First records of *Gracixalus supercornutus* (Orlov, Ho and Nguyen, 2004) and *Rhacophorus maximus* Günther, 1858 from Laos

Vinh Quang Luu1, 5, 6, Thomas Calame2, Truong Quang Nguyen1, 5, Annemarie Ohler4, Michael Bonkowski5 and Thomas Ziegler*, 5, 6

Abstract. Two rhacophorid anurans are recorded for the first time from Laos: *Gracixalus supercornutus* from hill evergreen forest of Salavan Province and *Rhacophorus maximus* from limestone forest of Khammouane Province. These discoveries bring the total species number of amphibians to 103 in Laos.

Keywords. Rhacophoridae, distribution, new records, Khammouane Province, Salavan Province.

Introduction

The knowledge on the species diversity of amphibians in Laos has remarkably increased during the last decade. Stuart (1999) reported the first checklist of amphibians from Laos with a total of 58 recognized species. At present, the number of amphibian species from Laos has almost doubled up to 101 species (Frost, 2014). Ranidae and Rhacophoridae are the two most species-rich families of amphibians in Laos with 28 and 23 recorded species, respectively, followed by Megophryidae (19 species), Microhylidae (14 species), Dicroglossidae (10 species), Bufonidae (4 species), Salamandridae and Ichthyophiidae (2 species each) as well as Hylidae (1 species) (Frost, 2014).

In 2012 and 2013, further field surveys were conducted in the hill evergreen forest within Xe Sap National Protected Area, Salavan Province, and...
limestone forest within Hin Nam No National Protected Area, Khammouane Province. Examination of voucher specimens from aforementioned sites revealed the existence of two rhacophorid amphibian species that have been not reported from Laos so far. We herein report the occurrence of *Gracixalus supercornutus* and *Rhacophorus maximus* for the first time from the country.

**Materials and methods**

Field surveys were conducted by T. Calame in Xe Sap National Protected Area (NPA), Salavan Province in May 2012 and by V. Q. Luu and N. V. Ha in Hin Nam No NPA, Khammouane Province from April to July 2013 (Figs. 1, 2). Specimens were collected by hand between 19:00 and 23:00. After taking photographs, specimens were anaesthetized, fixed in 80–85% ethanol and subsequently transferred into 70% ethanol for permanent storage. Voucher specimens were deposited in the collections of the National University of Laos (NUOL), Vientiane, Laos and the Vietnam Forestry University (VFU), Hanoi, Vietnam.

Measurements were taken with a digital calliper to the nearest 0.1 mm. Abbreviations are as follows: a.s.l.: above sea level; SVL, snout-vent length; HW, head width at the greatest cranial width; HL, head length from the rear of the lower jaw to the tip of the snout; UEW, upper eyelid width: greatest width of upper eyelids; IOD, interorbital distance; ED, horizontal diameter of eye; TD, horizontal diameter of tympanum; SL, 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. FLL, length of forelimb from axilla to elbow; HAL, hand length from elbow to the tip of third finger; NPL, nuptial pad length. HLL, length of hindlimb from tip of disk of toe IV to groin; FL, femur length; TL, tibia length; FOL, length of hindlimb from tip of disk of toe IV to posterior edge of tibia; MTTi, length of inner metatarsal tubercle. Terminology of morphological characters followed Orlov et al. (2010); Nguyen et al. (2013) and anuran webbing formula followed Glaw and Vences (2007).

**Results**

*Gracixalus supercornutus* (Orlov, Ho and Nguyen, 2004) (Fig. 3)

Specimen examined (n = 1). VFU A.2014.20, subadult, collected by T. Calame on 01 March 2012 in Xe Sap NPA, Salavan Province (16°03.917’N, 106°48.850’E, elevation ca. 1,120 m a.s.l.).
New records of rhacophorid amphibians from Laos

Morphological characters. SVL 19.0 mm; head longer than wide (HL 7.4 mm, HW 6.6 mm); snout pointed, longer than horizontal diameter of eye (SL 2.7 mm; ED 2.1 mm); canthus rostralis angular; loreal region concave; interorbital distance wider than internarial distance and upper eyelid (IOD 2.4 mm, IND 1.6 mm, UEW 1.1 mm); nostrils in lateral direction, closer to the tip of snout than to eye (SN 0.9 mm; END 1.7 mm); tympanum oval, smaller than tympanum-eye distance (TD 0.7 mm, TED 1.2 mm); supratympanic fold indistinct; vomerine teeth absent; tongue notched posteriorly. Forelimbs: FLL 4.3 mm, HAL 9.1 mm; relative length of fingers: I<II<IV<III; tip of fingers enlarged into large discs; finger free of webbing; subarticular tubercles distinct, rounded, formula 1, 1, 2, 2; dermal fringe along outer finger present; palmar tubercles visible. Hind limbs: foot length longer than tibia and femur (FOL 12.3 mm, TL 10.1 mm, FL 10.0 mm); relative length of toes: I<II<III=V<IV; discs of toes smaller than those of fingers; webbing formula: Io(1)–(1/2)iIIo(1/2)–(2)iIIIo(1)–(2/2)iIVo(2)–(1)iV; subarticular tubercles rounded, formula 1, 1, 2, 3, 2; dermal fringe along outer tarsus distinct; inner metatarsal tubercle present; outer metatarsal tubercle absent. Dorsal surface of head, body, and limbs covered by small tubercles; dermal fringes, area surrounding vent, and upper eyelids with tiny horned spines; ventral skin of throat, chest, belly and thigh granular. Coloration in life: Dorsal surface yellowish green with brown dots in different sizes; a brown marking, in T-shape present in interorbital region; under the eye and tympanum with white patches; dorsal surface of fingers and toes with dark bars; ventral surface yellowish white with white granules (determination after Orlov et al., 2004).

Distribution. G. supercornutus has been recorded from Central Vietnam: Da Nang, Thua Thien-Hue, Quang Nam, and Kon Tum provinces (Nguyen et al., 2009; Rowley et al., 2011). This is the first record of the species for Laos. It is noted that the Xe Sap NPA is contiguous to the Bach Ma National Park in Vietnam and the newly recorded locality of G. supercornutus in Laos is approximately 30 km in the west of the type locality of this species.

Natural history. The specimen was found in the evening (20:30) on a leaf, about 1.5 m above the ground, near a small stream. The main habitat was hill evergreen forest at an elevation of 1,120 m a.s.l., with some patches of open conifer forest.

Rhacophorus maximus Günther, 1858 (Fig. 4)

Specimens examined (n = 2). VFU A.2014.21, adult male and NUOL A–2014.3, adult female, collected from Hin Nam No NPA, in the area of Noong Ma Commune, Boulapha District, Khammouane Province on 11 May 2013 (17°16.981’N, 106°09.900’E, elevation 539 m a.s.l.).

Morphological characters. SVL 74.2 mm in the male, 93.5 mm in the female; head wider than long (HW 27.6–36.7 mm, HL 27.3–33.7 mm); snout rounded, longer than horizontal diameter of eye (SL 11.8–14.3 mm; ED 7.7–8.4 mm); canthus rostralis angular; loreal region concave; interorbital distance wider than internarial distance and upper eyelid (IOD 8.9–11.8 mm, IND 8.0–9.7 mm, UEW 6.2–7.4 mm); nostril in lateral direction, equidistant from snout and from eye (SN 5.5–6.9 mm; END 5.8–6.8 mm); tympanum rounded, distinctly greater than tympanum-eye distance (TD 4.4–4.8 mm, TED 2.2–2.8 mm), supratympanic fold indistinct; vomerine teeth absent; tongue notched posteriorly. Forelimbs: FLL 4.3 mm, HAL 9.1 mm; relative length of fingers: I<II<IV<III; tip of fingers enlarged into large discs; finger free of webbing; subarticular tubercles distinct, rounded, formula 1, 1, 2, 2; dermal fringe along outer finger present; palmar tubercles visible. Hind limbs: foot length longer than tibia and femur (FOL 12.3 mm, TL 10.1 mm, FL 10.0 mm); relative length of toes: I<II<III=V<IV; discs of toes smaller than those of fingers; webbing formula: Io(1)–(1/2)iIIo(1/2)–(2)iIIIo(1)–(2/2)iIVo(2)–(1)iV; subarticular tubercles rounded, formula 1, 1, 2, 3, 2; dermal fringe along outer tarsus distinct; inner metatarsal tubercle present; outer metatarsal tubercle absent. Dorsal surface of head, body, and limbs covered by small tubercles; dermal fringes, area surrounding vent, and upper eyelids with tiny horned spines; ventral skin of throat, chest, belly and thigh granular. Coloration in life: Dorsal surface yellowish green with brown dots in different sizes; a brown marking, in T-shape present in interorbital region; under the eye and tympanum with white patches; dorsal surface of fingers and toes with dark bars; ventral surface yellowish white with white granules (determination after Orlov et al., 2004).

Figure 4. Rhacophorus maximus (a. Male; b. Female) from Hin Nam No National Protected Area, Khammouane Province, Laos. Photograph by Vinh Quang Luu.
fold visible; vomerine teeth present; tongue cordate; internal vocal sac present in the male. Forelimbs: FLL 13.0–14.1 mm, HAL 36.7–50.4 mm; relative length of fingers: I<II<IV<III; tip of fingers enlarged into large discs, webbing formula: Io(1)–(1)IIo(0)–(1)IIIo(0)–(0)iIV; subarticular tubercles prominent, formula 1, 1, 2, 2; dermal fringe along outer finger present; palmar tubercles distinct; nuptial pad present in the male (NPL 6.2 mm). Hind limbs: foot length longer than tibia and femur (FOL 49.1–67.1 mm, TL 36.2–46.7 mm, FL 33.6–40.8 mm); relative length of toes: I<II<III=V<IV; toes fully webbed; dermal fringe along outer toe weakly developed; subarticular tubercles prominent, formula 1, 1, 2, 3, 2; inner metatarsal tubercle present (MTTi 2.9–4.8 mm); outer metatarsal tubercle absent. Dorsal skin of head, shoulder, thigh and tibia smooth with some granules in the female; dorsal skin of the male smooth; ventral skin granular, especially on throat, belly and under thighs. Coloration in life: Dorsal surface green with some yellow dots; a light stripe from the margin of the lower jaw to the groin; webbing and the tips of fingers and toes violet; ventral surface cream or violet of head, shoulder, thigh and tibia smooth with some granules in the female; dorsal skin of the male smooth; ventral skin granular, especially on throat, belly and under thighs. Coloration in life: Dorsal surface green with some yellow dots; a light stripe from the margin of the lower jaw to the groin; webbing and the tips of fingers and toes violet; ventral surface cream or violet isolated from the green part by a white line on flanks; lateral parts of body and femur with some reddish brown dots (determination after Anders and Rai, 2002).

**Natural history.** Both specimens of *R. maximus* were collected in the evening (19:45) on a leaf, near a slowly flowing stream at an elevation of 539 m. They were found after a heavy rain, the temperature was 26°C and the humidity was 81%. Wildenhaues et al. (2010) provided the first description of larval and juvenile stages of this species from Vietnam.

**Remarks.** Granules on dorsal surface of head, shoulder, thigh, and tibia are more distinct in the female than in the male, which is in contrast with the description of Anders and Rai (2002). Moreover, further studies are needed to clarify the phylogenetic relationship among populations of *R. maximus* because the widespread distribution of the species in different biogeographic subregions in Asia suggests that this species might include cryptic taxa.

**Discussion**

As mentioned above, although the species number of amphibians in Laos has increased between 1999 and 2013, the actual diversity of the amphibian fauna of this country is still underestimated. Since 2000, a total of 19 new species have been described from Laos, comprising seven species of Ranidae, six species of Megophryidae, three species of Rhacophoridae, two species of Salamandridae, and one species of Microhylidae (Stuart and Papenfuss, 2002; Ohler, 2003; Teiñé et al., 2004; Ohler et al., 2004; Stuart and Heatwole, 2004; Stuart and Bain 2005; Stuart and Chan-ard, 2005; Stuart et al., 2005; Bain et al., 2006; Ohler and Delorme, 2006; Orlov et al., 2010; Rowley et al., 2010; Stuart et al., 2010a; Stuart et al., 2010b; Ohler et al., 2011; Stuart et al., 2012; Chan et al., 2013; Matsui, 2013). According to Bain and Hurley (2011), the newly recorded locality of *R. maximus* in Khammouane is located in the Northern Annamites subregion whereas the new recorded locality of *G. supercornutus* in Salavan Province belongs to the Central Annamites subregion. Both subregions harbour a high level of species diversity (63 and 77 recorded species, respectively) and of endemism (19 and 36 endemic species, respectively) (Bain and Hurley, 2011). It is noted that many species that occur in neighboring countries (i.e. Cambodia, China, Thailand, and Vietnam), are expected to be found in Laos as well (see Frost, 2014). Therefore, further studies are required to fill the knowledge gap on the diversity and distribution of reptiles and amphibians in Laos, particularly in the remote montane forests in upland areas.

**Acknowledgements.** We are grateful to S. Wayakone, H. Chanthavong, K. Phanvilay (NUOL, Vientiane) and T. Gray (WWF Greater Mekong) for supporting our field research in Laos. Export of collected specimens was done due to the export permits Number 094–095/13 signed by the CITES Management Authority of Lao PDR. V. Q. Luu thanks C. V. Pham, N. T. Nguyen, and D. T. Bui (VFU, Hanoi) for supporting his work. We thank S. Southichack and T. Homsaysombath (Khammouane) for supporting our field research in Laos. Field work was funded by The Ruford Foundation and Idea Wild for V. Q. Luu. Work in the Xe Sap NPA forms part of the CarBi Project of WWF Greater Mekong and the government of Laos PDR through funds provided by WWF Germany and KfW Bankengruppe. Additional support came from grants to Global Wildlife Conservation from the Margot Marsh Biodiversity Fund and Ocean Park Conservation Foundation, Hong Kong, China. Research of V. Q. Luu in Germany is funded by the Ministry of Education and Training of Vietnam (MOET, Project 911) and the German Academic Exchange Service (DAAD). Research of T. Q. Nguyen in Germany is funded by the Alexander von Humboldt...
Stiftung/Foundation (VIE 114344). Last but not least we wish to thank Olivier Pauwels for kindly commenting on an earlier draft of the manuscript.

References


Accepted by Mirco Solé