth and transparent skin, and abdomen without black spots in *Feihyla* and *Chiromantis*). Moreover from *F. palpebralis* the new species further differs in absence



Fig. 9. *Feihyla palpebralis* from Bidoup – Nui Ba National park, Lam Dong Province, Vietnam (a); *Chiromantis vittatus* from Yunnan Province, China (b); *Ch. nongkhorensis* from Bu Gia Map National Park, Binh Phuok Province, Vietnam (c); vomerine teeth of *Feihyla palpebralis* (d).

of vomerine teeth (present in *F. palpebralis*). *Theloderma chuyangsinense* sp. nov. differs from *Nyctixalus pictus* (Peters, 1871) by presence of supratympanic fold (absent in *N. pictus*), absence of white tubercles on dorsal body surfaces (present in *N. pictus*), dark and spotted venter (vs. immaculate in *N. pictus*), rounded canthus rostralis (vs. sharp in *N. pictus*) and bony ridges from canthus rostralis to occiput absent (vs. present in *N. pictus*).

T. chuyangsinense sp. nov. is most resembling different small and medium-sized *Theloderma* species sensu Orlov et al., 2006; Bain et al., 2009, Li et al., 2009, and Rowley et al., 2011. From *T. asperum* (Boulenger, 1886) [= *Philautus albopunctatus* Liu et Hu, 1962 by Frost, 2011], *T. stellatum* Taylor, 1962, *T. licin* McLeod et Ahmad, 2007, and *Theloderma baibengensis* (Jiang, Fei et Huang, 2009) the new species differs in total absence of hand and finger webbing and absence of vocal sacs.

From *T. lateriticum* Bain, Nguyen et Doan, 2009 the new species differs by pale-yellow dorsal coloration (vs. brick-red dorsal coloration in *T. lateriticum*) and presence of warm dark-brown irregular shaped markings forming “X” pattern (absent in *T. lateriticum*). From *T. rhododiscus* (Liu et Hu, 1962) the new species differs by gray-brown ventral digital surfaces and presence of warm dark-brown irregular shaped markings forming “X” pattern (vs. bright orange-red ventral digital surfaces, and absence of “X”-shaped dorsal pattern in *T. rhododiscus*). The new species is most morphologically similar to the following small *Theloderma* species (sensu this paper): *T. laeve* (Smith, 1924); *T. truongsongensis* (Orlov et Ho, 2005); *T. nebulosum* Rowley, Le, Hoang, Dau et Cao, 2011; *T. palliatum* Rowley, Le, Hoang, Dau et Cao, 2011 and *Theloderma* sp. from Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam (Orlov et

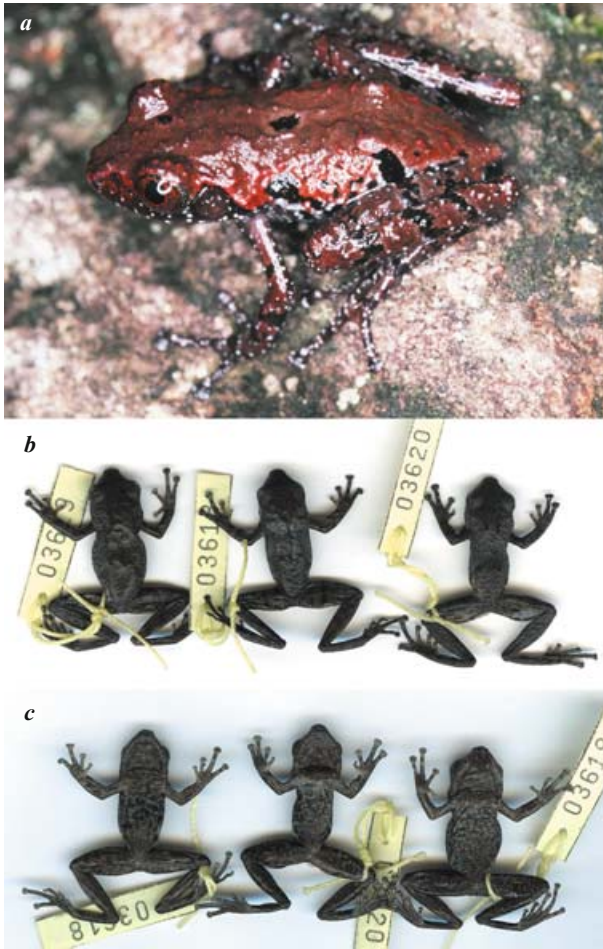


Fig. 10. *Theلودerma rhododiscus* from Fan Si Pan Mountain, Sa Pa, Lao Cai Province, Vietnam.

Ho, 2005, as part of *T. truongsongensis*) (Figs. 10 – 14). In their recent paper Rowley et al. (2011, see Fig. 3) basing on phylogenetic analysis of 16S ribosomal RNA mitochondrial gene partial sequences have shown that two new species putatively assigned to *Theلودerma* (*T. palliatum* from Lang Bian plateau and *T. nebulosum* from Ngoc Linh, Kon Tum) form separate phylogenetic lineages and group together with *T. rhododiscus*, *T. bicolor*, *T. corticale*, *T. gordonii*, and *T. laeve* (formerly *Chiro-mantis laevis*, treated as *T. truongsongensis* comb. nov. by Rowley et al., 2011; see below for details). Furthermore Rowley et al. (2011) in the diagnosis of *T. palliatum* indicate the following six distinctive morphological characters: “*Theلودerma palliatum* sp. nov. is distinguished from all other *Theلودerma* by a combination of (1) small body size (26.1 – 26.4 in two adult males), (2) absence of vomerine teeth, (3) presence of minute dorsal asperities, (4) no webbing on the hands, (5) pale to medium brown

dorsum with characteristic dark brown blotches and dark brown lateral surfaces extending from snout to groin, and (6) a bicolored iris, being pale gold in upper third and dark red in lower two-thirds.” In fact, six species of small rhacophorids putatively assigned to the genus *Theلودerma* [*T. laeve* (Smith, 1924); *T. truongsongensis* (Orlov et al., 2005); *T. nebulosum* Rowley, Le, Hoang, Dau et al., 2011; *T. palliatum* Rowley, Le, Hoang, Dau et al., 2011; *T. chuyangsinense* sp. nov.; and *Theلودerma* sp. (Phong Nha – Ke Bang National Park)] in principle agree with this diagnosis or certain statements with minor variation of coloration, skin structure and body size (Figs. 10 – 15). From *T. laeve* the new species can be easily distinguished by presence of tubercles at dorsal body and limb surfaces (absent in *T. laeve*). From *T. truongsongensis* the new species differs in body coloration patterns and presence of black spots on the internal surface of thighs (regular uniform dark mottling is pronounced on all ventral surfaces, internal surfaces of thighs and forelimbs with larger dark spots and blotches in the central part of belly; black spots on the internal surface of thighs encircled with turquoise in *T. truongsongensis* vs. irregular dark mottling pronounced only in posterior parts of belly and interior surfaces of hindlimbs; no turquoise color in coloration of the internal surfaces of thighs in *T. chuyangsinense* sp. nov.). From *T. nebulosum* and *T. palliatum* the new species differs with belly coloration: in *T. chuyangsinense* sp. nov. black blotches are present only in the posterior part of the belly and internal surfaces of hindlimbs (whereas black spots and blotches almost uniformly cover all ventral surface of body and inner surfaces of thighs and forelimbs in *T. nebulosum* and *T. palliatum*). The new species is further different from *T. palliatum* by the relative length of toes: $I < II < III < IV$ (relative length of toes $I < II < III = V < IV$ in *T. palliatum*, by Rowley et al., 2011). From *Theلودerma* sp. (Phong Nha – Ke Bang National Park) the new species is different by significantly smaller size, less developed dorsal warts and asperities and much lighter coloration (vs. SVL = 35 mm, dorsal warts and asperities well developed, dark-black dorsal patterns in *Theلودerma* sp. from Phong Nha – Ke Bang National Park). *T. chuyangsinense* sp. nov. differs from *T. bambusicolum* sp. nov. described below by dark spotted coloration of ventral surfaces and presence of strongly developed tubercles in supraorbital area and small tubercles dispersed along the dorsal surface of the body (vs. light unspotted violet belly, dorsal skin smooth in *T. bambusicolum* sp. nov.).

Theلودerma bambusicolum sp. nov.

Holotype. ZMMU A-4569 (Field ID ZMMU NAP-02908) an adult male from the Phuok Hoa envi-



Fig. 11. *Theloderma truongsongense* from Kon Plong, Kon Tum Province, Vietnam.

rons, Bu Gia Map National Park, Dak Ka River valley, Bu Gia Map commune, Bu Gia Map District, Binh Phuoc Province, 5 km W from the border with Dak Nong Province, southern Vietnam ($12^{\circ}19.6' N$ $107^{\circ}25.2' E$; 400 m a.s.l.), collected on 26.05.2011 by Nikolay A. Poyarkov (Figs. 16 and 17).

Paratypes. *Adults.* ZMMU A-4570 (A-4570-1-2; Field IDs ZMMU NAP-00319; ZMMU NAP-00320) — two adult males from the type locality: Phuok Hoa environs, Bu Gia Map National Park, Dak Ka River valley, Bu Gia Map commune, Bu Gia Map District, Binh Phuoc Province, 5 km W from the border with Dak Nong Province, southern Vietnam ($12^{\circ}19.6' N$ $107^{\circ}25.2' E$; ~400 m a.s.l.), collected on 13 – 21.04.2009 by Nikolay A. Poyarkov; and ZMMU A-4573 (A-4573-1-3; Field IDs ZMMU NAP-02906; ZMMU NAP-02907; ZMMU NAP-02918) — three adult females collected from the type locality on 26 – 29.05.2011 by Nikolay A. Poyarkov; ZMMU A-4571 (A-4571-1-4 (Field IDs ZMMU NAP-01644; ZMMU NAP-01645; ZMMU NAP-01659; ZMMU NAP-01662) — four adult males and A-4571-5 (Field ID ZMMU NAP-01660) — an adult female) from



Fig. 12. Holotype of *Theloderma nebulosum* (by J. J. L. Rowley).

Sui Lan stream bed near Phuoc Son Ranger Station, Cat Loc area, Cat Tien National Park, Lam Dong Province, southern Vietnam ($11^{\circ}37'22.5'' N$ $107^{\circ}17'57.2'' E$;



Fig. 13. *Theloderma palliatum*: holotype (a) (by J. J. L. Rowley) and juvenile from Bidoup Mountain, Bidoup – Nui Ba National park, Lam Dong Province, Vietnam (b, c).

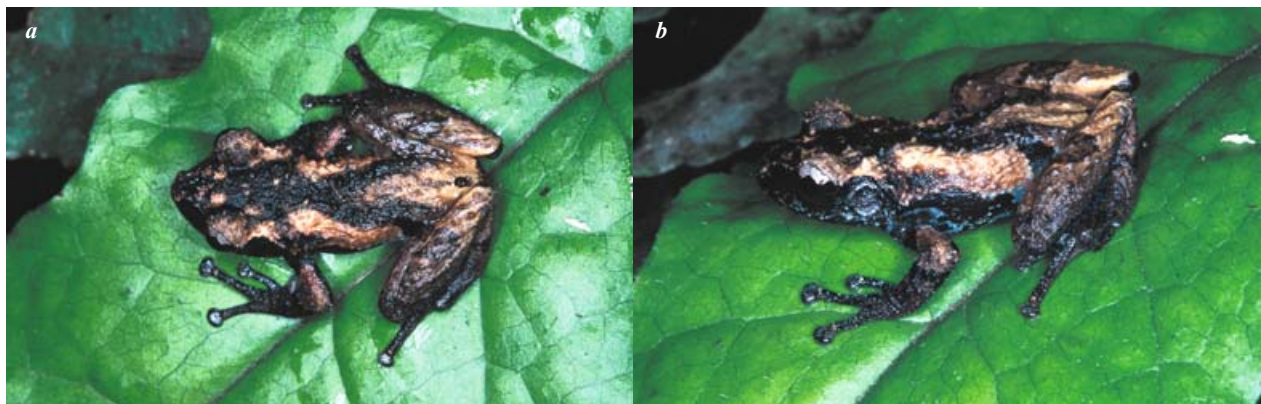


Fig. 14. *Theloderma* species from Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam, 350 m a.s.l.

135 m a.s.l.), collected on 20 – 25.06.2011 by Nikolay A. Poyarkov, Anna Vassilieva and Eduard Galoyan; ZFMK 89000 — an adult male collected in a stream valley near Ben Cau Ranger Station, Cat Loc area, Cat Tien National Park, Lam Dong Province, southern Vietnam (11°42'9.7" N 107°17'6.2" E; 164 m a.s.l.) collected by

Peter Geissler on 24.05.2009; ZMMU A-4572-1 (Field ID ZMMU NAP-00832a) — an adult female from the Da Tapo stream basin, environs of Bau Sau Ranger Station, Nam Cat Tien sector, Cat Tien National Park, Dong Nai Province, southern Vietnam (11°26'37.2" N 107°18'50.6" E; ~125 m a.s.l.), collected on 20.04.2010

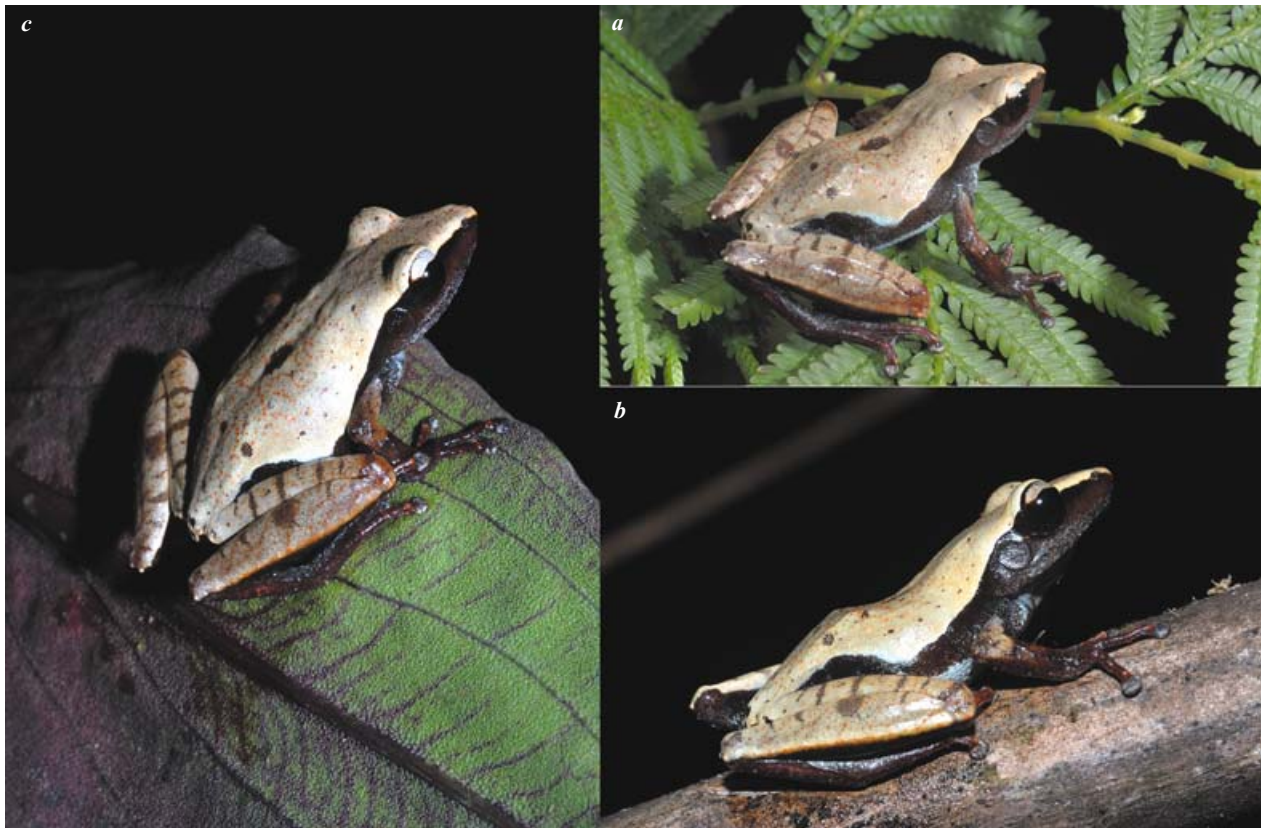


Fig. 15. *Theloderma laeve* from Mang Canh Village, Kon Plong District, Kon Tum Province, Vietnam, 1250 m a.s.l.

by Igor Palko and Anna B. Vassilieva. Photos of paratypes are shown in Figs. 16*b*, *c* and 17).

ZISP 10677 — adult male from the type locality: Phuok Hoa environs, Bu Gia Map National Park, Dak Ka River valley, Bu Gia Map commune, Bu Gia Map District, Binh Phuoc Province, 5 km W from the border with Dak Nong Province, southern Vietnam ($12^{\circ}19.6' N$ $107^{\circ}25.2' E$; ~400 m a.s.l.), collected on 13 – 21.04.2009 by Nikolay A. Poyarkov.

ZISP 10678 — adult female from the type locality: Phuok Hoa environs, Bu Gia Map National Park, Dak Ka River valley, Bu Gia Map commune, Bu Gia Map District, Binh Phuoc Province, 5 km W from the border with Dak Nong Province, southern Vietnam ($12^{\circ}19.6' N$ $107^{\circ}25.2' E$; ~400 m a.s.l.), collected on 26 – 29.05.2011 by Nikolay A. Poyarkov;

ZISP 10679 — adult male from Sui Lan stream valley near Phuoc Son Ranger Station, Cat Loc area, Cat Tien National Park, Lam Dong Province, southern Vietnam ($11^{\circ}37'22.5'' N$ $107^{\circ}17'57.2'' E$; 135 m a.s.l.), collected on 20 – 25.06.2011 by Nikolay A. Poyarkov, Anna Vassilieva and Eduard Galoyan;

Larvae. ZMMU A-4573-5 (Field IDs ZMMU NAP-02447 — a tadpole; and ZMMU NAP-02508 — a metamorph respectively) from the type locality collected by Nikolay A. Poyarkov and Anna B. Vassilieva on 12.06.2011; ZMMU A-4572-2 (Field ID ZMMU NAP-00832b) — a tadpole from the Da Tapo stream valley, environs of Bau Sau Ranger Station, Nam Cat Tien sector, Cat Tien National Park, Dong Nai Province, southern Vietnam ($11^{\circ}26'37.2'' N$ $107^{\circ}18'50.6'' E$; ~125 m a.s.l.), collected on 20.04.2010 by Anna B. Vassilieva; ZMMU A-4571-6-7 (Field ID ZMMU NAP-02507a-b) — tadpoles from Sui Lan stream bed near Phuoc Son Ranger Station, Cat Loc area, Cat Tien National Park, Lam Dong Province, southern Vietnam ($11^{\circ}37'22.5'' N$ $107^{\circ}17'57.2'' E$; 135 m a.s.l.), collected on 20 – 25.06.2011 by Nikolay A. Poyarkov, Anna Vassilieva and Eduard Galoyan (Fig. 18*a* – *c*). The tadpoles are attributed to *Theloderma bambusicolum* sp. nov. because they were reared from eggs laid by adults of the new species, 2 tadpoles were reared till the metamorphosis, the metamorphs showed coloration well corresponding to adults.



Fig. 16. Holotype of *Theloderma bambusicolum* sp. nov. ZMMU A-4569 (Field ID ZMMU NAP-02908) (a), forelimb (d) and hindlimb (e) of holotype; paratype: dorsal (b) and ventral (c) view.

Etymology. The specific epithet “*bambusicolum*” is a Latin adjective in neutral gender, derived from “*bambusa*” (Latin name for “bamboo”) and “*incola*” (Latin for “inhabitant”) in reference to ecological preferences of the new species, which is only found in dense bamboo forests; reproduction, egg laying, larval development of the new species takes place in cracked bamboo stalks filled with water (see *Habitat and natural history*).

Suggested common name. Bamboo moss frog (English), Éch cây sần cây tre (Vietnamese).

Diagnosis. The new species is putatively assigned to the genus *Theloderma* by the presence of distinct tympanum, terminal phalanx with a Y-shaped distal end, intercalary cartilage between the terminal and penultimate phalanges of digits, tips of digits expanded into large disks bearing circummarginal grooves, and the absence of co-ossification of the head skin to the skull, fingers not opposable to each other, not elongated vertebral column, bicolored iris, morphological similarities of tadpoles (see description) and peculiar reproductive behavior (small clutches of large eggs are deposited above water-

filled holes in bamboo trunks) (Liem, 1970; Rowley et al., 2011). *Theloderma bambusicolum* sp. nov. is a small species of *Theloderma* and is characterized by a combination of the following characters: SVL of adult males up to 25.66 mm (22.97 – 25.66 mm; $n = 10$), females up to 25.43 mm (23.01 – 25.43 mm; $n = 6$); body dorsoventrally compressed, elongated and relatively slender; head flat and a little pointed; tympanum round, relatively big and clearly visible, ~50% of eye length; dorsal skin smooth, no asperities or warts on dorsal body surface; ventral skin slightly granular; pupil horizontal; round choanae very big, vomerine teeth absent; webbing between toes moderately developed, webbing between fingers absent. Dorsal surface of body golden-beige with small dark brown spots and blotches of various sizes and irregular shape, usually arranged in a “X”-shaped figure; on the sides the pale golden background bordered with two wide dark brown dorsolateral stripes, with indistinct border from below; body sides and belly light, grayish pink to violet, without any patterns; iris bicolored being

pale gold in upper third and dark orange-red in lower two-thirds.

Description of holotype. Adult male, SVL 25.66 mm, body dorsoventrally compressed, elongated and relatively slender; head flat and a little pointed (HL 9.52 mm, HW 8.20 mm; ESL 15.74% of SVL); eye large (ED 3.35 mm); pupil horizontal; nostril round, cut in lateral direction. Dermal flaps along the external edge of the forelimbs and hindlimbs are absent. Dorsal skin smooth; ventral surface slightly granulated, especially in posterior part of body, more strongly tuberculous around cloaca and on the inner thigh. Tympanum small (TD1.57 mm), approximately 46.86% of eye length, separated from eye by distance less than 1/3 of tympanum length. Supratympanum fold slightly developed but distinct. Vomerine teeth absent; choanae big and round.

Forelimbs (FFL 14.52). Relative length of fingers: I = II < IV < III; tips of fingers dilated into moderately expanded disks; subarticular tubercles large, formula of subarticular tubercles: 1, 1, 2, 2; inner palmar tubercles very poorly developed (Fig. 16d); white velvety nuptial pad (NPL 1.20 mm) at the base of the thumb, webs between fingers absent.

Hindlimbs (HLL 39.78) about 2.74 times length of forelimb; TL 52.96% of SVL; FTL 8.45% of SVL; relative toes length I < II < III = V < IV; toes with rounded disks; subarticular tubercles roundish: 1, 1, 2, 3, 2; inner tarsal fold present; inner metatarsal tubercles roundish; webs between toes moderately developed, formula of webbing I(1)III(1)e(1)III(2)e(1)IVi(1)e(1)V(1.5) (Fig. 16e).

Coloration of holotype in life. Dorsal coloration is pale beige golden with tiny dark brown blotches and spots of irregular shape and size, arranged in an indistinct “X”-shaped pattern from head basis behind the eyes to cloaca; along the midline of dorsum goes thin light golden dorsomedial stripe with small irregular dark brown spots and blotches along it. On the sides the pale golden background of dorsum is bordered with two wide dark brown dorsolateral stripes lasting from snout tip to nostril, center of the eye, goes along supratympanic fold to the head basis behind the eyes, along the body flank and further backwards to groin. Dorsolateral stripes have clear and almost straight medial borders and indistinct lateral borders from below, here the dark brown color slowly vanishes and turns to grayish violet coloration of the lateral body sides. Coloration of body sides and belly light, grayish pink to beige violet, without any spots or patterns. On the outer surfaces of the extremities with tiny golden brown and dark brown spots forming an uniform pattern, proximal part of forelimbs, chest and axillary region beige pinkish to violet. On the outer surfaces of hindlimb golden brown mottling is not as dense



Fig. 17. Paratypes of *Theloderma bambusicolum* sp. nov. showing variation in coloration from Sui Lan stream bed near Phuoc Son Ranger Station, Cat Loc area, Cat Tien National Park, Lam Dong Province, southern Vietnam: a, b, males; c, female.

as on the forelimbs, along the outer surface of thighs, tarsus and tibio-tarsus a tiny straight golden line is distinct. Proximal part of hindlimbs, groin and inguinal region beige pinkish to violet. Outer surfaces of extremities are covered with few dark brown blotches of irregular shape; they are slightly larger on hindlimbs. Iris bicolored with pale gold in upper third and dark orange red in lower two-thirds, pupil black (Figs. 16a – c and 17).

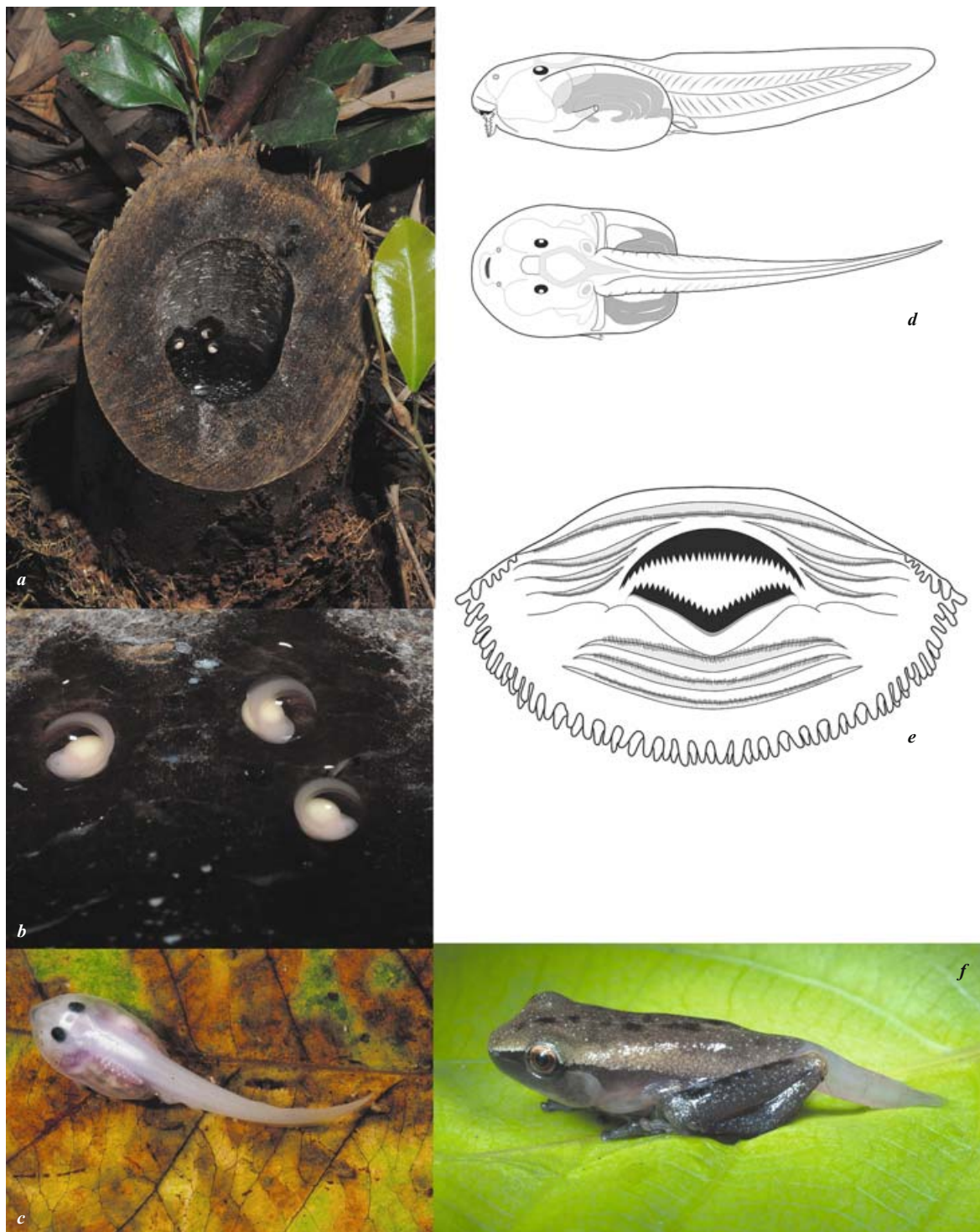


Fig. 18. Egg-laying site and embryos of *Theloderma bambusicolum* sp. nov. in the Phuok Hoa environs, Bu Gia Map National Park, Dak Ka river valley, Bu Gia Map commune, Bu Gia Map District, Binh Phuoc Province, 5 km W from the border with Dak Nong province, southern Vietnam: *a*, reproduction site in the chopped bamboo stem filled with water; *b*, embryos on the wall of bamboo stem; *c*, tadpole in life of *T. bambusicolum* sp. nov. from Sui Lan stream valley near Phuoc Son Ranger Station, Cat Loc area, Cat Tien National Park, Lam Dong Province, southern Vietnam; *d*, lateral and dorsal view of tadpole; *e*, oral disc; *f*, metamorph of *T. bambusicolum* sp. nov. the Phuok Hoa environs, Bu Gia Map National Park, Dak Ka River valley, Bu Gia Map commune, Bu Gia Map District, Binh Phuoc Province, 5 km W from the border with Dak Nong province, southern Vietnam.

Coloration of holotype in preservative. Coloration patterns correspond to those in life, but base color of dorsal surface fades to creamy white, and dark brown is slightly less warm in tone turning grayish-brown.

Measurements of holotype (in mm): SVL 25.66; A-G 11.61; HW 8.20; HL 9.52; HD 3.44; UEW 1.78; IOD 2.66; ED 3.35; TD 1.57; ESL 4.04; TED 0.61; IND 2.16; END 2.46; FLL 14.52; FFL 2.52; FTD 1.32; NPL 1.20; MKTi 0.82; MKTe 0.67; HLL 39.78; FL 11.71; TL 13.99; FOT 17.54; FTL 2.17; FFTL 9.31; HTD 1.22; MTTi 0.65; MTTe 0.67.

Variation and measurements of the paratypes. Variation of morphometric characters of the type series is given in Table 1. Coloration of the type series in general corresponds with coloration of the holotype; variation is insignificant and mostly pronounced in dorsal pattern of small dark spots and blotches, what seems to allow indi-

vidual specimen recognition. No sexual variation in coloration has been recorded.

Tadpole description. Morphological description is based on four tadpoles (Gosner stages 25 – 39) collected in dead bamboo stems filled with water: ZMMU NAP-02447 (Bu Gia Map National Park); ZMMU NAP-00832b (Nam Cat Tien National Park); ZMMU NAP-02507a-b (Cat Loc sector of Cat Tien National Park). The main morphometric parameters of the tadpoles are given in Table 2.

External morphology. Body oval (pyriform on earliest stages, with enlarged head), width/length ratio ~0.7; snout rounded. Eyes dorsal, pupils oriented dorsolaterally. White endolymphatic calcium deposits along the skull and vertebral column clearly visible. Tail relatively short, less than one and half of body length (TaL/BL = 1.30 – 1.45), with moderately developed muscular part; upper and lower fins reach the maximum height in the proximal

TABLE 1. Measurements of 16 Specimens [holotype: ZMMU A-4569 (NAP-02908) in bold, and paratypes: 9 males (ZMMU A-4570-1-2 (NAP-00319, 00320), A-4571-1-4 (NAP-01644, 01645, 01659, 01662), ZFMK 89000 and ZISP (10677, 10679) and 6 females ZMMU A-4573-1-3 (NAP-02906, 02907, 02918), A-4571-5 (NAP-01660), A-4572-1 (NAP-00832a), ZISP 10678] of *T. bambusicolum* sp. nov. (in mm)

Char.	Males										Females					
	4569	4570-1	4570-2	10677	4571-4	4571-3	4570-1	10679	4571-1	89000	4573-2	4573-1	4572-1	10678	4573-3	4571-5
SVL	25.66	24.62	24.69	23.15	24.22	23.73	23.45	22.97	23.56	23.24	25.43	23.01	24.13	24.73	25.32	24.35
A-G	11.61	12.22	11.82	11.23	11.48	11.38	11.56	11.21	11.34	11.72	12.29	11.36	11.96	12.63	12.61	11.91
HW	8.20	7.71	8.10	7.31	7.35	7.39	7.38	7.30	7.35	8.13	8.08	7.36	7.12	7.22	8.08	7.05
HL	9.52	8.50	8.24	7.78	8.26	7.86	7.96	7.68	7.76	7.94	8.84	7.88	8.26	8.30	8.84	8.12
HD	3.44	2.88	2.95	2.81	2.72	2.78	2.89	2.54	2.81	2.86	3.01	2.79	2.92	2.98	3.01	2.84
UEW	1.78	1.69	1.66	1.58	1.63	1.65	1.65	1.48	1.58	1.52	1.72	1.62	1.57	1.67	1.72	1.47
IOD	2.66	2.56	2.57	2.29	2.26	2.53	2.31	2.24	2.51	2.47	2.59	2.28	2.33	2.46	2.59	2.23
ED	3.35	3.39	2.83	2.67	2.71	2.67	2.88	2.89	2.68	2.63	3.29	2.79	3.08	3.27	3.29	3.13
TD	1.57	1.57	1.59	1.44	1.62	1.49	1.66	1.55	1.43	1.50	1.62	1.56	1.54	1.49	1.62	1.44
ESL	4.04	4.01	3.97	3.65	3.55	3.41	3.54	3.57	3.49	3.77	4.03	3.59	3.89	4.19	4.03	3.69
TED	0.61	0.88	0.88	0.72	0.70	0.80	0.85	0.71	0.82	0.68	0.93	0.75	0.74	0.64	0.93	0.71
IND	2.16	2.08	2.12	1.77	1.98	1.74	1.97	1.68	1.76	2.02	2.17	1.78	1.99	1.93	2.17	2.00
END	2.46	2.46	2.35	2.00	2.18	2.16	2.15	2.15	2.18	2.25	2.69	2.05	2.17	2.28	2.69	2.14
FLL	14.52	13.11	13.84	13.32	13.23	13.21	13.52	12.92	13.22	13.54	14.07	13.02	13.55	14.05	14.07	13.51
FFL	2.52	1.68	2.36	1.67	2.08	1.97	1.96	1.91	2.07	2.16	1.92	1.98	1.98	2.11	1.92	1.96
TFL	4.66	3.60	4.53	4.13	3.81	3.84	4.19	3.84	3.81	4.23	4.29	4.14	4.32	4.34	4.29	4.30
FTD	1.32	0.99	1.26	1.28	1.22	1.12	1.28	1.01	1.04	1.24	0.95	1.27	1.16	1.19	0.95	1.17
NPL	1.20	0.98	1.12	0.95	0.96	0.91	1.02	0.93	0.98	0.92	—	—	—	—	—	—
MCTi	0.82	0.55	0.72	0.76	0.59	0.79	0.69	0.78	0.73	0.71	0.57	0.79	0.68	0.81	0.57	0.66
MCTe	0.67	0.34	0.62	0.63	0.41	0.61	0.48	0.52	0.57	0.59	0.44	0.61	0.55	0.65	0.44	0.45
HLL	39.78	43.01	41.14	36.88	38.67	37.57	38.57	38.54	37.48	39.34	42.31	37.57	39.87	39.56	42.31	39.77
FL	11.71	11.73	12.15	10.25	10.33	10.16	10.75	10.69	10.19	12.17	13.31	10.13	11.72	11.66	13.31	11.70
TL	13.99	13.35	13.86	12.17	12.10	12.27	12.82	12.68	12.34	13.76	14.17	12.27	13.30	13.65	14.17	13.31
FOT	17.54	16.71	17.36	16.34	17.26	16.76	16.37	16.82	16.66	17.37	18.35	16.76	16.76	16.73	18.35	16.72
FTL	2.17	1.87	2.08	1.95	1.90	1.92	1.94	1.85	1.98	2.10	1.96	1.92	1.91	1.98	1.96	1.96
FFTL	9.31	10.28	9.48	9.83	9.58	10.53	9.56	9.52	10.52	9.28	11.26	10.53	10.05	10.75	11.26	9.76
HTD	1.22	1.23	1.18	1.28	1.17	1.27	1.20	1.17	1.25	1.16	1.15	1.27	1.18	1.24	1.15	1.19
MTTi	0.65	1.08	0.73	0.59	0.64	0.62	0.68	0.63	0.73	0.68	1.12	0.62	0.77	0.70	1.12	0.75
MTTe	0.67	0.61	0.77	0.67	0.68	0.71	0.72	0.67	0.76	0.72	0.81	0.71	0.68	0.78	0.81	0.69

third of the tail, upper fin does not extend on the trunk and slightly higher than lower fin. Spiracle sinistral, directed posterodorsally, represents a conical tube fused to the body wall with a short free distal portion. Vent tube slightly shifted dextrally, attached to the lower fin, moderately long, with oblique aperture oriented ventrocaudally. Narial apertures small, round, oriented rostrolaterally, surrounded by a low scalloped (6–7 lobes) rim (Fig. 18b–d).

Oral disc. Oral disc ventral, wide, elliptical, lower labium fringed with double row of conical papillae. Black spike-like labial denticles are arranged along the flat unpigmented ridges having a horizontal or (divided ones on the upper labium) oblique orientation: four on the upper labium (one undivided and three divided) and three on the lower labium (all undivided); labial denticles row formula is $4(2-4)/3$. In the smallest tadpole (stage 25) the fourth row on the upper labium was undeveloped. Horn beak is black, with a serrated cutting edges; the upper sheath is wide arch-shaped, lower wide V-shaped (Fig. 18e).

Coloration. Tadpoles in live are totally unpigmented, fleshy pink, semi-transparent, with clearly dis-

tinguishable white endolymphatic calcium deposits along the skull and vertebral column; black eyes and horn beak are clearly visible. In formalin-fixed specimens single, widely dispersed chromatophores are visible on the dorsal surface of the body and lateral surfaces of the tail; their density increases slightly with age (Fig. 18b, c).

Clutches and main developmental parameters.

All known clutches and tadpoles of *Theloderma bambusicolum* sp. nov. were found in cracked dead stems of bamboo shoots filled with waters. In Nam Cat Tien National Park in one such water filled hole were found two tadpoles of different larval stages (Gosner stages 25–26) and a recently laid egg attached to the inner surface of the bamboo shoot above the water. In Bu Gia Map National Park three eggs at the same embryonic stages were found in one bamboo stem, they hatched simultaneously. In Cat Loc National Park in one bamboo stem two tadpoles of slightly different larval stages were recorded.

Clutches normally comprise 2–3 eggs with slimy transparent external egg-capsules which are attached to the inner surface of a bamboo stem ~2–3 cm a.s.l. We do not have information on duration of embryonic development in the new species though it lasts for not less than a week (the clutch from Nam Cat Tien hatched after 6 days from collecting). Tadpoles start active feeding 5 days after hatching. Duration of larval development from hatching to the end of metamorphosis varies from 56 to 63 days. Metamorphs are comparatively large (SVL = 15.4–15.5 mm, $N=2$) vs. SVL = 22.97–25.32 in adults (Table 1). Coloration and dorsal pattern as well as external morphological characters well correspond to that of the adults.

Tadpoles were reared in the original breeding water-body — removed dead bamboo shoot with detritus, to avoid evaporation clean rain-water was regularly added. Tadpoles were fed on dry tropical fish food. Tadpoles were collecting pieces of food from the water surface as well as scrape food particles from the walls of the bamboo shoot.

Distribution. So far *Theloderma bambusicolum* sp. nov. was found in four provinces of southern Vietnam: (1) Phuok Hoa environs, Bu Gia Map National Park, Dak Ka river valley, Bu Gia Map commune, Bu Gia Map District, Binh Phuoc Province, 5 km W from the border with Dak Nong Province, southern Vietnam (12°19.6' N 107°25.2' E; ~400 m a.s.l.) (type locality; (2) the species was also recorded from the locality 5 km eastwards from the terra typica, on the territory of Dak Nong Province); (3) Sui Lan stream valley near Phuoc Son Ranger Station, Cat Loc area, Cat Tien National Park, Lam Dong Province, southern Vietnam (11°37'22.5" N 107°17'57.2" E; 135 m a.s.l.); (4) Ben Cau Ranger Station, Cat Loc area,

TABLE 2. The main morphometric parameters (in mm) of *T. bambusicolum* sp. nov. tadpoles [ZMMU A-4573-4-5 (Field IDs ZMMU NAP-02447; ZMMU NAP-02508; ZMMU A-4572-2 (Field ID ZMMU NAP-00832b); ZMMU A-4571-6-7 (Field ID ZMMU NAP-02507a–b)]

ID	NAP-00832b	NAP-02447	NAP-02507a	NAP-02507b
Gosner stage	25	31	32	39
TL	11.5	25.0	25.2	30.0
BL	4.2	10.2	10.5	13.0
TaL	7.3	14.8	14.7	17.0
BW	3.2	7.0	7.2	9.1
BH	2.3	5.9	6.3	9.2
TH	2.0	6.0	5.2	6.4
SVL	4.9	10.7	11.2	15.2
SSp	3.1	7.0	7.4	9.3
UF	0.7	2.1	1.8	2.2
LF	0.5	1.9	1.5	1.9
IN	1.3	2.3	2.1	2.2
IP	1.4	2.5	2.3	3.5
NR	0.7	0.9	1.0	1.1
NP	1.2	2.0	1.9	2.2
ED	0.2	0.9	1.0	2.0
ND	0.1	0.2	0.2	0.2
ODW	1.6	2.6	2.9	3.2

TL, total length; BL, body length; TaL, tail length; BW, body width; BH, body height; TH, tail height (maximal); SVL, snout-vent length; SSp, snout-spiraculum length; UF, upper fin height (maximal); LF, lower fin height (maximal); IN, inter-narinal distance; IP, inter-pupillar distance; NR, nario-rostral distance; NP, nario-pupillar distance; ED, eye diameter; ND, narial aperture diameter; ODW, oral disk width.



Fig. 19. Habitat of *Theloderma bambusicolum* in the type locality.

Cat Tien National Park, Lam Dong Province, southern Vietnam ($11^{\circ}42'9.7''$ N $107^{\circ}17'6.2''$ E; 164 m a.s.l.) and (5) Da Tapo stream basin, environs of Bau Sau Ranger Station, Nam Cat Tien sector, Cat Tien National Park, Dong Nai Province, southern Vietnam ($11^{\circ}26'37.2''$ N $107^{\circ}18'50.6''$ E; ~125 m a.s.l.) (Fig. 3). It seems that *Theloderma bambusicolum* sp. nov. shows an even wider distribution and inhabits tropical forests of Annamite Mountains foothills. New discoveries are expected in the provinces of southern Vietnam (Dak Nong, Bu Gia Map, Dong Nai, Lam Dong, and, possibly, Binh Thuan) on the altitudes from 100 to 400 m a.s.l. Also since the type locality of the new species is situated just in 20 km from Vietnamese-Cambodian border, a discovery of *Theloderma bambusicolum* sp. nov. in the adjacent part of Cambodia — Mondolkiri Province — is greatly anticipated.

Habitat. At the type locality in the Bu Gia Map National Park specimens were collected in lowland tropical forest in the valley of Dac Ka stream (Fig. 19). The forest condition varies from medium disturbed areas along the road and around the ranger station surrounded with non-disturbed parts of primary multidominant tropical forest. This area is quite hilly, with Dac Ka River tributaries

forming numerous gorges. The forest floor is covered with numerous rocks of volcanic tuff; the canopy is closed for large parts. The forest composition is dominated by Dipterocarpaceae (*Dipterocarpus*, *Hopea*), Fabaceae (*Azelia*), Moraceae (*Ficus*), Lythraceae (*Lagerstroemia*), Anacardiaceae (*Mangifera*) trees. Disturbed forest areas along the roads and in the areas of forest clearings house dense bamboo and rattan palm bushes. In two other known localities — Nam Cat Tien sector (Dong Nai Province) and Cat Loc sector (Lam Dong Province) of Cat Tien National Park *T. bambusicolum* was also recorded in dense bamboo vegetation on the slopes of forest stream valleys. In Nam Cat Tien the bamboo and rattan palm jungles are located in the valley of Da Tapo stream surrounded by undamaged primary multidominant tropical forest. In Cat Loc, the Sui Lan stream flows through greatly damaged pieces of tropical forest almost entirely consisting of bamboos and rattan palms with occasional big trees and mostly open canopy. In all cases *T. bambusicolum* were recorded in bamboo bushes, since this type of plant community is often growing in secondary forests and damaged forest parts, the new species possibly can tolerate quite disturbed communities.



Fig. 20. Foot flagging of *Theloderma bambusicolum*.

Natural history. During two field surveys in the Bu Gia Map National Park in April, 2009 and May, 2011 all specimens were collected in bamboo bushes along the road, approximately in 50–100 m from the nearest stream. All specimens were collected at night time; animals are especially active after heavy rains — up to 17 calling males per 100 m of the road were registered on 26.05.2011. Calling males were registered and located: almost always the male occupies a bamboo leaf or horizontal branch usually around 30–100 cm above the ground in dense bushes. To the human ear, the advertisement call of *T. bambusicolum* sounds like a series of 6–9 notes rising increasing metallic ringing, resembling hammering a tiny anvil. The advertisement call of *T. bambusicolum* sounds very similar to calls of local orthopteran species and can be easily confused. Males appear to be territorial — usually after a series of 5–10 calls male jumps to next bamboo leaf in 20–30 cm and continues calling. The territory demarcated by calling spots usually is ~1–2 m² and often encompasses the potential breeding waterbody — a hollow stem of a bamboo half filled with water, which is probably advertised by the resident male. Silent females were found sitting on leafs close to breeding waterbodies and sometimes registered inside the bamboo stem sitting on the wall. We have not ob-

served amplexus or egg laying behavior, though we found freshly laid clutches consisting of 2–3 eggs attached to the inner surface of the bamboo stem above the water. Males were also found inside the bamboo stems during the day time.

One of the most unusual natural history features of *Theloderma bambusicolum* sp. nov. is a peculiar way of visual communication between males during the reproductive season. On 26–29.05.2011 after heavy evening rains, we were able to observe male territorial behavior in the new species. Calling activity was observed maximum at 9 p.m. till 1 a.m., with up to 17 calling males per 100 m of transect recorded. Resident males after a series of calls demonstrated a clear visual signaling by foot-flagging display (leg waving): slowly the left hindlimb was straightened and waved, after this movement the absolutely similar movement was made by the right hindlimb (Fig. 20). Usually after visual signaling, the resident male jumped to another calling spot on his territory and started calling. If not disturbed in 5–7 min he repeated the leg waving behavior and moved again. In general for three days of observations we recorded foot-flagging display in 8 different males. Moreover we have observed 2 males (a resident and a possible intruder) performing foot-flagging display in front of each other for approximately 3 or 4 min.

Though our observations are so far anecdotal, we believe that the observed behavior is used in visual communication in the *Theloderma bambusicolum* sp. nov. Although anurans are well known to use auditory signals as the primary mode of intraspecific communication (Gerhardt, 1994; Rand, 1988; Wells, 1977), individuals of some species perform remarkable visual displays in variable social contexts (Davison, 1984; Haddad and Giaretta, 1999; Harding, 1982; Lindquist and Hetherington, 1996; Richards and James, 1992). Reviews on the use of visual displays by anuran amphibians (Hoedl and Amezcuita, 2001; Amezcuita and Hoedl, 2001), reveal that all species performing visual displays perform acoustic displays as well, which makes it difficult to separate the functional role of each mode of communication. To our knowledge, this is the first report of visual displays and leg waving behavior in the family Rhacophoridae. A detailed description of acoustic and territorial behavior of *Theloderma bambusicolum* sp. nov. will be published elsewhere.

Comparisons. *Theloderma bambusicolum* sp. nov. (SVL 23.01–25.66 mm) can be distinguished from large congeners *T. bicolor* (Bourret, 1937), *T. corticale* (Boulenger, 1903), *T. gordonii* Taylor, 1962, *T. horridum* (Boulenger, 1903), *T. kwangsiense* Liu and Hu, 1962, *T. leporosum* Tschudi, 1838, *T. moloch* (Annandale, 1912), *T. nagalandense* Orlov, Dutta, Ghate et Kent, 2006,

T. phrynoderma (Ahl, 1927), and *T. ryabovi* Orlov, Dutta, Ghate et Kent, 2006 (adult males SVL over 40 mm) by its small size; moreover all large congeners possess heavily warty skin on dorsal surface with well developed dorsal asperities forming conspicuous ridges (dorsal skin smooth with no tubercles or asperities in *Theloderma bambusicolum* sp. nov.). *Theloderma bambusicolum* differs from all species of small rhacophorids known from Indochina and southern China in its appearance and following morphological details. From members of the genus *Chiromantis* *Theloderma bambusicolum* sp. nov. differs in having not opposable fingers and body being not elongated (vs. opposable fingers and elongated trunk in *Chiromantis*, see Liem, 1970). From *Chiromantis doriae* (Boulenger, 1893), *Chiromantis nongkhorensis* (Cochran, 1927), and *Chiromantis vittatus* (Boulenger, 1887) (Fig. 9b, c) the new species differs by iris coloration: *Theloderma bambusicolum* sp. nov. has iris of eye bi-colored with pale gold in upper third and dark orange red in lower two-thirds (vs. monochrome yellow or brown color of iris in species of *Chiromantis*). From *Feihyla palpebralis* (Smith, 1924) the new species differs by absence of vomerine tooth (vomerine tooth present in *F. palpebralis*) (Fig. 9a, d).

Theloderma bambusicolum sp. nov. differs from the majority of species of *Philautus*, *Kurixalus*, and *Raorchestes* [*Philautus maosonensis* Bourret, 1937; *Philautus abditus* Inger, Orlov et Darevsky, 1999; *Philautus petilus* Stuart et Heatwole, 2004; *Philautus aurifasciatus* (Schlegel, 1837); *Philautus cardamonis* Ohler, Swan et Daltry, 2002; *Philautus cinerascens* (Stoliczka, 1870); *Philautus garo* (Boulenger, 1919); *Philautus kempii* (Annandale, 1912); *Philautus tythius* Smith, 1940; *Kurixalus ananjevae* (Matsui et Orlov, 2004); *Kurixalus baliogaster* (Inger, Orlov et Darevsky, 1999); *Kurixalus banaensis* (Bourret, 1939); *Kurixalus carinensis* (Boulenger, 1893); *Kurixalus odontotarsus* (Ye et Fei, 1993); *Kurixalus verrucosus* (Boulenger, 1893); *Raorchestes gryllus* (Smith, 1924); *Raorchestes longchuanensis* (Yang et Li, 1978); *Raorchestes parvulus* (Boulenger, 1893); *Raorchestes menglaensis* (Kou, 1990); *Raorchestes shillongensis* (Pillai et Chanda, 1973)] of Indochina by relatively slender and flat body, pale golden color of the back and a light creamy-violet belly.

Moreover, from majority of *Kurixalus* species the new species differs in absence of vomerine teeth (present in the genus *Kurixalus*). From *Gracixalus ananjevae* the new species is different in its dorsal and ventral coloration (pale-golden dorsal coloration and light not spotted pinkish or gray-violet coloration of ventral surfaces in *Theloderma bambusicolum* sp. nov.). From green *Gracixalus* species [*Gracixalus gracilipes* (Bourret, 1937); *G. supercornutus* Orlov, Ho et Truong, 2004; *Gracixalus*

guyeti Nguyen, Hendrix, Böhme, Vu et Ziegler, 2008; and *Gracixalus quangi* Rowley, Dau, Nguyen, Cao et Nguyen, 2011]. *Theloderma bambusicolum* sp. nov. further differs by pale-golden dorsal coloration and light not spotted pinkish or gray-violet coloration of ventral surfaces (green or greenish color of the back, transparent skin and belly without dark spots in green *Gracixalus*).

Theloderma bambusicolum sp. nov. differs from *Nyctixalus pictus* (Peters, 1871) by its supratympanic fold (absent in *N. pictus*), absence of white tubercles on dorsal surface of the body (present in *N. pictus*), rounded almost absent canthus rostralis (vs. sharp canthus rostralis in *N. pictus*), bony ridges from canthus rostralis to occiput absent (vs. present in *N. pictus*).

T. bambusicolum sp. nov. resembles different small species of *Theloderma* sensu Orlov et al., 2006; Bain et al., 2009, Li et al., 2009 and Rowley et al., 2011. From *T. asperum* (Boulenger, 1886) [= *Philautus albopunctatus* Liu et Hu, 1962 by Frost, 2011], *T. stellatum* Taylor, 1962, *T. licin* McLeod et Ahmad, 2007, and *Theloderma baibengensis* (Jiang, Fei et Huang, 2009) the new species differs in total absence of finger webbing and smooth dorsal skin (vs. finger webbing developed, dorsal skin with tubercles and asperities). From *T. lateriticum* Bain, Nguyen et Doan, 2009 the new species is distinct in pale-golden dorsal coloration (vs. brick-red dorsal coloration in *T. lateriticum*) with dark brown spots forming a “X”-shaped pattern (absent in *T. lateriticum*). From *T. rhododiscus* (Liu et Hu 1962) the new species is distinct in gray-brown ventral digital surfaces and presence of the “X”-shaped dorsal pattern (vs. bright orange-red ventral digital surfaces, “X”-shaped dorsal pattern absent in *T. rhododiscus*). From *T. bambusicolum* other small *Theloderma* species such as *T. truongsongense* (Orlov et Ho, 2005); *T. nebulosum* Rowley, Le, Hoang, Dau et Cao, 2011; *T. palliatum* Rowley, Le, Hoang, Dau et Cao, 2011, and *T. chuyangsinense* sp. nov. are different in spotted ventral coloration and presence of strongly or moderately developed tubercles and asperities in supraorbital area and small tubercles dispersed along the dorsal surface of the body (vs. light unspotted pinkish or gray-violet ventral coloration and smooth dorsal skin in *T. bambusicolum* sp. nov.). From *T. laeve* (Smith, 1924) the new species differs in light coloration of ventral surfaces (vs. grayish belly with dark spots in *T. laeve*) and in pale-golden dorsal coloration with dark brown spots forming a “X”-shaped pattern (absent in *T. laeve*).

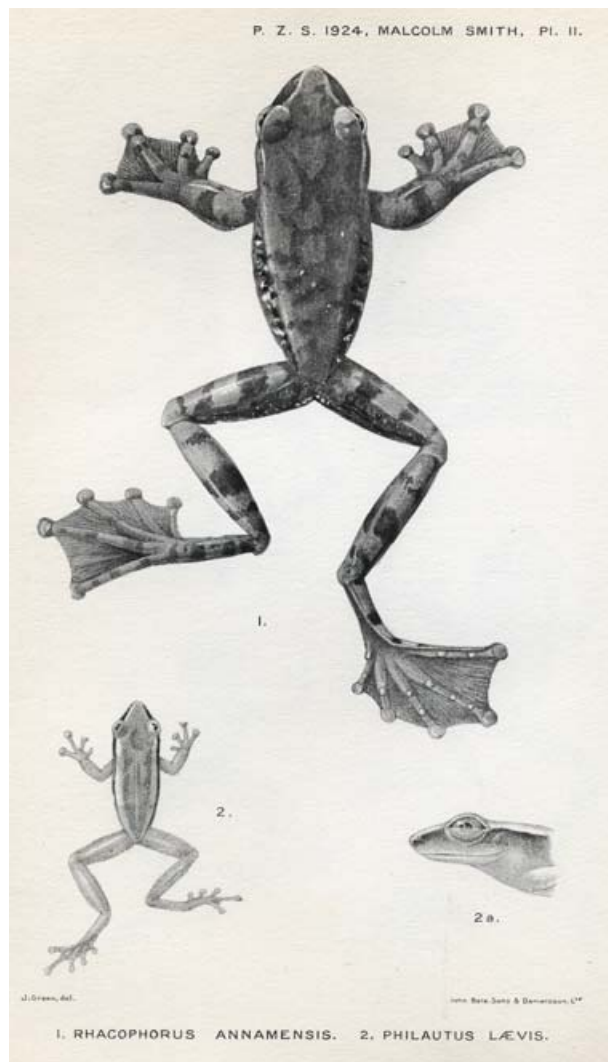


Fig. 21. Pictures of holotype of *Philautus laevis* by Smith, 1924.

TAXONOMY AND DISTRIBUTION NOTES ON SMALL *Theloderma* WITH TWO NEW COMBINATIONS

***Theloderma laeve* new combination**
[= *Chiromantis laevis* (Smith, 1924)] and
***Theloderma truongsongense* new combination**
[= *Philautus truongsongensis* Orlov et Ho 2005]

In the paper of Rowley et al. (2011) *Philautus truongsongensis* Orlov et Ho 2005 was referred to genus *Theloderma*, *Theloderma truongsongensis* new combination was offered: “We included *Philautus truongsongensis* Orlov et Ho 2005 in the molecular analysis due to its morphological similarity with the new Kon Tum and

Langbian specimens, along with members of possible sister groups to the genus as outgroups: *Nyctixalus pictus*, *Kurixalus eiffingeri* (type species for the genus *Kurixalus*) and *Philautus aurifasciatus* (type species for the genus *Philautus*) (Rowley et al., 2011).”

However, it should be noted that in this article *Philautus laevis* Smith, 1924 [= *Chiromantis laevis* — Frost et al., 2006] was considered as *Philautus truongsongensis* because of an erroneous identification. So on page 7 in Fig. 2 in No. AMS R 171 510 a typical *Chiromantis laevis* is shown (for comparison: Fig. 21 — drawings by Smith, 1924, plate II (2-2a) and figures by Orlov et al., 2004, p. 63 — Fig. 24) but *Philautus truongsongensis* (*Theloderma truongsongense* comb. nov.) is indicated. In view of erroneous identification this new combination can not be accepted. Even without going into details of the comparison should be noted that *Chiromantis laevis* has smooth skin, especially on the dorsal surface, while *Philautus truongsongensis* has “small tubercles also dispersed along the dorsal surface of the body, skin slightly tuberculous” (Orlov and Ho, 2005).

Nevertheless, there is no doubt that *Chiromantis laevis* (*T. truongsongense* sensu Rowley) shall be assigned to *Theloderma* genus on the basis of Rowley et al. (2011) conclusions: “Our preliminary molecular phylogenies suggest that the Kon Tum Plateau specimens are most closely related to *Philautus truongsongensis*, differing by 8.5% from the single *P. truongsongensis* (= *Chiromantis laevis* sensu this article) analyzed and >8.5% at the 16S rRNA gene from all *Theloderma* in the analysis. The Langbian specimens appear most closely related to *T. rhododiscus*, but differed by 8.5 – 8.8% from this species and >8.5% at the 16S rRNA gene from all *Theloderma* specimens in the analysis.” Thus *Theloderma laeve* new combination (sensu this article) should be proposed.

***Theloderma laeve* (Smith, 1924) comb. nov.** (Figs. 15 and 22)

Philautus laevis Smith, 1924, *Proc. Zool. Soc. London*, 1924, 230 – 231. Holotype: M. Smith 2439, by original designation; BMNH 1947.2.5.94 by Bossuyt and Dubois (2001), *Zeylanica*, 6, 43. Type locality: “Sui Kat, alt. 1000 m, Langbian Plateau, S. Annam,” Vietnam (Fig. 3).

Chirixalus laevis — Inger in Frost, 1985, *Amph. Species World*: 538.

Chiromantis laevis — Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan, Raxworthy, Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green, and Wheeler, 2006, *Bull. Am. Mus. Nat. Hist.*, 297, 367.



Fig. 22. *Theloderma leave* from Kon Plong, Kon Tum Province, Vietnam, dorsal (a) and ventral (b).

Theloderma truongsone comb. nov. — Rowley, Le, Hoang, Dau and Cao (2011), *Zootaxa*, **3098**, 1 – 20(7).

Distribution. Inhabits mountain regions in Thua Thien-Hue (Bach Ma National Park), Da Nang (Ba Na National Park), Quang Nam (Song Thanh), Kon Tum (Ngoc Ling Nature Reserve and Mang Canh Village, Kon Plong District), Gia Lai (Kon Cha Rang Nature Reserve, An Khe District; K Bang and Krong Pa Districts) and

Dak Lak (Ea So Nature Reserve, Ea Kar District, 12°56' N 108°37' E) provinces at the elevation 700 – 1400 m a.s.l. (Smith, 1924; Bourret, 1942; Orlov et al., 2001, 2002, 2004; Orlov and Ho, 2005; Orlov, Ananjeva, 2007; Nguyen et al., 2009; Rowley et al., 2011) (Fig. 3).

Unconfirmed and doubtful localities. Indication to *Theloderma laeve* (as *Chiromantis laevis* — Nguyen et al., 2009) in Nghe An Province (Pu Mat Nature Reserve), we consider as erroneous.

Taxonomic comment. Above in the description of *T. chuyangsinense* sp. nov. it was noted that *T. leave* (Smith, 1924); *T. truongsone* (Orlov et Ho, 2005); *T. nebulosum* Rowley, Le, Hoang, Dau et Cao, 2011; *T. palliatum* Rowley, Le, Hoang, Dau et Cao, 2011; *T. chuyangsinense* sp. nov.; and *Theloderma* sp. (Phong Nha – Ke Bang National Park) are subject to very similar morphological diagnosis, differing very little details in color, the external structure of the skin and body size, forming a group of similar and closely related species (Figs. 1, 11 – 15, 16a – c, 17, 22). We also propose to apply the *Theloderma truongsone* new combination (sensu this article).

***Theloderma truongsone* (Orlov et Ho, 2005)
new combination (Figs. 1 and 2)**

Philautus truongsone Orlov and Ho (2005), *Russ. J. Herpetol.*, **12**(2), 137(137 – 144). Holotype: ZISP 7407. Type locality: “Ban Cup village, Huong Hoa District, Quang Tri Province, central Vietnam (16°55'09" N 106°35'04" E, 400 m elevation)” (Fig. 3.).

Distribution. Found in Quang Binh (Phong Nha – Ke Bang National Park), Quang Tri (Ban Cup village, Huong Hoa District — type locality), Thua Thien – Hue (Bach Ma National Park, A Luoi and Huong Thuy Districts), Da Nang (Ba Na National Park) Kon Tum (Mang Canh Village, Kon Plong District, Ngoc Linh Nature Reserve), Gia Lai (Buon Luoi, 20 km northwest of the town Kannack — 14°20' N 108°36' E, An Khe District; Kon Cha Rang, 60 km northwest of the town Kannack, An Khe District) and Dak Lak (Ea So Nature Reserve, Ea Kar District, 108°37' E 12°56' N) provinces at the elevation 350 – 1400 m a.s.l. (Orlov, Ananjeva, 2007; Nguyen et al., 2009) (Fig. 3).

Taxonomic comment. The combination *Theloderma truongsone* comb. nov. — Rowley, Le, Hoang, Dau and Cao (2011), *Zootaxa*, **3098**, 1 – 20(7) — can be applied only to *Theloderma laeve* (Smith, 1924) and does not belong to *Theloderma truongsone* sensu this article.

Theloderma species (Fig. 14)

Philautus truongsone — part in Orlov and Ho (2005), *Russ. J. Herpetol.*, **12**(2), 142(137 – 144).

Distribution. The species is found in Phong Nha – Ke Bang National Park in Quang Binh Province at the elevation 350 m a.s.l. (Fig. 3) (Orlov, Ananjeva, 2007; Orlov et al., 2010).

Taxonomic comment. This species was placed within *Philautus truongsone*, but in our opinion should now be considered as a distinct species of the genus *Theloderma*.

New record of *Theloderma palliatum* Rowley, Le, Hoang, Dau et Cao, 2011

Rowley et al. (2011) described this species from montane evergreen forest in Bidoup-Nui Ba National Park, Lac Duong District, Lam Dong Province, Vietnam at the elevation 1500 – 1625 m a.s.l. (Figs. 3 and 13a). On 12.07.11 on the southern slope of Bidoup mountain at elevation 1820 m a.s.l. we discovered a hollow horizontal tree trunk, with mossy interior walls and partially filled with water with a layer of dark organic substance and detritus on the bottom. On the inner walls of the hollow two typical theloderm clutches were found, with 5 and 4 developing embryos correspondingly. In addition, tadpoles of different developmental stages, from newly hatched to premetamorphic stages were recorded. A pre-metamorphic tadpole was reared till metamorphosis; adult frog was identified as *Theloderma palliatum* Rowley, Le, Hoang, Dau et Cao, 2011 on the basis of great morphological similarity of the froglet with the description of adult *T. palliatum* in the original article by Rowley et al. (2011). (Figs. 13b, c and 23).

Tadpole description of *Theloderma palliatum* Rowley, Le, Hoang, Dau et Cao, 2011

In appearance the tadpole of *T. palliatum* is quite similar to the tadpoles of other species of *Theloderma*, in particular, *T. stellatum* (Wassersug et al., 1981), *T. asperum* (Leong, Lim, 2003), and *T. nebulosum* (Rowley et al., 2011). Morphological description is based on two tadpoles (Gosner stages 27 – 28) collected in tree hollow filled with water: ZMMU NAP-02515 (Bi Dup – Nui Ba National Park). The main morphometric parameters of

TABLE 3. The Main Morphometric Parameters (in mm) of *Theloderma palliatum* Rowley, Le, Hoang, Dau et Cao, 2011 tadpoles

Sample ID	Gosner stage	TL	BL	TaL	BW	BH	TH	SVL	SSp	
NAP-02515a	27	21.2	9.2	11.9	6.6	5.2	5.1	10.0	6.3	
NAP-02515b	28	23.0	10.1	12.9	7.6	6.8	5.6	11.0	6.5	
		UF	LF	IN	IP	NR	NP	ED	ND	ODW
NAP-02515a	27	1.4	1.6	2.0	2.5	0.9	2.0	0.85	0.4	2.4
NAP-02515b	28	1.4	1.6	2.1	2.7	0.9	2.0	0.9	0.4	2.6

the tadpoles is given in Table 3. A more detailed description, including figures showing mouthpart structures, will follow later.

External morphology. Body oval, depressed dorso-ventrally, width/length ratio approximately 0.72 – 0.75; snout almost straight. In fixed specimens lateral lymphatic sacs are visible on each side of body; they look as thickened horizontal ridges extending along the posterior half of the body at midlevel. Eyes dorsal, pupils oriented dorsolaterally. Tail relatively short, less than one and half of body length ($TaL/BL = 1.28 - 1.29$), with rounded tip and well developed muscular part. Upper tail fin originates slightly posteriorly to the level of tail base; upper and lower fins reach the maximum height in medium third of the tail. Spiracle sinistral, directed posterodorsally, represents a relatively wide and short tube fused to the body wall without free distal portion. Vent tube medial, attached to the lower fin, moderately long, with oblique aperture oriented ventrocaudally. Narial apertures small, round, oriented rostrally, surrounded by a thickened rim. Mouth anteroventral, bordered with elliptical oral disc.

Oral disc. Oral disc wide, elliptical, lower labium fringed with double row of conical papillae. Black spike-like labial denticles are arranged along the flat unpigmented ridges having a horizontal or oblique orientation: four on the upper labium (one undivided and three divided) and three on the lower labium (all undivided); labial denticles row formula is $4(2-4)/3$. Horn beak possess a serrated cutting edges; the upper and lower sheaths are wide arch-shaped.

Coloration. Tadpoles in life have a dense brown pigmentation on the dorsal and lateral surface of body and tail; ventral surface is much clearer, grayish in color. Lower half of lower tail fin is totally unpigmented. Eyes and keratinized mouthparts are black. Lines of neuromasts are poorly visible on the head and on the dorsal surface of body and tail.

REDESCRIPTION AND DISTRIBUTION OF *Raorchestes gryllus*

Raorchestes gryllus (Smith, 1924) (Figs. 6a and 24)

Philautus gryllus Smith, 1924, *Proc. Zool. Soc. London*, **1924**, 225 – 234. **Holotype:** M. Smith 2439, by original designation; BMNH 1947.2.5.95 by Bossuyt and Dubois (2001), *Zeylanica*, **6**, 44 (Fig. 25).

Pseudophilautus gryllus — Li, Che, Murphy, Zhao, Zhao, Rao, and Zhang (2009), *Mol. Phylogenet. Evol.*, **53**, 511.



Fig. 23. Tadpole of *Theلودerma palliatum* from Bidoup Mount, Bidoup – Nui Ba National park, Lam Dong Province, Vietnam.

Raorchestes gryllus — Biju, Shouche, Dubois, Dutta, and Bossuyt (2010), *Curr. Sci. Bangalore*, **98**, 1120 (1119 – 1125).

Type locality. “Langbian Peaks, alt. 2000 m, Langbian Plateau, S. Annam,” Vietnam.

Distribution. Various research including some recent works report *R. gryllus* for relatively wide area comprising the major part of northern and southern Vietnam, the species was reported for the following provinces: Lam Dong, Dak Lak, Gia Lai, Kon Tum, Lao Cai, Ha Giang, Cao Bang, Tuyen Quang, Lang Son, Vinh Phuc, Thanh Hoa, and Bac Thai and also for Laos: Sepian, Boloven Highlands and Champasak Province (Bourret, 1937, 1939, 1942; Orlov et al., 2002; Teynie et al., 2004; Nguyen et al., 2005, 2009; Frost, 2011). Originally the species was described as *Philautus gryllus* by Smith (1924) from Langbian Plateau in Lam Dong Province, southern Vietnam. Later Bourret (1937, 1939, 1942) identified material from Tam Dao, Tonkin as *P. gryllus* and thus included North Vietnam into the species range. Bourret’s view on distribution of *P. gryllus* was later repeated in all subsequent works by various authors. However on Fig. 161 of his work Bourret (1942:460) gives pictures of *P. gryllus* types (syntypes) from Smith (1924, plate III) (Figs. 25 and 26) and also adds a picture of a larger *Philautus* specimen identified as *P. gryllus* Smith, 1924. SVL of this specimen comprises 43 mm (vs. 25 – 27 mm in *P. gryllus* by original description) and most likely it corresponds to cf. *Kurixalus odontotarsus* (Ye and Fei, 1993) (Fig. 26). Many later works also sometimes identified as *P. gryllus* other species of *Kurixalus*, including *Kurixalus banaensis* (Bourret, 1939); *Kurixalus verrucosus* (Boulenger, 1893), and other species. According to our opinion reliable records of *Raorchestes* (= *Philautus*) *gryllus* are only located in Lang Bian plateau and adjacent isolated mountain systems of southern Truong Son in Dak Lak and Lam Dong provinces of Vietnam. Possibly this species also inhabits mountains of Gia

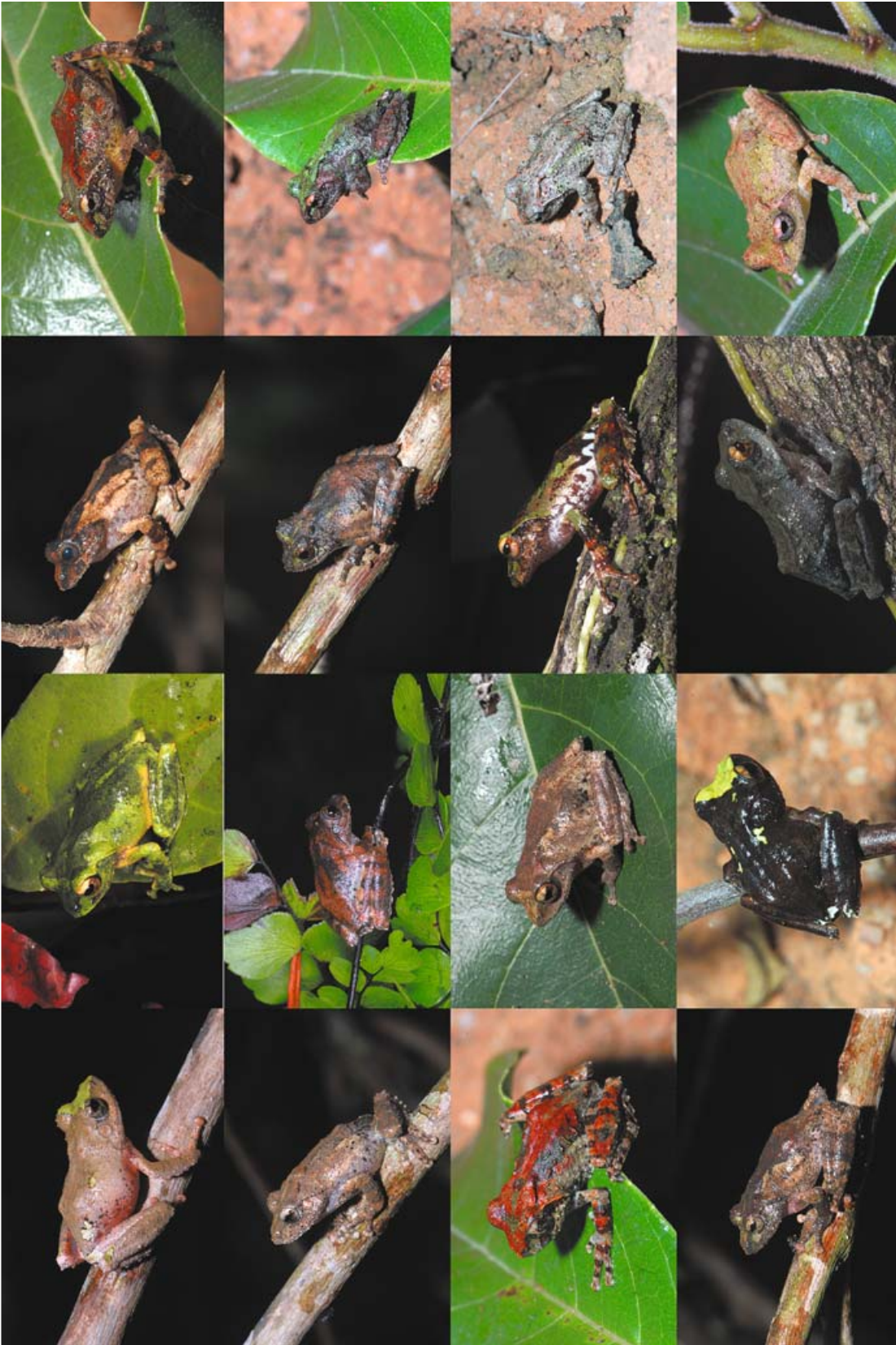


Fig. 24. Polymorphism of *Raorchestes gryllus* from Chu Yang Sin and Bidoup – Nui Ba National parks.

Lai, Kon Tum and Thua Thien-Hue provinces, however extent of this species in Central Vietnam needs to be confirmed in light of several sympatric morphologically very similar species that have been reported to occur throughout this area, e.g., *Kurixalus verrucosus* (Boulenger, 1893) and *Kurixalus banaensis* (Bourret, 1939). Species identification basing on just morphological characters is complicated and wide application of molecular identification methods is required. It is noteworthy that Biju et al. (2010) basing on molecular data of Li et al. (2009) confirm affiliation of *Philautus gryllus* with the newly established genus *Raorchestes* Biju et al., 2010. However, the specimens used in phylogenetic analysis by Li et al. (2009) were collected from Pac Ban, Tuyen Quang, North Vietnam, the area where according to our understanding records of *Raorchestes* (= *Philautus*) *gryllus* sensu stricto seem to be highly improbable. Moreover, the majority of *Raorchestes* Biju et al., 2010 species, e.g., *Raorchestes glandulosus* (Jerdon, 1854) [type species], *Raorchestes resplendens* Biju, Shouche, Dubois, Dutta et Bossuyt, 2010, and *Raorchestes parvulus* (Boulenger, 1893) lack dermal fringes on the outer edge of fore- and hindlimbs, whereas it is well developed in *Raorchestes gryllus* and morphologically similar members of the genus *Kurixalus*. Finally, there are some differences in appearance of egg capsule which is transparent in *Raorchestes* species (Biju et al., 2010) and some Sri Lankan *Philautus* sensu lato species (Bahir et al., 2005), whereas in *Raorchestes gryllus* egg capsule is quite thick and semi-transparent (for details see Reproductive biology and clutches below). Thus we believe that allocation of *Philautus gryllus* Smith, 1924 to the genus *Raorchestes* is preliminary taxonomic act. However it is evident that actual phylogenetic position and taxonomic allocation of *Raorchestes gryllus* as well as taxonomic structure of the genus *Raorchestes* Biju et al., 2010 requires further research and clarification by means of molecular phylogenetic analyses.

Redescription

Diagnosis. *Raorchestes gryllus* (sensu this article) is characterized by the following combination of morphological attributes: robust body; head relatively large and broad; pupil horizontal; choanae small, rounded, not hidden by the edge of the jaw; vomerine teeth absent; nostril round, cut in lateral direction, a little nearer the tip of the snout than the eye; tympanum big, round, distinctly visible; snout of males pointed and more rounded in females; canthus rostralis fairly distinct; dorsal skin slightly tuberculous, ventral skin slightly granular; dermal fringes well developed on the outer edges of both forelimbs and outer edge of tarsus (Smith (1924) indicates that this species is distinguished from *Philautus petersi* (Boulenger, 1900)

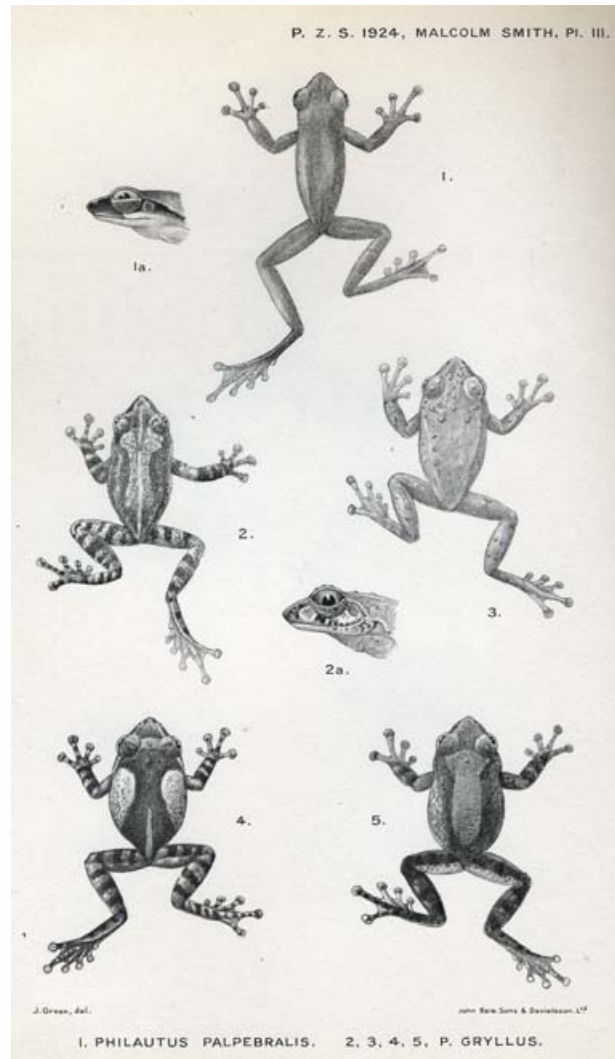


Fig. 25. Syntypes of *Philautus gryllus* by Smith, 1924 (plate II, Figs. 2 – 5).

and *Philautus aurifasciatus* (Schlegel, 1837): “in the fringe of tubercles along the outer sides of the limbs”); webs between fingers not developed, only a rudiment faintly visible web is developed between fingers 3 and 4. The male has a large subgular vocal sac.

Forelimbs. Relative length of fingers: $I < II < IV < III$; tips of fingers dilated into large expanded disks; fingers with round discs having circummarginal grooves; subarticular tubercles rounded, large, formula of subarticular tubercles: 1, 1, 2; 1; inner palmar tubercles good developed, roundish; well developed white nuptial pad on the thumb; webbing on hands are absent, only a rudiment faintly visible web is noticeable between third and

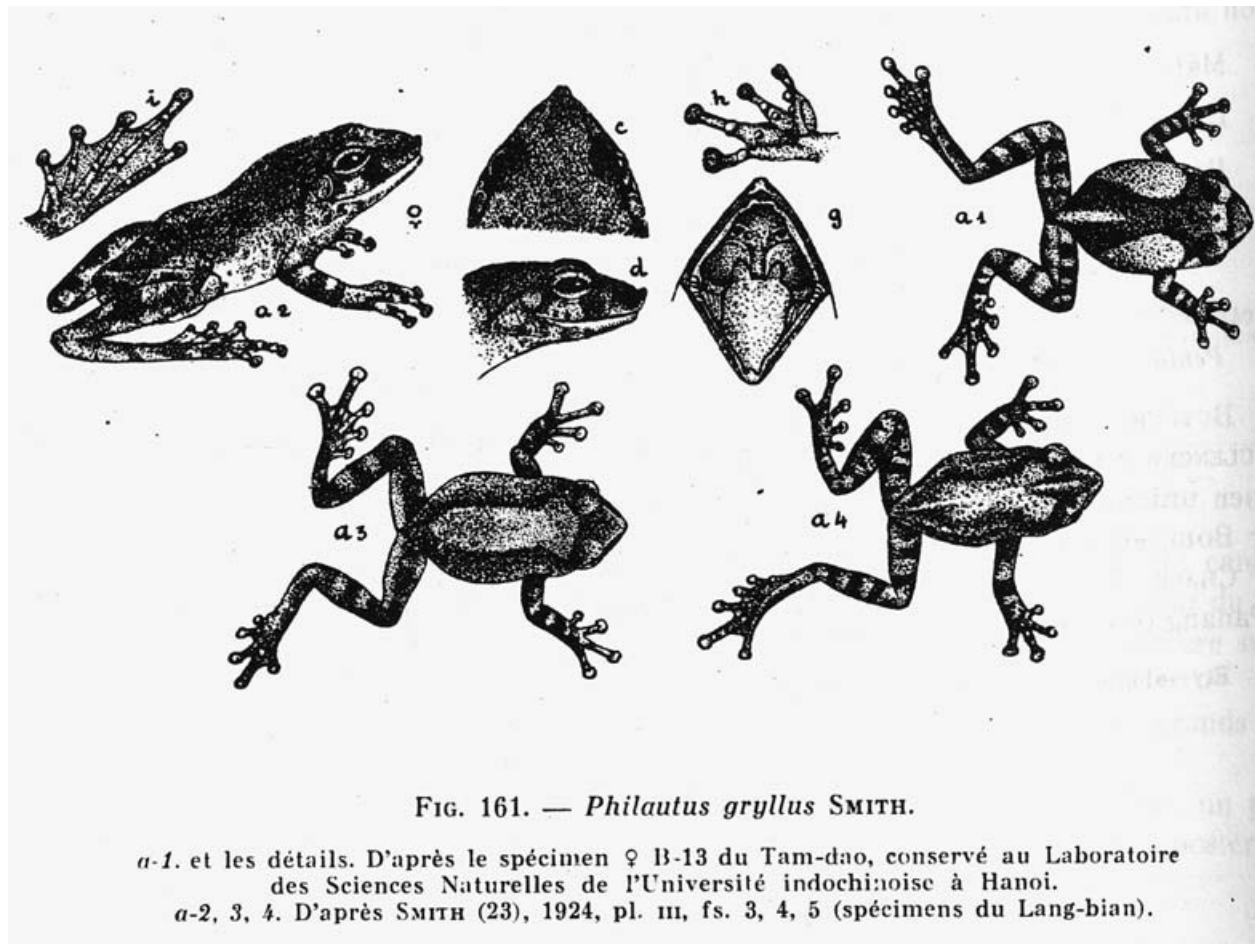


Fig. 26. Drawings of *Philautus gryllus* from Bourret (1942:460, Fig. 161): *Ph. gryllus* types from Smith (1924, plate III) and also adds a picture of a larger *Philautus* specimen from northern Vietnam (Tam Dao National Park, Vinh Phuc Province) identified as *P. gryllus* Smith, 1924.

fourth fingers. Dermal fringe along the outer edge of forelimb is well developed.

Hindlimbs. Relative toes length $I < II < III < V < IV$; discs of toes smaller than those of fingers; toes with rounded disks; subarticular tubercles distinct, roundish: 1, 1, 2, 3, 2; inner tarsal fold present; inner metatarsal tubercles roundish; webs between toes moderately developed, formula of webbing $I(1)II(1)e(0.5)III(1.5)e(0)IV(1)e(1)V(0)$. Dermal fringe along the outer edge of tarsus is well developed.

This species is remarkable due to its extraordinary variability in coloration and dorsal patterns (Fig. 24). Dorsal coloration may combine different hues of green, yellow, red, brown, grayish and almost black colors, the background colors can quickly change depending on physiological condition of the animal. Morphometric measurements for 5 females: ZISP 10557 – 10561 (ZISP F Nos. 474; 475; 490; 673; 684) and 15 males: ZISP

10542 – 10556 (ZISP F Nos. 517; 686; 660; 590; 464; 663; 586; 492; 596; 678; 501; 595; 592; 583; 593) are shown in Table 4.

Reproductive biology and clutches

Two clutches of *Raorchestes gryllus* were found on 28.06.10 and 30.06.10, on the top of the southern peak of Hon Giao mountain (Bidoup — Nui Ba National Park, border of Lam Dong and Khanh Khoa provinces) on different altitudes (1680 and 2000 m a.s.l.) (Fig. 27a). Clutches were kept in wet moss and leaf litter in boxes with temperature approximately 20 – 24°C. Both clutches were found on the ground: the first one was found in the roots of a small tree growing on a slope of stream-bed, the second one was laid under the rotten log in the humid soil covered with mosses. Clutches were not buried, just laid on the ground. First clutch consisted of 21 eggs, second — 22. Eggs adhered to each other but were easily separated without any damage for the egg

TABLE 4. Measurements of 20 specimens [15 males: ZISP 10542 – 10556 (ZISP F Nos. 517; 686; 660; 590; 464; 663; 586; 492; 596; 678; 501; 595; 592; 583; 593) and 5 females: ZISP 10557 – 10561 (ZISP F Nos. 474; 475; 490; 673; 684)] of *Raorchestes gryllus* from Dak Lak and Lam Dong Provinces (in mm)

Character	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♀	♀	♀	♀	♀
SVL	24.71	24.08	23.72	25.49	23.84	26.53	27.82	26.36	23.69	24.40	28.57	24.41	24.54	25.78	26.67	33.52	32.69	32.74	28.10	24.66
A-G	12.16	12.00	11.98	12.53	12.02	13.13	15.20	13.11	11.99	12.83	16.93	12.85	12.88	12.26	12.98	18.63	18.19	18.38	15.21	12.31
HW	9.83	9.84	9.83	10.05	9.79	10.74	11.31	10.68	9.80	10.12	12.34	10.19	10.52	9.85	11.05	14.77	14.65	14.75	12.31	9.67
HL	8.78	8.56	8.34	8.94	8.58	10.17	11.72	10.07	8.35	8.58	11.92	8.55	9.18	8.64	9.24	14.91	14.12	13.98	11.77	8.29
HD	4.98	4.95	4.83	5.03	4.75	5.19	6.04	5.15	4.81	5.37	6.84	5.38	5.57	4.83	6.13	7.14	7.10	7.15	6.12	4.77
UEW	3.75	3.52	3.48	3.77	3.44	3.94	4.82	3.84	3.28	3.61	5.52	3.52	3.78	3.72	3.87	6.11	5.87	5.85	4.84	3.42
IOD	3.82	3.68	3.71	3.98	3.62	4.16	5.12	4.12	3.72	3.84	5.41	3.74	4.02	3.68	4.98	6.51	6.23	6.17	5.42	3.21
ED	4.00	3.88	3.96	3.95	3.88	4.05	4.21	3.95	3.88	3.89	4.58	3.88	3.98	3.57	4.35	5.20	5.31	5.24	4.25	3.85
TD	2.26	2.12	2.14	2.38	2.12	2.41	2.48	2.37	2.23	2.28	2.68	2.26	2.44	2.28	2.78	3.47	3.28	2.95	2.49	1.92
ESL	4.35	4.41	4.31	4.52	4.27	4.69	5.23	4.49	4.29	4.53	5.73	4.51	4.66	4.33	4.81	6.53	6.55	6.46	5.50	4.29
TED	0.93	0.91	0.88	1.01	0.92	1.04	1.07	1.02	0.89	1.08	1.18	1.02	1.14	0.96	1.11	1.38	1.37	1.52	1.07	0.76
IND	2.12	2.14	2.05	2.14	2.00	2.29	2.59	2.31	2.17	2.45	2.92	2.51	2.65	2.12	2.24	3.41	3.48	3.45	2.69	2.14
END	2.20	2.18	2.13	2.23	2.11	2.27	2.68	2.28	2.15	2.32	3.06	2.44	2.42	2.24	2.68	3.48	3.56	3.57	2.77	2.10
FLL	15.33	15.18	15.16	15.78	15.06	16.61	19.64	16.53	15.23	18.22	19.82	18.26	18.87	15.76	16.23	22.61	22.48	22.53	19.12	15.93
FFL	2.98	3.05	2.82	2.93	2.74	3.17	3.29	3.05	2.86	3.12	3.44	3.06	3.26	2.87	3.09	4.45	4.49	4.32	3.49	2.92
TFL	5.64	5.72	5.57	5.70	5.62	5.89	6.07	5.76	5.61	5.82	6.59	5.80	5.92	5.67	6.57	6.85	6.93	7.07	6.06	4.99
FTD	1.31	1.28	1.19	1.33	1.15	1.38	1.72	1.35	1.21	1.58	1.76	1.56	1.69	1.28	1.34	2.15	2.15	2.12	1.76	1.28
NPL	2.22	2.19	2.14	2.26	2.02	2.26	2.33	2.16	2.15	2.32	2.38	2.33	2.51	2.26	2.30	—	—	—	—	—
HLL	40.98	40.80	40.79	41.18	40.39	41.44	48.86	41.34	41.01	46.48	49.71	46.41	48.39	40.98	46.19	59.33	58.30	57.35	48.89	40.64
FL	12.12	12.10	12.14	12.14	12.02	12.14	14.52	12.14	12.26	14.44	14.92	14.38	14.94	12.08	14.24	17.45	17.42	17.15	14.54	11.79
TL	12.82	12.78	12.72	12.93	12.72	13.03	14.64	13.02	12.82	14.78	15.04	14.76	15.28	12.88	14.93	17.82	17.63	17.23	14.63	12.61
FOT	16.04	15.92	15.91	16.11	15.65	16.27	19.70	16.18	15.93	17.26	19.75	17.27	18.17	16.02	17.02	24.06	23.25	22.97	19.72	16.24
FTL	2.26	2.26	2.18	2.24	2.10	2.32	2.91	2.32	2.18	2.26	2.91	2.26	2.26	2.24	2.24	3.17	3.15	3.15	2.91	2.23
FFTL	6.26	6.52	6.48	7.06	5.86	7.01	8.43	7.01	6.48	6.52	8.43	6.52	6.52	7.06	7.06	9.86	9.88	9.73	8.43	6.74
HTD	0.96	0.95	0.92	1.05	0.81	1.07	1.09	1.07	0.92	0.95	1.09	0.95	0.95	1.05	1.05	1.55	1.52	1.56	1.09	0.95

capsule. Egg capsule gelatinous, quite thick, slightly blurred, brownish and semi-transparent. The first clutch was collected at the stage 2b (following Bahir et al., 2005); egg external diameter was around 8.15 mm, internal diameter (with external egg capsule removed) — 6.3 mm (measured $N=2$). The second clutch was collected at the stage 4 (following Bahir et al., 2005); average egg external diameter comprised 9.37 mm (9.15 – 9.63 mm, measured $N=5$). Direct development, froglets at hatching had short reduced tails and remains of yolk in guts. Hatchlings coloration well corresponded to adult coloration. Froglet SVL at hatching varies insignificantly 6.3 – 6.9 mm ($N=7$) (Fig. 27b). Embryonic development from the collection to hatching lasted for 25 – 30 days for both clutches.

REDESCRIPTION AND TAXONOMY OPINION ABOUT *Rhacophorus calcaneus* SMITH, 1924 AND *Rhacophorus chuyangsinensis* ORLOV, NGUYEN ET HO, 2008 AND REDESCRIPTION OF THE NEW SPECIES *Rhacophorus*

Taxonomical comments. Inger et al. (1999) mentioned 16 species of rhacophorids from Gia Lai Province,

8 of which at first found in Vietnam after their description, and 3 species described as new (*Rhacophorus exochopygus* Inger, Orlov et Darevsky, 1999; *Kurixalus baliogaster* (Inger, Orlov et Darevsky, 1999); *Philautus abditus* Inger, Orlov et Darevsky, 1999). Among new records in that paper is particularly important to note *Feihyla palpebralis* (Smith, 1924); *Theloderma stellatum* Taylor, 1962; *Theloderma gordonii* Taylor, 1962; *Rhacophorus annamensis* Smith, 1924; and *Rhacophorus calcaneus* Smith, 1924. With regard to the latter species on page 34 – 35 Inger et al., (1999) given an extended description, which was preceded by the following statement: “These frogs from Buon Luoi, Tram Lap and Kon Cha Ran appear to be the first specimens of *R. calcaneus* collected since the unique holotype was described by Smith (1924)” (Fig. 28). Orlov et al. (2008) provide a description of *Rhacophorus chuyangsinensis* Orlov, Nguyen et Ho, 2008 from Chu Yang Sin National Park, Krong Bong District, south part of Dak Lak Province, central Vietnam. Further study of rhacophorids of this region of Vietnam has led us to the view that (1) the description of *Rhacophorus chuyangsinensis* corresponds to description of *Rhacophorus calcaneus* Smith, 1924, and this name should be considered as a junior synonym



Fig. 27. Eggs (a) and embryo before hatching (b) of *Raorchestes gryllus*.

of *R. calcaneus* Smith, 1924 (Fig. 29) and (2) *R. calcaneus* (sensu Inger et al., 1999) should be described as a new species.

***Rhacophorus robertingeri* sp. nov.**
(Figs. 30a, b, 31 – 33)

Holotype. ZISP 10662 an adult male from the Mang Canh village, Kon Plong District, Kon Tum Province, 14°41'18" N 108°19'28" E, Vietnam; 1200 m a.s.l. elevation, collected on May 15, 2006, by Nguyen Thien Tao, Daniel A. Melnikov, Roman A. Nazarov, Nikolai L. Orlov and Ho Thu Cuc (Fig. 30a, b).

Etymology. The specific name is given in honor of Professor Robert Frederick Inger, famous zoologist, herpetologist and explorer of the world fauna of amphibians and reptiles, mostly in Asia, the author of numerous descriptions of amphibians and reptiles, a leading expert in the field of amphibian fauna of Southeast Asia, Curator Emeritus of Division of Amphibians and Reptiles of the Field Museum, Chicago, USA.



Fig. 28. Drawings of holotype of *R. calcaneus* from Smith, 1924 (Plate I, Figs. 3-3a).

Diagnosis. *Rhacophorus robertingeri* sp. nov. is characterized by a combination of the following characters: habitus stocky; head relatively large and broad; snout sharply pointed, sloping downward in front of nostrils, projecting beyond lower jaw; nostril round, cut in lateral direction of snout; nostril closer to tip of snout than to eye; pupil horizontal; canthi sharp, weakly constricted; lores sloping, weakly concave; diameter of eye less than length of snout; interorbital wider than eyelid; tympanum less than half diameter of eye, distinctly visible; vomerine teeth in oblique groups beginning near anterior corns of rounded choanae. Finger tips with large, round discs, those of outer fingers wider than tympanum; first finger webbed to subarticular tubercle, second finger to just below disc, third finger to distal edge of distal



Fig. 29. *Rhacophorus calcaneus* from Chu Yang Sin National Park, Krong Bong District, south part of Dak Lak Province, Vietnam.

subarticular tubercle laterally, and fourth finger midway between disc and tubercle; subarticular tubercles conspicuous. Discs of toes smaller than those of fingers; web to base of discs of first three toes laterally and fifth toe medially, narrowly to disc laterally on fourth toe; a low oval inner but no outer metatarsal tubercle. Dorsal skin generally smooth; a striating, strong supratympanic fold extending just beyond level of axilla; throat finely granular; ventral skin granular, especially below the waist front forelimb to the groin; dermal fringes well developed along the outer edges of forelimbs and tarsus; pointed projection at tibiotarsal articulation very well defined; a long, pointed projection at tibiotarsal joint; a low supra-anal ridge; several large, pointed tubercles below vent. Mail nuptial pad white, on dorsal and medial surfaces of first metacarpal; vocal sac openings elongated.

Background and pattern of dorsal coloration are highly variable, dominated by yellow-and red-brown tones with orange, cream, white and dark brown spots disordered, the ventral surface of the body can be light gray, cream, ivory color, without spots, or with a well-pronounced dark nettles.



Fig. 30. Holotype (ZISP 10662) of *Rhacophorus robertingeri*, dorsal (a) and ventral (b) view; forelimb (c) and hindlimb (d) of paratype *Rhacophorus robertingeri* (ZISP 10654).

Description of the holotype. Adult male, SVL 40.15 mm, habitus stocky; body dorsoventrally compressed; head relatively large and broad (HL 14.63 mm, HW 14.11); snout sharply pointed (ESL 17.26% of SVL), sloping downward in front of nostrils, projecting beyond lower jaw; eye large (ED 6.73 mm); pupil horizontal; canthi sharp, weakly constricted; lores sloping, weakly concave; tympanum is relatively small (TD 2.69 mm), round, distinctly visible, less than half diameter of eye, separated from eye by distance less than 1/2 of tympanum length; interorbital wider than eyelid; supratympanic fold strong developed; vomerine teeth in oblique groups beginning near anterior corns of rounded choanae; tongue attached anteriorly, deeply notched posteriorly; nostril round, cut in lateral direction of snout; nostril closer to tip of snout than to eye. Dorsal skin generally smooth; a striating, strong supratympanic fold extending just beyond level of axilla; throat finely granular; ventral skin granular, especially below the waist front forelimb to the groin, strongly developed tubercles in area around cloaca, dermal fringes developed along the outer margins of forelimbs and tarsus; a low supra-anal ridge. Mail nuptial pad white, on dorsal and medial surfaces of first metacarpal; vocal sac openings elongated.



Fig. 31. Paratype (ZISP 10662) of *Rhacophorus robertingeri*, dorsal (a) and ventral (b) view.

Forelimbs: FLL 25.76 mm; relative length of fingers: $I < II < IV < III$; finger tips with large, round discs, those of outer fingers wider than tympanum; first finger webbed to subarticular tubercle, second finger to just below disc, third finger to distal edge of distal subarticular tubercle laterally, and fourth finger midway between it and tubercle; subarticular tubercles conspicuous, formula of subarticular tubercles: 1, 1, 2; 2; palmar tubercles elongated; well developed white nuptial pad on the thumb, on dorsal and medial surfaces of first metacarpal (Fig. 30d).

Hindlimbs: Pointed projection at tibiotarsal articulation very well defined; HLL (59.53 mm) about 2.31 times length of forelimb (25.76); tibia length 42.56% of SVL; FTL 13.07% of SVL; FFTL 26.05% of SVL; relative toes length $I < II < III < V < IV$; toes with rounded disks; discs of toes smaller than those of fingers; webs between toes moderately developed, web to base of discs of first three toes laterally and fifth toe medially, narrowly to disc laterally on fourth toe; a low oval inner but no outer metatarsal tubercle; subarticular tubercles distinct, roundish: 1, 1, 2, 3, 2; formula of webbing $I(0.5)II(0.5)e(0)III(0)e(0)IV(0.5)e(0.5)V(0)$ (Fig. 30c).

Coloration in life. Coloration of the dorsal surface red-brown with black and brown spots of irregular shape; lilac-white spots pass from the eye to the groin almost merging into a continuous strip, forming a ring around cloaca; along the outer surface of the tarsus and the tibia extend elongated spots of lilac-white color; the ventral surface of body yellowish-cream with rare darker nettles (Figs. 32 and 33).

Color in alcohol. Color patterns in alcohol correspond with color in life, but the color intensity decreases to grayish-brown color (Fig. 30a, b).

Measurements of holotype (in mm): Body and head: SVL 40.15; A-G 19.37; HW 14.11; HL 14.63; HD 7.61; UEW 5.52; IOD 7.45; ED 6.73; TD 2.69; ESL 6.93;

TED 1.55; IND 4.09; END 3.82. **Forelimbs:** FLL 25.76; FFL 5.92; TFL 7.22; FTD 3.18; NPL 4.35; MKTi 2.65; MKTe 2.56. **Hindlimbs:** HLL 59.53; FL 17.30; TL 17.09; FOT 25.14; FTL 5.25; FFTL 10.46; HTD 2.38; MTTi 1.97; MTTe 1.93.

Paratypes. ZISP 8300 – 8306, 8309, 8311 – 8314, 10652, 10653; ZMMU A-4568-1, A-4568-2 — 15 adult males and ZISP 8307, 8310, 10654, 10656; ZMMU A-4568-3 — 5 adult females from the Mang Canh Village, Konplong District, Kon Tum Province, $14^{\circ}41'18''$ N $108^{\circ}19'28''$ E, Vietnam, 1200 m a.s.l. elevation, collected on April 12, 2005, by Sergei A. Ryabov, Nikolai L. Orlov and Ho Thu Cuc; ZISP 10657 — an adult female and ZISP 10658 – 10661, 10663 – 10666 — eight adult males from the same locality, collected on May 15, 2006, by Nguyen Thien Tao, Daniel A. Melnikov, Roman A. Nazarov, Nikolai L. Orlov, and Ho Thu Cuc (Fig. 31).

Variation and measurements (in mm) of the paratypes. Variation of the type series is presented in Table 5. Coloration of paratypes in general corresponds to the color described for the holotype, but the number, size and location of white and dark spots on the back greatly varies as well as the number of dark specks on the ventral side. Both patterns may be completely absent (Figs. 32, 33).

Habitat and natural history. Mountain areas in Gia Lai, Kon Tum, Quang Nam-Da Nang and Thua Thien-Hue provinces at elevations from 400 to 1700 m a.s.l. Frog inhabits the valley of mountain streams in predominantly primary monsoon and rain forests. These are forest areas with closed canopy mainly on gentle slopes of the mountains (in Kon Tum and Thua Thien-Hue provinces) or gentle valleys of streams (Gia Lai Province in Tay Nguyen Plateau) with groves of large trees and tree ferns, thorny palms, lianas and various epiphytes. Forest is cut by a large number of cascade streams, with aggregations of stones and rocks, covered with epiphytes and ferns.

Frogs avoid light areas, inhabiting very shady areas. They were always noted two peaks of reproduction — in March – June and October – November, less active reproduction was noted also in the summer months. Maximum activation occurs after heavy rains and during the small protracted rains. At night, just after sunset we can hear clear distinctive clicking calls of males. Individual males abruptly vocalize during the day — in cloudy, rainy weather, which clearly demonstrate their presence. Singing males occupied the position on the trees and in the shrubs along streams, usually at a height of 2 – 5 m and at a distance of 20 – 30 m from the stream, often in 2 – 5 m from the stream. Couples in amplexus are observed on the vegetation above the water in those areas

where cascade streams form the backwaters, wetlands spills with a thick layer of leaf litter, they avoid open coast.

Compared with other related species of the genus (*R. annamensis*, *R. rhodopus*, *R. kio*), inhabiting the same parts of the forest, they never form large aggregations. Usually we counted in 100 m of bank of the stream in appropriate habitats at the peak of reproductive activity ~5–6 singing adult males and one–two pair in amplexus (Fig. 33e). Such a density was observed in May and October in Buon Luoi, Tram Lap, Kon Cha Rang (Kannack town, An Khe District, Gia Lai Province, Vietnam, 750–1100 m a.s.l. elevation); Mang Khanh (Kon Plong, Kon Tum province, Vietnam, 1200–1250 m a.s.l. elevation) and Bach Ma (Thua Thien-Hue Province, Vietnam, 500 m a.s.l. elevation). Construction of the elongated nests occurs only after darkness. A pair in amplexus participate in construction process, but almost all of the actions are made by the female (slimy excretions and hind legs whipping on “foam”). Maximal diameter of constructed nest is 10–14 cm.

The nests most resemble the nests of *R. kio*, they are located on the branches of a bush in twisted leaves, at a height of 0.5–2 m above the ground, often within a few meters from the water (Fig. 34). The construction of the nest and laying of 100–500 large eggs without a pigment occurs within 5–6 h after darkness. Apparently, the developing larvae from the collapsing nest washes into the stream flows in the rain for 4–5 days.

Distribution. Species inhabits mainly mountain regions in northern part of Tay Nguyen Plateau in Gia Lai (A Yun Pa Proposed Nature Reserve in Krong Pa District; Buon Luoi and Tram Lap Villages, Kon Cha Rang Nature Reserve in An Khe and Tay Son Districts; Kon Ka Kinh National Park, K’Bang, Dak Doa and Mang Yang Districts) and Kon Tum (Ngok Linh Nature Reserve — Ngok Linh Mountain in Dac Glei District and Kon Plong District) provinces, as well as in Quang Nam-Da Nang (Ba Na-Nui Chua Nature Reserve) and Thua Thien-Hue (Bach Ma National Park) provinces, Vietnam (Fig. 35).

TABLE 5. Measurements of 20 Specimens (holotype: male ZISP 10662, in bold, and paratypes: 14 males ZISP 8300–8306, 8309, 8311–8314, 10652, 10653; ZMMU A-4568-1, A-4568-2 — 15 adult males and ZISP 8307, 8310, 10654, 10656; ZMMU A-4568-3 — 5 adult females) of *Rhacophorus robertingeri* sp. nov. (in mm)

Character	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♀	♀	♀	♀	♀
SVL	40.15	40.37	39.84	37.11	43.55	40.59	42.68	41.37	37.71	41.06	40.94	36.04	38.45	38.97	41.32	57.68	56.91	54.08	49.35	56.75
A-G	19.37	19.46	18.67	16.05	19.76	17.13	18.94	21.41	21.06	18.83	20.47	17.57	17.18	18.47	22.07	28.69	29.11	27.43	23.36	27.78
HW	14.11	14.54	14.59	13.78	15.09	14.74	14.87	14.56	14.12	14.22	14.59	12.96	14.52	15.05	15.15	22.68	21.03	19.86	18.62	21.32
HL	14.63	14.86	14.43	14.06	14.89	14.32	14.25	15.27	14.14	14.65	15.02	13.84	14.17	14.68	15.22	21.35	19.58	19.98	19.26	20.89
HD	7.61	7.65	7.23	7.03	8.75	7.47	7.82	7.78	6.98	7.42	7.75	5.68	7.57	7.86	8.14	11.15	10.49	9.95	8.48	11.42
UEW	5.52	5.73	5.64	5.27	5.94	5.62	5.68	5.42	5.39	5.63	5.72	5.14	5.75	5.32	5.89	7.44	6.79	6.71	6.27	7.18
IOD	7.45	6.97	7.46	6.98	7.62	6.93	7.64	7.06	6.82	6.98	7.48	5.94	7.02	7.63	7.98	8.06	7.93	8.07	7.81	7.87
ED	6.73	6.68	6.69	6.25	6.88	6.71	6.73	6.48	6.19	6.50	6.58	5.87	6.38	6.61	6.92	7.96	7.95	6.72	6.35	7.85
TD	2.69	2.72	2.78	2.38	2.75	2.51	2.48	2.55	2.43	2.72	2.68	2.26	2.46	2.53	2.79	3.47	3.13	2.95	2.65	3.52
ESL	6.93	6.94	6.45	6.52	7.07	6.71	7.05	6.98	6.59	6.89	6.74	5.94	6.36	6.83	7.13	10.26	9.61	9.56	9.13	10.34
TED	1.55	1.71	1.57	1.31	1.72	1.58	1.67	1.32	1.27	1.43	1.62	1.12	1.24	1.56	1.72	1.95	1.98	2.14	2.17	1.72
IND	4.09	4.14	4.25	4.14	4.38	4.32	4.59	4.41	4.17	4.35	4.04	3.82	4.32	4.41	4.84	5.63	5.02	5.68	5.36	5.34
END	3.82	3.88	3.52	3.23	3.92	3.90	3.68	3.57	3.40	3.51	3.72	3.32	3.42	3.28	3.88	5.74	5.55	4.73	4.88	5.67
FLL	25.76	25.68	24.57	22.78	25.66	26.61	26.62	26.14	22.85	25.78	24.83	23.01	24.27	25.73	26.28	39.72	33.74	32.78	30.09	35.83
FFL	5.92	5.95	5.82	4.93	5.74	5.02	5.89	5.36	4.86	5.14	5.49	5.14	5.66	5.87	6.09	9.76	9.61	9.74	9.49	9.82
TFL	7.22	7.32	7.57	6.70	7.62	6.93	7.22	7.38	6.72	7.24	7.10	6.58	5.92	5.67	6.57	12.45	11.74	8.75	8.98	11.27
FTD	3.18	3.28	2.99	3.13	3.45	3.38	3.74	3.15	3.14	3.58	3.26	2.86	3.19	3.38	3.94	4.23	3.85	3.92	4.19	4.67
NPL	4.35	4.59	4.24	4.12	5.02	4.26	4.33	4.22	4.31	4.33	4.38	4.13	4.21	4.56	4.97	—	—	—	—	—
MCTi	2.65	2.67	2.35	2.32	2.81	2.44	2.38	2.41	2.33	2.52	2.46	2.46	2.38	2.45	2.83	3.72	3.89	3.32	3.28	3.81
MCTe	2.56	2.61	2.46	2.35	2.93	2.53	2.63	2.76	2.46	2.38	2.38	2.42	2.27	2.43	2.72	3.36	3.52	3.25	2.89	3.55
HLL	59.53	62.07	60.55	55.48	67.70	65.29	67.86	66.56	59.11	64.14	64.79	58.08	60.99	63.42	67.89	94.05	92.22	90.30	84.39	88.90
FL	17.30	17.83	16.28	15.54	18.12	18.27	17.52	17.19	16.26	16.87	17.02	16.73	17.34	18.12	18.34	26.02	25.32	25.07	22.73	24.89
TL	17.09	18.22	18.35	16.83	20.49	19.12	21.64	21.02	17.82	20.31	21.12	17.96	18.98	19.58	21.13	29.51	29.54	27.83	26.16	27.57
FOT	25.14	26.02	25.92	23.11	29.09	27.90	28.70	28.35	25.03	26.96	26.75	23.39	24.67	25.72	28.42	38.52	37.36	37.45	35.50	36.44
FTL	5.25	5.26	5.18	5.14	6.78	6.32	5.91	6.12	5.82	5.31	5.29	5.06	5.16	5.24	6.64	8.14	7.45	3.15	7.32	7.46
FFTL	10.46	10.52	10.48	9.60	12.33	10.01	11.43	10.52	9.48	10.78	10.83	9.51	9.96	10.84	11.36	16.01	15.49	9.73	12.63	15.23
HTD	2.38	2.25	2.02	2.05	2.18	2.27	2.09	2.07	1.92	2.35	2.09	1.94	2.35	2.28	2.36	3.13	2.96	3.01	3.04	2.95
MTTi	1.97	1.94	1.78	1.73	2.02	1.82	1.92	1.82	1.91	1.92	2.01	1.68	1.80	1.97	2.04	3.04	3.27	3.12	3.04	3.22
MTTe	1.93	1.93	1.69	1.71	1.99	1.75	1.88	1.77	1.73	1.86	1.85	1.62	1.69	1.82	2.01	2.83	3.05	2.98	2.56	2.92



Fig. 32. Polymorphism of *Rhacophorus robertingeri* from type locality.

Unconfirmed and doubtful localities. Apparently from the distribution should be excluded following localities:

R. robertingeri (as *R. calcaneus*) — Tam Dao, Vinh Phuc and Huong Son, Ha Tinh (Nguyen et al., 2009) mis-

identification with *R. orlovi*; *R. robertingeri* (as *R. calcaneus*) — Chu Yang Sin, Dak Lak and Bidoup, Lac Duong, Lam Dong (Orlov, Ananjeva, 2007; Nguyen et al., 2009) misidentification with juv. *Rhacophorus vampyrus*; *R. robertingeri* (as *R. calcaneus*) — Da Teh,



Fig. 33. Polymorphism of *Rhacophorus robertingeri* from type locality (a – d) and amplexus (e).



Fig. 34. Nest of *Rhacophorus robertingeri* from type locality.

Lam Dong (Nguyen et al., 2009) possibly due to misidentification with *Rhacophorus rhodopus*.

Comparisons. *Rhacophorus robertingeri* sp. nov. is sympatric or parapatric with such other species of the genus *Rhacophorus* Kuhl et Van Hasselt, 1822, as *R. annamensis* Smith, 1924, *R. exechopygus* Inger, Orlov et Darvsky, 1999, *R. kio* Ohler et Delorme, 2006, *R. rhodopus* Liu et Hu, 1960, *R. marmoridorsum* Orlov, 2008, *R. feae* Boulenger, 1893, *R. orlovi* Ziegler et Köhler, 2001. Two other species of group: *R. calcaneus* Smith, 1924, and *R. vampyrus* Rowley, Le, Thi, Stuart et Hoang, 2010 are distributed in the mountains of more southern Lam Dong and Dak Lak provinces (Fig. 35).

R. maximus Günther, 1858, *R. hoanglienensis* Orlov, Lathrop, Murphy et Ho, 2001, *R. hungfuensis* Liu et Hu, 1961, *R. dorsovirens* Bourret, 1937, *R. spelaus* Orlov, Gnophanxay, Phimminith et Phomphoumy, 2010, *R. nigropunctatus* Liu, Hu et Yang, 1962, *R. minimus* Rao, Wilkinson et Liu, 2006, *R. duboisi* Ohler, Marquis, Swan et Grosjean, 2000, *R. appendiculatus* (Günther, 1858), *R. dugritei* (David, 1872), *R. dennysi* Blanford, 1881, *R. omeimontis* (Stejneger, 1924), *R. puerensis* (He, 1999), *R. yinggelingensis* Chou, Lau et Chan, 2007, *R. yaoshanensis* Liu et Hu, 1962, *R. chenfu* Liu, 1945 are also known in northern Vietnam, Laos and southern

China; *R. bipunctatus* Ahl, 1927, *R. dulitensis* Boulenger, 1892, *R. pardalis* Günther, 1858, *R. prominans* Smith, 1924, *R. reinwardtii* (Schlegel, 1840), *R. robinsonii* Boulenger, 1903, *R. cyanopunctatus* Manthey et Steiof, 1998 inhabit southern Indochina. *Rhacophorus suffry* Bortoloi, Bortamuli et Ohler, 2007 lives in Eastern Himalaya.

R. robertingeri sp. nov. (adult males SVL 37.11 – 43.55 mm) can further be distinguished from large congeners *R. kio*, *R. reinwardtii*, *R. prominans*, *R. feae*, *R. maximus*, *R. duboisi*, *R. omeimontis*, and *R. dennysi*, (adult males SVL over 58 mm); in addition, these large species are totally or partly green (yellow and red-brown in *R. robertingeri* sp. nov.). New species differs from the large brown *R. annamensis*, *R. exechopygus*, *R. robinsonii*, and *R. pardalis* (adult males SVL over 45 mm) by smaller size and different webbing pattern: web reaching edge of subarticular tubercle of first finger, to disc of three outer fingers; whereas first finger webbed to subarticular tubercle, second finger to just below disc, third finger to distal edge of distal subarticular tubercle laterally, and fourth finger midway between disc and tubercle in *R. robertingeri* sp. nov. (Fig. 30d). From small and medium-sized bright green or greenish species *R. hungfuensis*, *R. yaoshanensis*, *R. yinggelingensis*, *R. dorsovirens*, *R. nigropunctatus*, *R. minimus*, *R. dugritei*, *R. puerensis*, *R. chenfu*, *R. suffry* new species is distinguished by a yellow-brown or pinkish color. From *R. rhodopus* and *R. bipunctatus* new species differs by somewhat larger size (adult males: SVL 37.11 – 43.55 mm in *R. robertingeri* sp. nov.; SVL 33.1 – 39.8, 35 – 37 mm in *R. rhodopus* and *R. bipunctatus*) and color (dorsal coloration mostly yellow-brown or pinkish with orange and dark brown spots disordered, the ventral surface of the body can be light gray, cream, ivory, the first three fingers and the webbing between red-brown or gray, no large black spots with blue speckles in the underarm and groin — in *R. robertingeri* sp. nov.; dorsal coloration predominantly red-brown, ventral body color, the first three fingers and the webbing between them always bright yellow, paired, large, black symmetric spots with blue speckles in the underarm and groin always present — in *R. rhodopus* and *R. bipunctatus*).

All species of the genus *Rhacophorus* (*R. bipunctatus*, *R. hoanglienensis*, *R. appendiculatus*, *R. kio*, *R. marmoridorsum*, *R. orlovi*, *R. rhodopus*, *R. spelaus*, *R. exechopygus*, *R. annamensis*), having the more or less developed pointed projection at tibiotarsal articulation, this structure only exists as a small protrusion of the proximal dermal fringe of tarsus, whereas in *R. robertingeri* sp. nov. this structure shows strong development and really seems to continue the tibia, which can be noted only in *R. vampyrus* and *R. calcaneus* (Figs. 32, 33a – d, and 36). These species differ from the new species by

Fig. 35. Distribution of *Rhacophorus calcaneus* species group in Vietnam and localities studied. Icon information is given in the legend; icons with dots in the middle denote species' type localities. **Localities information:** *Rhacophorus robertingeri* sp. nov.: 1, *R. robertingeri* sp. nov. — Dong Ngai, Thua Thien – Hue (Orlov, Ananjeva, 2007); 2, *R. robertingeri* sp. nov. — A Luoi, Thua Thien – Hue (Nguyen et al., 2009); 3, *R. robertingeri* sp. nov. — Bach Ma National Park, Bach Ma, Thua Thien – Hue (Nguyen et al., 2009); 4, *R. robertingeri* sp. nov. — Hon Thuy, Thua Thien – Hue (Nguyen et al., 2009); 5, *R. robertingeri* sp. nov. — Nam Dong, Thua Thien – Hue (Nguyen et al., 2009); 6, *R. robertingeri* sp. nov. — Ba Na-Nui Chua Nature Reserve, Ba Na, Da Nang (Nguyen et al., 2009); 7, *R. robertingeri* sp. nov. — Tra My, Quang Nam (Nguyen et al., 2009); 8, *R. robertingeri* sp. nov. — Ngoc Linh Nature Reserve, Ngoc Linh Mountain in Dac Glei district, Kon Tum (Orlov, Ananjeva, 2007; Nguyen et al., 2009); 9a, *R. robertingeri* sp. nov. — Kon Plong district, Kon Tum (Nguyen et al., 2009); 9b, Mang Canh village, Kon Plong district, Kon Tum province, 14°41'18" N 108°19'28" E, Vietnam; 1200 m a.s.l. elevation (this paper, terra typica of *R. robertingeri*); 10, *R. robertingeri* sp. nov. — Mo Nit, Quang Ngai (Tran et al., 2010); 11, *R. robertingeri* sp. nov. — K Bang, Gia Lai (Nguyen et al., 2009); 12, *R. robertingeri* sp. nov. — Kon Cha Rang, Gia Lai (Nguyen et al., 2009); 13, *R. robertingeri* sp. nov. — Kon Ka Kinh National Park, K' Bang, Dak Doa and Mang Yang Districts, Gia Lai; 14, *R. robertingeri* sp. nov. — Buon Luoi, Kon Cha Rang Nature Reserve, An Khe District, Gia Lai, province; 15, *R. robertingeri* sp. nov. — Tram Lap Villages, Tay Son District, Binh Dinh province; 16, *R. robertingeri* sp. nov. — A Yun Pa Proposed Nature Reserve in Krong Pa district, Gia Lai, province; *Rhacophorus calcaneus*: 17a, *R. calcaneus* — Chu Yang Sin National Park, Krong Bong and Lak Districts, Dak Lak Province, Vietnam; 12°25'28.3" N 108°21'04.1" E, elevation 1600 m a.s.l.; 17b, *R. calcaneus* — Chu Yang Sin National Park, Krong Bong and Lak Districts, Dak Lak Province, Vietnam; 12°24'28.9" N 108°23'19.8" E, elevation 1800 m a.s.l.; 18a, *R. calcaneus* — Chu Yang Sin National Park, Krong Bong and Lak Districts, Dak Lak Province, Vietnam; 12°23'0.84" N 108°20'57.1" E, elevation 1300 m a.s.l.; 18b, *R. calcaneus* — Chu Yang Sin National Park, Krong Bong and Lak Districts, Dak Lak Province, Vietnam; 12°24'41.5" N 108°23'07.7" E, elevation 1300 m a.s.l. (type locality of *R. chuyangsinensis*); 21, *R. calcaneus* — Hon Giao, Bidoup Nui Ba National Park, Khanh Khoa/Lam Dong; 23a, *R. calcaneus* — Giang Ly, Bidoup – Nui Ba National Park, Lam Dong; 23b, *R. calcaneus* — Bidoup – Nui Ba National Park, Long Lanh environs, Bidoup Mt., Lam Dong; 24, *R. calcaneus* — “Langbian Peaks, alt. 2000 m, S. Annam (by original description),” Lam Dong Province, Vietnam (type locality of *R. calcaneus*); *Rhacophorus vampyrus*: 19, *R. vampyrus* — Chu Yang Sin National Park, Krong Bong and Lak Districts, Dak Lak Province, Vietnam; 12°24'41.5" N 108°23'07.7" E, elevation 1300 m a.s.l.; 20, *R. vampyrus* — Hon Giao, Bidoup – Nui Ba National Park, Khanh Khoa/Lam Dong (type locality of *R. vampyrus*); 22, *R. vampyrus* — Bidoup – Nui Ba National Park, Long Lanh environs, Bidoup Mt., Lam Dong.

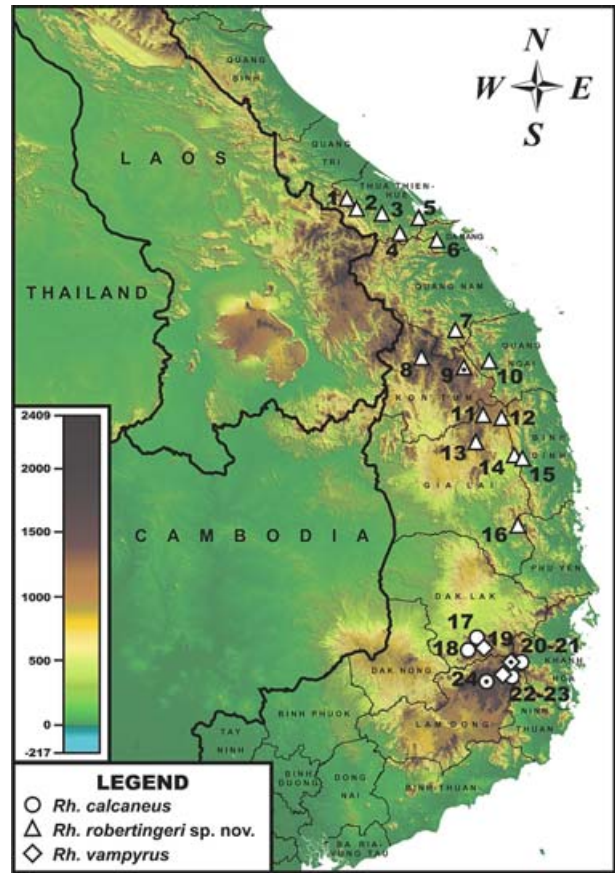


Fig. 36. *Rhacophorus vampyrus* from Bidoup Nui Ba National Park, Long Lanh environs, Bidoup Mt., Lam Dong.

obligatory presence of big, black pair of symmetrical spots in the underarm and groin (always absent in *R. robertingeri* sp. nov.).

Additionally the new species has snout sharply pointed (more rounded snout in *R. vampyrus*); dorsal coloration red-brown (green or bluish, or grayish in *R. calcaneus*). From *R. hoanglienensis*, *R. appendiculatus*, *R. marmoridorsum*, and *R. spelaeus* the new species differs by red-brown or pinkish color of dorsum and sharply pointed snout (gray-brown and more rounded snout in *R. hoanglienensis*, *R. orlovi*, and *R. spelaeus*), from *R. appendiculatus* by smooth skin (tuberculate in *R. appendiculatus*); from *R. marmoridorsum* by lack of chocolate marble pattern covering the entire back (color of the back with a chocolate figures forming marble pattern in *R. marmoridorsum*).

Photographs of a number of above mentioned species are given in papers of Orlov and Ho, 2004 (*Russ. J. Herpetol.*, **11**(1), 51 – 65), 2005 (*Russ. J. Herpetol.*, **12**(2), 137 – 144); Orlov et al., 2001 (*Russ. J. Herpetol.*, **8**(1), 17 – 44), 2002 (*Russ. J. Herpetol.*, **9**(2), 81 – 104), 2006 (*Russ. J. Herpetol.*, **13**(2), 135 – 154), 2008 (*Russ. J. Herpetol.*, **15**(1), 67 – 84; *Russ. J. Herpetol.*, **15**(2), 133 – 140), 2009 (*Russ. J. Herpetol.*, **16**(4), 295 – 303).

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APPENDIX 1. Genera and Species of Rhacophorid Frogs Recorded in Vietnam

Chiromantis Peters, 1854

- Chiromantis doriae* (Boulenger, 1893)
- Chiromantis nongkhorensis* (Cochran, 1927)
- Chiromantis vittatus* (Boulenger, 1887)

Feihyla Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan, Raxworthy, Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green et Wheeler, 2006

- Feihyla palpebralis* (Smith, 1924)

Gracixalus Delorme, Dubois, Grosjean et Ohler, 2005

- Gracixalus gracilipes* (Bourret, 1937)
- Gracixalus guyeti* Nguyen, Hendrix, Böhme, Vu et Ziegler, 2008
- Gracixalus jinxiuensis* (Hu, 1978)
- Gracixalus supercornutus* (Orlov, Ho et Nguyen, 2004)

Kurixalus Ye, Fei et Dubois, 1999 in Fei, 1999

- Kurixalus ananjevae* (Matsui et Orlov, 2004)
- Kurixalus baliogaster* (Inger, Orlov et Darevsky, 1999)
- Kurixalus banaensis* (Bourret, 1939)
- Kurixalus carinensis* (Boulenger, 1893)
- Kurixalus odontotarsus* (Ye et Fei, 1993) in Ye, Fei et Hu, 1993
- Kurixalus verrucosus* (Boulenger, 1893)

Nyctixalus Boulenger, 1882

- Nyctixalus pictus* (Peters, 1871)

Philautus Gistel, 1848

- Philautus abditus* Inger, Orlov et Darevsky, 1999
- Philautus maosonensis* Bourret, 1937

Polypedates Tschudi, 1838

- Polypedates colletti* (Boulenger, 1890)
- Polypedates leucomystax* (Gravenhorst, 1829)
- Polypedates megacephalus* Hallowell, 1861
- Polypedates mutus* (Smith, 1940)

***Rhacophorus* Kuhl et van Hasselt, 1822**

- Rhacophorus annamensis* Smith, 1924
Rhacophorus appendiculatus (Günther, 1858)
Rhacophorus bipunctatus Ahl, 1927
Rhacophorus calcaneus Smith, 1924
Rhacophorus dennysi Blanford, 1881
Rhacophorus dorsoviridis Bourret, 1937
Rhacophorus duboisi Ohler, Marquis, Swan et Grosjean, 2000
Rhacophorus dugritei (David, 1872)
Rhacophorus exechopygus Inger, Orlov et Darevsky, 1999
Rhacophorus feae Boulenger, 1893
Rhacophorus hoanglienensis Orlov, Lathrop, Murphy et Ho, 2001
Rhacophorus hungfuensis Liu et Hu, 1961
Rhacophorus kio Ohler et Delorme, 2006
Rhacophorus marmoridorsum Orlov, 2008
Rhacophorus maximus Günther, 1858
Rhacophorus nigropunctatus Liu, Hu et Yang, 1962
Rhacophorus orlovi Ziegler et Köhler, 2001
Rhacophorus robertingeri sp. nov.

***Raorchestes* Biju, Shouche, Dubois, Dutta et Bossuyt, 2010**

- Raorchestes gryllus* (Smith, 1924)
Raorchestes parvulus (Boulenger, 1893)

***Theloderma* Tschudi, 1838**

- Theloderma asperum* (Boulenger, 1886)
Theloderma bambusicola sp. nov.
Theloderma bicolor (Bourret, 1937)
Theloderma chuyangsinense sp. nov.
Theloderma corticale (Boulenger, 1903)
Theloderma gordonii Taylor, 1962
Theloderma kwangsiense Liu et Hu, 1962
Theloderma laeae (Smith, 1924)
Theloderma lateriticum Bain, Nguyen et Doan, 2009
Theloderma lacin McLeod and Ahmad, 2007
Theloderma nebulosum Rowley, Le, Hoang, Dau et Cao, 2011
Theloderma palliatum Rowley, Le, Hoang, Dau et Cao, 2011
Theloderma ryabovi Orlov, Dutta, Ghate et Kent, 2006
Theloderma rhododiscus (Liu et Hu, 1962)
Theloderma stellatum Taylor, 1962
Theloderma truongsongense (Orlov et Ho, 2005)

APPENDIX 2. List of specimens examined

- Kurixalus ananjevae* (as *Chirixalus ananjevae*): ZISP Fn KUHE 31963 (holotype), ZISP 6756.
Kurixalus banaensis (as *Philautus banaensis*): ZISP Fn 39302, 39317, 39361, 39462, 39542, 39550, 39551, 39786, 39898.
Kurixalus carinensis (as *Philautus carinensis*): ZISP Fn 19136 – 19141, 22104 – 22107, 36092, 36093, 36095, 36102, 36103.
Kurixalus baliogaster (as *Rhacophorus baliogaster*): FMNH 252839 (holotype, Fn 61617); FMNH 252840 – 252842, 222100, 222104, 252840 (paratypes); ZISP 8291 – 8297; 8322, 8323.

Kurixalus verrucosus (as *Rhacophorus verrucosus*): MVZ 226467, 226468; MVZ Fn, 26315; 26321, 26322; ROM 30013, 30001, 30006, 29996, 30031, 30030, 30025, 30018, 30010, 30019, 30034, 30009, 30016, 30039, 30011, 30014, 30032, 30007.

Rhacophorus angulirostris: FMNH 250957, 250958, 235037, 235038, 235316, 235317, 250962 – 250965.

Rhacophorus annamensis: FMNH 262123; ROM 27977 – 27982 (Fn14007 – 14012); 27983 – 27987 (Fn14025 – 14029), 41019, 41020; IEBR 843 – 855; ZISP 8233 – 8255; 8288; 8349 – 8360; 8421 – 8449.

Rhacophorus appendiculatus: ROM Fn 1044; ROM (as *Rhacophorus verrucosus*) 27975, 27976, 38938, 38941, 30007 – 30042, 29971, 29974, 29989 – 29996, 30000 – 30003, 30006; IEBR 1113 – 1118; CAS 105970, 105971; FMNH 14297 – 14299, 72406, 72407, 76991, 76992; ZISP 8298; ZISP Fn 03915 – 03921.

Rhacophorus baluensis: FMNH 235957 – 235959, 239220, 239221, 239224, 239227, 71854 (paratype), 250966, 241906 – 241909.

Rhacophorus bipunctatus: (as *Rhacophorus reinwardti bipunctatus*) CAS-SU 3278; FMNH 265967 – 265971.

Rhacophorus bimaculatus: FMNH 221749, 221750.

Rhacophorus calcaneus: (as *Rhacophorus chuyangsinensis*) ZISP 8179 (holotype) and 8180, 8181 (paratypes).

Rhacophorus chenfu: FMNH 232963 – 232970, 49430, 49431 (paratypes), 232965 – 232970; CIB 528 (holotype), 525 (paratype).

Rhacophorus dennysii: ZISP 8343 – 8348; 6074; IEBR (as *Polypedates dennysii*) 109 – 136, 815 – 824, 1528; ZISP 8343 – 8348; 6074; CIB 6410742, 6410831.

Rhacophorus dorsoviridis: ROM 38006 – 38011, 38014 – 38018, 38608.

Rhacophorus duboisi: (as *Rhacophorus omeimontis*) ROM 38758 – 38761, 38763 – 38786; ZISP 8267 – 8287; 8324.

Rhacophorus dulitensis: FMNH 245880 – 245887, 251906, 248919 – 248921.

Rhacophorus dugritei: IEBR 833 – 836; ROM 38639, 38641 – 38652, 38654 – 38657, 38659 – 38666, 38668, 38669; ZISP 8289; 8460 – 8463; KIZ 751372, 791368; CIB 741532, 741533, 7910113, 7910211.

Rhacophorus everetti: FMNH 239244, 239247 – 239249, 239252, 239254, 239255, 71855, 250974 – 250979.

Rhacophorus exechopygus: FMNH 252841 (holotype), FMNH 252842, 252843 (paratypes); ZISP 8229 – 8232.

Rhacophorus feae: ZISP 8342; 8459; IEBR 329 (as *Polypedates feae*); FMNH 265862; ZISP 8342 (Fn 21419); 8459; CAS-SU (Amp) 6388 (as *Polypedates feae*).

Rhacophorus gongshanensis: CIB 0723, 820849, 05553; KIZ 810485 (holotype), 810723, 0552 – 0555 (paratypes).

Rhacophorus harrissoni: FMNH 240967 – 24970, 250984, 249833 – 249838.

Rhacophorus hoanglienensis: ROM 37997 (holotype).

Rhacophorus hungfuensis: ROM 37996; CIB 570960.

Rhacophorus javanus: FMNH 178321.

Rhacophorus kajau: FMNH 248928, 245925 – 245929.

Rhacophorus kio: (as *Rhacophorus reinwardti*) ZISP 8220 – 8228; 8329 – 8341; 8378 – 8380 FMNH 252377 – 252386; ROM 28015.

Rhacophorus marmoridorsum ZISP 8217 (holotype), 8218, 8219 (paratypes).

- Rhacophorus maximus*: FMNH 213931, 213932; KIZ 79110226.
- Rhacophorus nigropalmatus*: FMNH 230901 – 230909, 76996 – 76999, 248929, 249830, 245930 – 245934.
- Rhacophorus omeimontis* (as *Polypedates omeimontis*): FMNH 250746 – 250759; CIB 561068, 561066, 55.V.19, 55.V.05; (as *Rhacophorus pingbianensis*): KIZ 654003 (holotype), 654004, 965003 (paratypes).
- Rhacophorus orlovi*: ROM 27988 – 27997; 29866 – 29868; ZISP 8260 – 8266; 8325 – 8328; 8454 – 8458; FMNH 255654 – 265660; (as *Rhacophorus bimaculatus*) FMNH 253156.
- Rhacophorus pardalis*: FMNH 221695 – 221736, 63423 – 63429, 63434, 77000 – 77009, 251074, 251075.
- Rhacophorus prominatus*: FMNH 152594, 50679, 50680.
- Rhacophorus puerensis*: KIZ 0624, 0489.
- Rhacophorus rhodopus*: ROM 38639, 38650, 38667; (as *Rhacophorus bipunctatus*) ROM 27994 – 27997 (Fn 1072 – 1076; ZISP 8256 – 8259; 8320, 8321; 8381; 8383 – 8420; 8450 – 8453 (Fn 1062 – 1064, Fn 1016 – 1018); ROM 27998 – 28014 (Fn 14049 – 14066); (as *Rhacophorus bimaculatus*) ROM Fn 14597 – 14600; CIB 571171 (holotype); KIZ 8510263, 8510265; IEBR 616 – 624; (as *Rhacophorus bipunctatus*) FMNH 253114 – 253155.
- Rhacophorus robertingeri* sp. nov. (as *Rhacophorus calcaeus*): IEBR 242, 251, 295; ZISP 8290, 8361 – 8377, 8382, 8316 – 8319; ZISP 10653, 10655, 10657 – 10666, 10662 (holotype) and ZISP 10652, 10654, 10656, 8299 – 8315 (paratypes).
- Rhacophorus reinwardti*: FMNH 245955, 245956.
- Rhacophorus rufipes*: FMNH 251909.
- Rhacophorus spelaeus*: ZISP 9077 (holotype), 9078, 9079 (paratypes).
- Rhacophorus translineatus*: CIB 73110031.
- Rhacophorus yaoshaneasis*: CIB 6883 (holotype).
- Gracixalus supercornutus* (as *Philautus supercornutus*) ZISP 7248 (holotype), 7249, 7250 and IEBR 332, 333 (paratypes).
- Gracixalus gracilipes* FMNH 213963 – 213970; ZISP Fn 31205 – 31212, 28445 – 28449.
- Gracixalus jinxiuensis* ZISP Fn 18391 – 18393.
- Philautus maosonensis* ZISP Fn 14552, 14561 – 14568.
- Philautus abditus* FMNH 252833 (holotype), 252834 – 252838 (paratypes); ZISP Fn 32111 – 32116.
- Philautus petilus* FMNH 257902 (holotype).
- Theloderma asperum* ZISP 7542 – 7546, 7559, 7560; FMNH 255379, 261896, 262787, 261897; ROM 27968, 30246 – 30254, 30255 – 30265, 30270, 31249, 35161, 36974, 36975, 36822 – 36825, 38002, 38003, 38299, 39379, 39380, 38413.
- Theloderma bicolor* ZISP 7547 – 7550, 7558; ROM 38004, 38005.
- Theloderma corticale* FMNH 254285, 254286; MVZ 223905, 226099 – 226106; ROM 30260, 30261, 30266 – 30269; ROM 34873, 32581 – 32584, 31250 – 31265; 38315; ZISP 6151 (a, b), 6069 (1 – 17), 7551 – 7554; [*Rhacophorus corticalis* BMNH 1947 – 28.39 (1903.4 – 29.74), BMNH 1947.28.40 (1903.7.2.27) (syntypes)]; (*Rhacophorus fruhstorferi* ZMB 26563 (holotype)).
- Theloderma gordonii* FMNH 172248 (holotype); FMNH 253615, 253616, 254287; MVZ 226469; ROM 30262 – 30265, 30417, 35159, 35160, 37998; ZISP 6070, 6071, 7555, 7561, 7562.
- Theloderma horridum* ZMB 47976; FMNH 240962, 186600 – 186602; (holotype of *Philautus horridus* BMNH 1947.2.7.97 (1903.4.13.111)).
- Theloderma kwangsiense* (holotype of *Theloderma leprosus kwangsiensis* CIB 601687).
- Theloderma leporosa* (holotype of *Polypedates leprosum* BMNH 1947.2.9.19 (87.7.30.1)).
- Theloderma nagalandense* (holotype of *Theloderma nagalandensis* MCZMI/Anura Type/1).
- Theloderma ryabovi* ZISP 7592, 7593, 7594, 7595, 7596, 7597; (holotype of *Theloderma ryabovi* ZISP 7502).
- Theloderma stellatum* FMNH 253617 – 25326, 26786, 211527, 211831, 183711 – 183715; MVZ 222113 – 222117; ROM 30271, 30273, 30276 – 30279, 30309 – 30312, 32528, 33123 – 33132, 32134, 33143, 33157 – 33161, 41036; ZISP 6427, 7556 – 7657, 7563; (holotype of *Theloderma stellatum* FMNH 172249).
- Theloderma chuyangsinense* sp. nov. ZISP 10541 (holotype).
- Theloderma bambusicolum* sp. nov. ZMMU NAP 02908 (holotype) and ZMMU NAP 00319, 01645, 00320, 01662, 01659, 00319, 01644, 02907, 02906, 00832, 02918, 01660; ZFMK 89000; ZISP 10677 – 10679 (paratypes).
- Theloderma truongsongense* (as *Philautus truongsongensis*) ZISP 7407 (holotype); ZISP 7408 – 7423 (paratypes).
- Theloderma laeve* ZISP Fn 39369, 39522, 39523.
- Theloderma lateriticum* IEBR A.0860 (AMNH 168757) ZISP Fn 147, 148.
- Theloderma rhododiscus* IEBR 59 (AMNH 163892, holotype); ZISP Fn 03618 – 03620.
- Raorchestes parvulus* MVZ 223821, 223822 (as *Philautus parvulus*); FMNH 254254, 254255 (as *Philautus parvulus*).
- Raorchestes gryllus* ZISP 10543 – 10651.
- Liuxalus romeri* (Smith, 1953) FMNH 224294 – 224304 (as *Philautus romeri*).
- Feihyla palpebralis* MVZ 222014, 222015, 221967, 221968 (as *Chirixalus palpebralis*); FMNH 253572, 253003 – 253007 (as *Chirixalus palpebralis*); ZISP Fn 36043, 36044, 36047.
- Chiromantis vittatus* IEBR 630; ROM 30368, 30358, 30334, 30332, 30370.30356, 30351, 30348, 30333, 30353, 30354, 30358.
- Chiromantis doriae* ROM 40843 – 40862; MVZ 222112 (as *Chirixalus doriae*).
- Chiromantis nongkhorensis* IEBR 660, 661.
- Nyctixalus pictus* FMNH 221790 – 221792; ZISP Fn 28879.
- Nyctixalus margaritifer* ZISP Fn 14406 – 14408.

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