New records of tree frogs (Anura: Rhacophoridae: Rhacophorus) from Son La Province, Vietnam

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Abstract. Based on a new frog collection from the northwestern region of Vietnam, we report six additional species of the genus Rhacophorus for the amphibian fauna of Son La Province: Rhacophorus dorsovirdis, R. duboisi, R. feae, R. maximus, R. orlovi and R. rhodopus. Our findings bring the species number of the genus Rhacophorus to eight in Son La Province. In addition, we provide further morphological and natural history data for these newly recorded species.

Keywords: distribution, morphology, natural history, new records, Rhacophorus, Son La Province, taxonomy

Introduction

In the recent checklist of the herpetofauna of Vietnam, Nguyen et al. (2009) listed 16 species of the genus Rhacophorus. Since then many new species of Rhacophorus have been discovered from the country, viz. Rhacophorus vampyrus Rowley, Le, Tran Stuart and Hoang, 2010; Rhacophorus heleneae Rowley, Tran, Hoang and Le, 2012; Rhacophorus robertingeri Orlov, Poyarkov, Vassilieva, Ananjeva, Nguyen, Nguyen and Geissler, 2012; Rhacophorus larissae Ostroshabov, Orlov and Nguyen, 2013; and Rhacophorus viridimaculatus Ostroshabov, Orlov and Nguyen, 2013 (Rowley et al., 2010; Rowley et al., 2012; Orlov et al., 2012; Ostroshabov et al., 2013).

In Son La Province, Nguyen et al. (2009) documented only two species of Rhacophorus, namely R. denysi and R. kio. We herein report six new records of Rhacophorus for Son La Province based on newly collected specimens from Copia Nature Reserve (Thuan Chau District), Sop Cop Nature Reserve (Sop Cop and Song Ma districts), Ngoc Chien Commune (Muong La District), and Muong Bang and Muong Do communes (Phu Yen District).

Material and Methods

Sampling.—Field surveys were conducted in Son La Province (Fig. 1) by A.V. Pham, T.V. Nguyen, N.T.B. Nguyen, M.T. Nguyen, N.T.T. Tran, H.T. Pham and D.A. Vi from 13 to 15 October 2012 and from 19 to 21 April 2013 in Copia Nature Reserve (NR); by A.V. Pham and T.V. Nguyen from 27 April to 2 May 2013 in Sop Cop NR; by A.V. Pham and T.V. Nguyen from 7 to 12 June and 17 to 25 July 2013 in Copia NR; by A.V. Pham, T.V. Nguyen, H.V. Tu, D. A. Vi and Q.X. Cu from 13 to 15 September 2013 in Copia NR; by A.V. Pham, T.V. Nguyen from 27 April to 2 May 2013 in Sop Cop NR; by A.V. Pham and T.V. Nguyen from 7 to 12 June and 17 to 25 July 2013 in Copia NR; by A.V. Pham, T.V. Nguyen, H.V. Tu, D. A. Vi and Q.X. Cu from 13 to 15 September 2013 in Copia NR; by A.V. Pham and D.A. Vi from 1 to 13 April 2014; by T.Q. Nguyen, A.V. Pham, H.N. Ngo, T.V. Nguyen and H.V. Tu from 14 to 26 April 2015 in Muong La District; and by A.V. Pham, H.V. Tu and N.B. Song from 15 to 22 June 2016 in Phu
Yen District (all hereafter AVP et al.). Specimens were collected by hand between 16:00h and 23:00h. After taking photographs, specimens were anaesthetized with ethyl acetate, fixed in 80% ethanol and subsequently stored in 70% ethanol. Specimens were deposited in the collections of the Department of Zoology, Faculty of Biology and Chemistry, Tay Bac University (TBU), Son La Province, and the Institute of Ecology and Biological Resources (IEBR), Hanoi, Vietnam.

**Morphological characters.**—Measurements were taken to the nearest 0.1 mm using digital calliper. Abbreviations are as follows: snout-vent length (SVL); head length, from tip of snout to the articulation of the jaw (HL); head width, at greatest width of the jaw (HW); snout length, from the anterior portion of the eye to the tip of the snout (SL); distance from anterior edge of nostril to tip of snout (SNL); distance from anterior corner of eye to posterior edge of nostril (NEL); eye diameter (ED); interorbital distance (IOD); maximum width of upper eyelid (UEW); tympanum diameter (TD); forearm length, from elbow to base of outer palmar tubercle (FLL); hand length, from base of outer palmar tubercle to tip of finger III (HAL); thigh length, from vent to knee (FL); tibia length (TIB); maximum shank width (TBW); foot length, from distal end of tibia to tip of distal phalanx of III (FOT); and above sea level (asl.).

**Results**

*Rhacophorus dorsoviridis* Bourret, 1937

Green-back Treefrog / Ech cay lung xanh (Fig. 2a)

Specimens examined (n = 4). One adult male (TBU PAE 525) and three adult females (TBU PAE 526–528) collected by AVP et al., 14 September 2013, near Nong Vai Village, Co Ma Commune, Thuan Chau District, within Copia NR (21°19.620′N, 103°35.098′E, elevation 1610 m asl.).

Morphological characters.—Measurements were taken to the nearest 0.1 mm using digital calliper. Abbreviations are as follows: snout-vent length (SVL); head length, from tip of snout to articulation of the jaw (HL); head width, at greatest width of the jaw (HW); snout length, from the anterior portion of the eye to the tip of the snout (SL); distance from anterior edge of nostril to tip of snout (SNL); distance from anterior corner of eye to posterior edge of nostril (NEL); eye diameter (ED); interorbital distance (IOD); maximum width of upper eyelid (UEW); tympanum diameter (TD); forearm length, from elbow to base of outer palmar tubercle (FLL); hand length, from base of outer palmar tubercle to tip of finger III (HAL); thigh length, from vent to knee (FL); tibia length (TIB); maximum shank width (TBW); foot length, from distal end of tibia to tip of distal phalanx of III (FOT); and above sea level (asl.).

**Rhacophorus dorsoviridis Bourret, 1937**

Green-back Treefrog / Ech cay lung xanh (Fig. 2a)

Specimens examined (n = 4). One adult male (TBU PAE 525) and three adult females (TBU PAE 526–528) collected by AVP et al., 14 September 2013, near Nong Vai Village, Co Ma Commune, Thuan Chau District, within Copia NR (21°19.620′N, 103°35.098′E, elevation 1610 m asl.).

Morphological characters. SVL male 54.1 mm (n = 1), females 52.6–55.2 mm (mean±SD 54.1 ± 1.4, n = 3); head wider than long (HL 19.8 mm, HW 20.5 mm in the male; HL 18.2–19.2 mm, HW 20.7–21.4 mm in females); snout round, longer than horizontal diameter of eye (SL 8.8 mm, ED 5.8 mm in the male; SL 8.4–
specimens were found between 20:00h and 22:00h; one male was sitting on leaves near a stream, about 2 m above the ground and a pair was swimming in a pool. Surrounding habitat was mixed evergreen forest of small hardwoods, bamboo and shrub.

Ecological notes. Specimens were found between 20:00h and 22:00h while sitting on leaves, about 3–7 m above the ground, near a stream in the evergreen forest. Distribution. In Vietnam, *R. dorsovirdis* has been recorded from Lao Cai and Lai Chau provinces (Nguyen et al., 2009). Elsewhere, this species is known from China (Yunnan) (Frost, 2016).

**Ecological notes.** Specimens were found between 20:00h and 22:00h; one male was sitting on leaves near a stream, about 2 m above the ground and a pair was swimming in a pool. Surrounding habitat was mixed evergreen forest of small hardwoods, bamboo and shrub.
Distribution. In Vietnam, *R. duboisi* is known from Lao Cai and Ha Giang provinces (Nguyen et al., 2009). Elsewhere, this species has been reported from China (Yunnan) (Frost, 2016).

**Rhacophorus feae** Boulenger, 1893

Brown-folded Treefrog / Ech cay phe (Fig. 2c)

Specimens examined (n = 4). Two adult males (TBUPAE 37, 96) and two adult females (TBUPAE 36, 97) collected by AVP et al., 14 and 15 October 2012, near Hua Ty Village, Co Ma Commune, Thuan Chau District, within Copia NR (21°21.256′N, 103°35.170′E, elevation 1480 m asl.).

Morphological characters. SVL males 102.4–104.0 mm (n = 2), females 112.0–120.4 mm (n = 2); head wider than long (HL 30.5–34.0 mm, HW 34.0–34.3 mm in males; HL 38.3–40.1 mm, HW 38.4–41.0 mm in females); snout round, longer than horizontal diameter of eye (SL 15.1–18.0 mm, ED 10.5–11.3 mm in males; SL 18.9–19.2 mm, ED 14.0–14.2 mm in females); nostrils oval, on lateral side, closer to the tip of snout than to the eye (SNL 6.2–8.0 mm, NEL 9.0–10.0 mm in males; SNL 8.5–8.6 mm, NEL 10.3–11.0 mm in females); canthus rostralis distinct; loreal region concave; interorbital distance wider than upper eyelid (IOD 11.4–13.2 mm, UEW 8.1–11.0 mm in males; IOD 12.3–13.2 mm, UEW 9.5–11.5 mm in females); tympanum round (TD 7.0 mm in males, 7.3–8.8 mm in females); supratympanic fold distinct; vomerine teeth present; tongue notched posteriorly.

Forelimbs: forearm (FLL 20.0–22.0 mm in males, 23.0–25.8 mm in females), shorter than hand (HAL 34.5–35.0 mm in males; HAL 39.5–42.0 mm in females); relative length of fingers: I<II<IV<III; tip of fingers enlarged into large discs; webbing formula: I1–1II0–½III0–0IV; subarticular tubercles distinct, formula 1, 1, 2, 2; inner metatarsal tubercle distinct, oval.

Hindlimbs: shanks about five times longer than wide (TL 48.8–50.0 mm, TBW 11.0–11.8 mm in males; TL 54.4–57.0 mm, TBW 13.5–14.2 mm in females), shorter than thigh (FL 53.0–53.5 mm in males, 58.4–58.6 mm in females); foot length (FOT 45.0–46.7 mm in males, 49.0–50.0 mm in females); relative length of toes: I<II<III<½IV<½IV; toes fully webbed; tip of fingers enlarged into large discs; subarticular tubercles present, round, formula 1, 1, 2, 3, 2; inner metatarsal tubercle distinct; outer metatarsal tubercle absent.

Dorsal surface of head, body and limbs smooth; dorsolateral folds absent; throat smooth; chest, belly and ventral surface of thighs granular.

Colouration in life: Dorsal surface green with some white spots; supratympanic fold reddish brown; webbing greenish yellow; throat and chest creamy; belly and ventral surface of thighs purplish brown (determination after Boulenger, 1893; Orlov et al., 2008; Ostroshabov et al., 2013; Luu et al., 2014).

Ecological notes. Specimens were found between 19:00 h and 21:00 h while sitting on leaves near a stream, about 4–6 m above ground in the evergreen forest.

Distribution. In Vietnam, *R. feae* has been recorded from Lai Chau and Lao Cai provinces in the North southwards to Lam Dong and Dong Nai provinces (Nguyen et al., 2009; Luu et al., 2014). Elsewhere, this species is known from China, Myanmar, Laos, and Thailand (Frost, 2016).

**Rhacophorus maximus** Günther, 1858

White-lipped Treefrog / Ech cay lon (Fig. 2d)

Specimen examined (n = 1). One adult male (TBUPAE 603) collected by AVP et al., 2 April 2014, near Kha Village, Pung Banh Commune, Sop Cop District, within Sop Cop NR (21°00.342′N, 103°20.293′E, elevation 1230 m asl.).

Morphological characters. SVL 74.0 mm; head wider than long (HL 25.1 mm, HW 26.2 mm); snout round, longer than horizontal diameter of eye (SL 12.0 mm; ED 7.8 mm); nostrils oval, on lateral side, closer to the tip of snout than to the eye (SNL 5.8 mm, NEL 6.0 mm); canthus rostralis angular; loreal region concave; interorbital distance wider than upper eyelid (IOD 8.9 mm, UEW 6.2 mm); tympanum distinct (TD 5.0 mm); supratympanic fold distinct; vomerine teeth present; tongue notched posteriorly.

Forelimbs: forearm (FLL 13.2 mm) shorter than hand (HAL 23.4 mm); relative length of fingers: I<II<IV<III; tips of fingers enlarged into large discs; webbing formula: I1–I1II0–½III0–0IV; subarticular tubercles distinct, formula 1, 1, 2, 3, 2; inner metatarsal tubercle distinct; outer metatarsal tubercle absent.

Dorsal skin smooth; dorsolateral folds absent; throat, belly and lower surface of limbs granular.

Colouration in life: Dorsal surface green with some yellow dots; supratympanic fold green; flanks brown.
with a light stripe from the margin of the lower jaw to the groin; ventral surface cream (determination after Anders and Rai, 2002; Orlov et al., 2008; Hecht et al., 2013; Ostroshabov et al., 2013; Luu et al., 2014).

Ecological notes. A single specimen was found at 21:00 h while sitting on a stone near a stream in the evergreen forest.

Distribution. In Vietnam, R. maximus has been recorded from Bac Giang, Thanh Hoa and Quang Binh provinces (Nguyen et al., 2009; Pham et al., 2016). Elsewhere, this species is known from India, Nepal, China, Thailand, and Laos (Luu et al., 2014; Frost, 2016).

**Rhacophorus orlovi** Ziegler & Köhler, 2001

Orlov’s Frog / Ech cay ooc-lop (Fig. 2e)

Specimens examined (n = 3). Two adult males and one adult female collected by AVP et al.: One adult male (IEBR A.2016.9: Field No. SL.2016.47) and one adult female (IEBR A.2016.10: Field No. SL.2016.46), collected on 17 June 2016, near Bang Village, Muong Bang Commune (21°05.642’N, 104°47.889’E, elevation 1050 m asl.); one adult male (IEBR A.2016.11: Field No. SL.2016.106), collected on 20 June 2016, near Lan Village, Muong Do Commune, Phu Yen District (21°12.301’N, 104°43.049’E, elevation 980 m asl.).

Morphological characters. SVL males 37.4–41.5 mm (n = 2), female 53.4 mm; head longer than wide (HL 15.0–15.6 mm, HW 14.4–14.7 mm in males; HL 20.3 mm, HW 19.1 mm in the female); snout round, longer than horizontal diameter of eye (SL 6.5–6.8 mm, ED 5.7–6.4 mm in males; SL 8.5 mm, ED 7.7 mm in the female); nostrils oval, on lateral side, closer to the tip of snout than to the eye (SNL 2.1–2.9 mm, NEL 3.7–3.9 mm in males; SNL 3.4 mm, NEL 5.7 mm in the female); canthus rostralis distinct, slightly rounded; loreal region concave; interorbital distance wider than upper eyelid (IOD 5.1–5.5 mm, UEW 3.3–4.0 mm in males; IOD 7.5 mm, UEW 4.5 mm in the female); tympanum distinct, round (TD 3.0–3.1 mm in males, 4.6 mm in female); supratympanic fold distinct; vomerine teeth distinct; tongue notched posteriorly.

Forelimbs: forearm (FLL 7.8–8.5 mm in males, 11.6 mm in the female) shorter than hand (HAL 10.5–11.5 mm in males, 16.6 mm in the female); relative length of fingers: I<II<IV<III; tip of fingers enlarged into discs; disc on finger III narrower than tympanum diameter; webbing formula: 1½–2½II1½–2½III2–2½IV; subarticular tubercles distinct, formula 1, 1, 2, 2; inner metatarsal tubercles indistinct.

Hindlimbs: shanks about five times longer than wide (TL 20.4–20.5 mm, TBW 3.1–4.0 mm in males; TL 29.3 mm, TBW 5.0 mm in the female), longer than thigh (FL 20.2–20.3 mm in males, 28.5 mm in the female); foot length (FOT 27.0–27.3 mm in males, 38.1 mm in the female); relative length of toes: I<II<III<V<IV; webbing formula: I1–1½II1–2III1–2IV2–1V; tip of fingers enlarged into discs; subarticular tubercles present, formula 1, 1, 2, 3, 2; inner metatarsal tubercle distinct; outer metatarsal tubercle absent. Dorsal skin smooth; chin and chest smooth; belly and underside of thighs slightly granular.

Colouration in life: Dorsal surface brown; temporal region with some light spots; flanks gray with some diffuse dark mottling in axillary region; groin brown with black mottling. Dorsal surface of limbs with dark bars; posterior part of thighs black with white spots; webs dark grey; ventral surface light brown (determination after Ziegler and Köhler, 2001; Ostroshabov et al., 2013).

Ecological notes. Specimens were found between 20:00h and 21:00h while sitting on leaves near a stream, about 4–5 m above the ground in the evergreen forest.

Distribution. In Vietnam, R. orlovi has been recorded from Lao Cai, Ninh Binh and Thanh Hoa provinces in the North southwards to Gia Lai Province (Nguyen et al., 2009; Pham et al., 2016). Elsewhere, this species is known from Laos and Thailand (Frost, 2016).

Remarks. The specimens from Son La differ from the type series of R. orlovi (see Ziegler and Köhler, 2001) in having a larger size (SVL 37.4–41.5 mm versus 31.3–37.4 mm in males; 53.4 mm versus 36.6–48.4 mm in females). The specimens of R. orlovi from Son La are also morphologically similar to R. hoanglienensis but they differ from the latter by having light spots in the temporal region (vs. absent in R. hoanglienensis); and the snout round (vs. pointed in R. hoanglienensis).

**Rhacophorus rhodopus** Liu & Hu, 1960

Red-webbed Treefrog / Ech cay mang boi doi (Fig. 2f)

Specimens examined (n = 4). Two adult males and two adult females collected by AVP et al.: two adult males (TBUPAE 280, 510), 20 April and 22 July 2013, near Hua Ty Village (21°20.763’N, 103°35.546’E, elevation 1480 m asl.) and one adult female (TBUPAE 364), 10 June 2013, near Nong Vai Village (21°20.243’N, 103°34.699’E, elevation 1470 m asl.), Co Ma Commune, Thuan Chau District within Copia NR; one adult female (IEBR A.2016.12: Field No. SL.2016.47), 2 May 2013, near Tin Toi Village, Dom Cang Commune, Sop Cop District within Sop Cop NR (21°01.190’N,
Morphological characters. SVL males 35.6–37.0 mm (n=2), females 40.0–40.4 mm (n=2); head wider than long (HL 12.0–13.5 mm, HW 12.3–13.7 mm in males; HL 14.0–14.4 mm, HW 14.3–14.4 mm in females); snout pointed at tip, longer than horizontal diameter of eye (SL 5.1–5.7 mm, ED 5.0–5.5 mm in males; SL 6.0 mm, ED 5.3 mm in females); nostrils round, on lateral

Figure 2. a) *Rhacophorus dorsoviridis* (TBU PAE 525, adult male), b) *R. duboisi* (SL.2015.91, adult male), c) *R. feae* (TBUPAE 96, adult male), d) *R. maximus* (TBUPAE 603, adult male), e) *R. orlovi* (SL.2016.46, adult female), and f) *R. rhodopus* (TBUPAE 280, adult male) from Son La Province, Vietnam. Photos: A. V. Pham.

103°34’179”E, elevation 1670 m asl.)
side, closer to the tip of snout than to the eye (SNL 2.5–2.8 mm, NEL 2.8–3.0 mm in males; SNL 3.0–3.1 mm in females); canthus rostralis obtuse; loreal region concave; interorbital distance wider than upper eyelid (IOD 3.9–4.3 mm, UEW 2.8–3.1 mm in males; IOD 5.0–5.1 mm, UEW 3.0–3.1 mm in females); tympanum distinct (TD 2.3–2.7 mm in males, 2.7–3.1 mm in females); vomerine teeth present; tongue notched posteriorly; males with a large external vocal sac.

Forelimbs: Forearm short, thin (FLL 6.7–7.8 mm in males, 8.4–8.5 mm in females), shorter than hand (HAL 10.9–11.0 mm in males, 11.5–12.3 mm in females); relative finger lengths I<II<IV<III, tips of fingers enlarged into large discs; webbing formula: I–I½II–I½III–I½IV; subarticular tubercles distinct, formula 1, 1, 2, 2; metatarsal tubercles indistinct; males with nuptial pad.

Hindlimbs: Shank six times longer than wide (TL 17.0–17.5 mm, TW 2.5–2.6 mm in males; TL 19.7 mm, TW 3.0–3.5 mm in females), longer than thigh (FL 15.8–16.3 mm in males, 17.4 mm in females); foot length (FOT 15.5–15.6 mm in males, 17.0–17.3 mm in females); relative toe lengths: I<II<III<IV<IV; toes fully webbed; tip of fingers enlarged into large discs; subarticular tubercles present, formula 1, 1, 2, 3, 2; inner metatarsal tubercle small.

Dorsal skin and flanks smooth; dorsolateral folds absent; throat and chest smooth; belly and underside of thighs slightly granular.

Colouration in life. Dorsum reddish brown with many dark spots; flanks white with brown spots with a distinct black spot at axilla; ventral surface yellow (determination after Orlov et al., 2008; Hecht et al., 2013; Ostroshabov et al., 2013).

Ecological notes. Specimens were found between 20:00h and 22:30h on leaves, about 1.5–5 m above the forest floor.

Distribution. In Vietnam, R. rhodopus has been recorded from Lao Cai Province southwards to Lam Dong and Dong Nai provinces (Nguyen et al., 2009; Hecht et al., 2013). Elsewhere, this species is known from India, China Myanmar, Laos, Thailand and Cambodia (Forst, 2016).

Discussion

Our six new records, comprising Rhacophorus dorsoviridis, R. duboist, R. feae, R. maximus, R. orlovi and R. rhodopus, bring the total species number of the genus Rhacophorus to eight in Son La Province (see Nguyen et al. 2009). Son La Province is located in the northwestern region, one of the four biodiversity centres of Vietnam (Tordoff et al., 2004). One new species (Tylototriton anguliceps) and several new country records of amphibians have been reported from this province since 2010, namely Leptobrachium masatakasatoi, Leptolalax eos, L. minimus, Megophrys daweimontis, Anolops vitreus, Babina lini, Hylarana cubitalis, and H. menglaensis (Le et al., 2014; Pham et al., 2014; Le et al., 2015; Pham et al., 2016). Further field surveys are likely to reveal a much greater diversity of amphibians from Son La Province.

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