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First report on the amphibian fauna of Ha Lang karst forest, Cao Bang Province, Vietnam

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Abstract. A total of 21 species of amphibians was documented on the basis of a new herpetological collection from the karst forest of Ha Lang District, Cao Bang Province. Three species, *Odorrana bacboensis*, *O. graminea*, and *Rhacophorus maximus*, are recorded for the first time from Cao Bang Province. The amphibian fauna of Ha Lang District also contains a high level of species of conservation concern with one globally and two nationally threatened species and three species, *Odorrana mutschmanni*, *Gracixalus waza*, and *Theloderma corticale*, which are endemic to Vietnam.

Keywords: Amphibians, karst forest, distribution, diversity, new records, Cao Bang Province.

INTRODUCTION

Recent herpetological research has underscored the special role of karst habitats in promoting speciation of reptiles and amphibians in the border areas between Vietnam and China (Pham et al. 2016c). Numerous new species and new country records have been recently discovered in the border region of both countries, for example *Odorrana geminata* Bain, Stuart, Nguyen, Che & Rao, 2009; *Protobothrops trungkhanhensis* Orlov, Ryabov & Nguyen, 2009; *Oligodon nagao* David, Nguyen, Nguyen, Jiang, Chen, Teynié & Ziegler, 2012; *Gekko adleri* Nguyen, Wang, Yang, Lehmann, Le, Ziegler & Bonkowski, 2013 (Bain et al. 2009; Orlov et al. 2009; David et al. 2012; Nguyen et al. 2013c; Guo et al. 2016). In addition, some other new species, that were recently described from Ha Lang forest in Cao Bang Province, are also expected to be found in the karst formations in Guangxi Province of China, viz. *Gracixalus waza* Nguyen, Le, Pham, Nguyen, Bonkowski & Ziegler, *Hemiphyllodactylus zugi* Nguyen, Lehmann, Le, Duong, Bonkowski & Ziegler, and *Odorrana mutschmanni* Pham, Nguyen, Le, Bonkowski & Ziegler (Nguyen et al. 2013a, 2013b; Pham et al. 2016c). These new discoveries of reptiles and amphibians from Cao Bang Province underline the still significantly underestimated biodiversity of northeastern Vietnam. Based on the results of our recent field surveys in the period between 2011 and 2015, we herein provide the first list of amphibians recorded from Ha Lang karst forest in Cao Bang Province.

MATERIAL & METHODS

Field surveys were conducted in the Ha Lang forest of Cao Bang Province (Fig. 1) in October 2011, in April and May 2012, in July 2014, and in April 2015 by T.Q. Nguyen, C.T. Pham, D.T. Le, H.T. An, M. Bonkowski, S. Herbst, T. Lehmann, M. Bernardes, and M. van Schingen. Survey transects were set up along streams, ponds, cave entrances, limestone cliffs, in the valleys, and forest paths. The main habitat type was secondary karst forest of medium and small hardwoods mixed with shrubs and vines at elevations between 400 to 700 m above sea level (Fig. 2). After taking photographs, the specimens were anaesthetized with ethylacetate, fixed in 80% ethanol for 4-6 hours and subsequently stored in 70% ethanol. Voucher specimens have been deposited in the collections of the Institute of Ecology and Biological Resources (IEBR), Hanoi, Vietnam, and the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), Bonn, Germany.

Morphological identification generally followed Bourret (1942), Taylor (1962), Inger et al. (1999), Ziegler (2002), Bain & Nguyen (2004), Bain et al. (2003), Nguyen et al. (2013a), and Mo et al. (2015). Measurements were taken with a digital caliper to the nearest 0.1 mm. Abbreviations are as follows: ED: horizontal eye diameter (eye length), EN: distance between anterior corner of eye and nostril, HL: head length, HW: head width, IND: internarial distance, IOD: interorbital distance, SN: distance between nostril and tip of snout, SL: snout length, SVL: snout-vent length (from tip of snout to cloaca), TD: max-

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Fig. 1. Map showing the survey site (red spot) in Ha Lang District in Cao Bang Province, Vietnam.

Fig. 2. Limestone karst forest in Ha Lang District, Cao Bang Province, Vietnam. Photo: T.Q. Nguyen.

imum tympanum diameter, TED: distance between anterior margin of tympanum and posterior corner of eye, UEW: width of upper eyelid, and asl.: above sea level. Sex was determined by the presence of internal vocal sac opening or gonadal inspection.

RESULTS

Taxonomic accounts

Bufonidae

***Duttaphrynus melanostictus* (Schneider, 1799)** (Fig. 3a)

Identification was based on direct observations in the field and photographs: Cranial crests conspicuous, black and more distinct on supraorbital region; parietal crest absent; parotoid glands prominent, elongated; tympanum distinct, round; dorsum and upper surface of limbs with conical, spiny warts; warts smaller on flanks; ventral surface granular; fingers free of webbing, toes with webbing at base.

Coloration in life: Upper head and dorsum yellowish grey to dark brown with black spines; ventral cream (determination after Bourret 1942; Ziegler 2002).

Ecological notes. Several individuals were found in the evening in rice fields and forest paths.

Distribution. This is a common species in Vietnam. Elsewhere, the species has been known from Sri Lanka, India, Pakistan, Nepal, China, Myanmar, Laos, Thailand, Cambodia, Malaysia and the Philippines (Nguyen et al. 2009).

Microhylidae

***Microhyla fissipes* Boulenger, 1884** (Fig. 3b)

Specimens examined. Three adult females (IEBR 3828: SVL 19.0 mm, IEBR 3829: SVL 19.9 mm, IEBR 3830: SVL 16.0 mm) collected by T.Q. Nguyen et al. on 6 April 2012, at elevations between 492 and 631 m asl.

Morphological characters. Body flattened, triangle shaped; head small, longer than wide (HL 5.5–6.2 mm, HW 4.8–5.2 mm); snout length greater than eye diameter (SL 2.1–2.4 mm, ED 1.7–2.0 mm); nostril closer to tip of snout than to eye (SN 1.0–1.2 mm, EN 1.5–1.8 mm); interorbital distance broader than internarial distance and upper eyelid (IOD 1.7–1.8 mm, IND 1.5–1.6 mm, UEW 1.1–1.3 mm); tympanum hidden; vomerine teeth absent; tongue notched posteriorly. Fingers free of webbing, with

Fig. 3. a) *Duttaphrynus melanostictus*, b) *Microhyla fissipes*, c) *M. heymonsi* d), *M. pulchra*, e) *Fejervarya limnocharis*, f) *Hoplobatrachus rugulosus*, g and h) *Limnonectes bannaensis*. Photos: C.T. Pham and H.T. An.

small discs; relative length of fingers I<II<IV<III; toes with rudimental webbing, without discs; relative length of toes I<II<V<III<IV; subarticular tubercles well developed; inner and outer metatarsal tubercles small; tibio-tarsal articulation reaching to the eye. Dorsal and ventral skin smooth; supratympanic fold indistinct.

Coloration in life: Dorsal head and body brown, with a grayish brown patch from orbit to hind body, a dark patch on dorsolateral fold; ventral surface cream (determination after Bourret 1942; Manthey & Grossmann 1997; Ziegler 2002; Bain & Nguyen 2004).

Ecological notes. The specimens were found between 19:00 and 23:00 in corn fields.

Distribution. This is a widespread species in Vietnam. Elsewhere, the species is known from China, Taiwan, Myanmar, Laos, Thailand, Cambodia, Malaysia and Singapore (Nguyen et al. 2009).

***Microhyla heymonsi* Vogt, 1911** (Fig. 3c)

Specimen examined. One adult male (IEBR 3831: SVL 22 mm) collected by T.Q. Nguyen et al. on 3 May 2012, at an elevation of 487 m asl.

Morphological characters. Body flattened, triangle shaped; head longer than wide (HL 8.3 mm, HW 6.4 mm); snout obtusely pointed, pronounced, somewhat longer than eye (SL 2.9 mm, ED 2.3 mm); nostrils closer to tip of snout than to eye (SN 1.1 mm, EN 1.5 mm); interorbital distance broader than internarial distance and upper eyelid (IOD 2.3 mm, IND 2.1 mm, UEW 1.5 mm); tympanum hidden; vomerine teeth absent; tongue round posteriorly; male with vocal sacs.

Fingers free of webbing, with small discs; relative length of fingers I<II<IV<III; toes with rudimental webbing; relative length of toes I<II<V<III<IV; subarticular tubercles well developed; inner and outer metatarsal tubercles small; tibio-tarsal articulation reaching nearby tip of snout. Dorsal and ventral skin smooth; supratympanic fold indistinct.

Coloration in life: Dorsal head and body light brown, with a white stripe from tip of snout to cloaca, and a small dark spot in the middle of the back; lateral sides of head and flanks dark brown; anterior part of thighs, cloacal region and lower parts of feet black; limbs with thin transverse bars; ventral surface white to grey; male with black vocal sacs (determination after Bourret 1942; Ziegler 2002; Bain & Nguyen 2004)

Ecological notes. The specimen was collected at 19:00 in a small rivulet. The surrounding habitat was mixed secondary forest, bamboo, small hardwoods, liane and shrub.

Distribution. This is a widespread species in Vietnam. Elsewhere, the species is known from India, China, Laos, Thailand, Cambodia, Malaysia and Indonesia (Nguyen et al. 2009).

***Microhyla pulchra* (Hallowell, 1861)** (Fig. 3d)

Specimens examined. One adult female (IEBR 3832: SVL 24.8 mm) and one adult male (IEBR 3833: SVL 29 mm) collected by T.Q. Nguyen et al. in April 2012, at elevations between 492 and 594 m asl.; one adult female (IEBR 3834: SVL 28.6 mm) collected by C.T. Pham et al. on 14 June 2014, at an elevation of 537 m asl.

Morphological characters. Body flattened, triangle shaped; head longer than wide (HL 8.4–9.4 mm, HW 6.9–7.4 mm); snout obtusely pointed, slightly pronounced, longer than eye (SL 3.3–3.6 mm, ED 2.7–3.1 mm); pupil round; interorbital distance broader than upper eyelid (IOD 2.1–2.5 mm, UEW 1.7–1.9 mm); tympanum indistinct; vomerine teeth absent; tongue round posteriorly; male with vocal sacs. Fingers free of webbing; tips of fingers not enlarged; relative length of fingers I<II<IV<III; toes webbed, webbing formula I2/3-1II1/3-11/2III1-2IV21/2-1V; relative length of toes I<II<V<III<IV; subarticular tubercles well developed; inner metatarsal tubercles present, outer metatarsal tubercles round; tibio-tarsal articulation reaching between eye and tip of snout. Dorsal skin smooth; a distinct fold present between posterior edges of the eyes; ventral skin smooth; cloacal region granular.

Coloration in life: Dorsum brown with a dark band between eyes; several V-shaped dark and lighter alternating bands on dorsum pointing to the head; dark transversal band from posterior corner of the eye towards upper flanks; rear of flanks and inner parts of legs yellow; limbs with transverse bars; ventral surface whitish yellow; throat and chest speckled with dark (determination after Bourret 1942; Ziegler 2002; Bain & Nguyen 2004).

Ecological notes. The specimens were collected between 19:00 and 22:00. One specimen was found in a corn field. Other specimens were found on forest paths, the surrounding habitat was mixed secondary forest of bamboo, small hardwoods, liane and shrub.

Distribution. This is a common species in Vietnam. Elsewhere, this species in known from northeastern India to southern China, Cambodia, Guam, Laos and Thailand (Frost 2017).

Dicroglossidae

***Fejervarya limnocharis* (Gravenhorst, 1829)** (Fig. 3e)

Specimens examined. One adult female (IEBR 3835: SVL 41 mm) and one adult male (IEBR 3836: SVL 33 mm) collected by T.Q. Nguyen et al. on 6 April 2012, at elevations between 492 and 516 m asl.

Morphological characters. Head longer than wide (HL 13.2–15.9 mm, HW 12.7–14.6 mm); snout pointed, longer

than eye (SL5.4–6.9 mm, ED 4.1–5.6 mm); canthus rostralis obtuse; loreal region oblique; nostrils closer to tip of snout than to eye (NS 2.6–3.2 mm, EN 3.2–3.6 mm); internarial distance and upper eyelid broader than interorbital distance (IND 3.0–3.6mm, UEW 2.9–3.4mm, IOD 2.4–2.5mm); tympanum distinct (TD 2.0–2.6 mm); vomerine teeth present; tongue bifid; male with vocal sacs. Fingers free of webbing; tips of fingers not enlarged; relative length of fingers II<IV<I<III; toes webbed, webbing formula I1/4-1II1/4-11/4III3/4-2IV2-2/3V; relative length of toes I<II<III<V<IV; subarticular tubercles well developed; inner metatarsal tubercles present, outer metatarsal tubercles small; tibio-tarsal articulation reaching to eye. Dorsal skin granular with several irregular dermal folds; ventral surface smooth; supratympanic fold distinct; males with nuptial pads.

Coloration in life: Dorsal head and body greyish green with camouflage-pattern; light vertebral stripe present or absent; lips with dark vertical bars; limbs with transverse bars or spots; ventral surface white; throat marbled with black in males (determination after Bourret 1942; Manthey & Grossmann 1997; Ziegler 2002).

Ecological notes. The specimens were found between 19:00 and 20:00 in the rice field.

Distribution. In Vietnam, this species has been reported from the entire country. Elsewhere, this species is known from China, Myanmar, Laos, Cambodia, Thailand, Malaysia and Indonesia (Frost 2017).

***Hoplobatrachus rugulosus* (Wiegmann, 1834)** (Fig. 3f)

Specimen examined. One adult female (IEBR 3837: SVL 62.5 mm) collected by T.Q. Nguyen et al. on 17 October 2011, at an elevation of 620 m asl.

Morphological characters. Head broader than long (HW 27.8 mm, HL 25.3 mm); nostril oval, closer to eye than to tip of snout (NS 5.1 mm, EN 4.4 mm); interorbital distance and internarial distance smaller than upper eyelid (IOD 3.2 mm, IND 4 mm, UEW 5.6 mm); tympanum round, smaller than eye diameter (TD 4.5 mm, ED 8.3 mm); vomerine teeth present; tongue bifid. Arms short; fingers without webbing; tips of fingers obtusely pointed; relative length of fingers II<I<IV<III; outer metatarsal tubercle absent; hind limbs short; toes fully webbed, tips of toes pointed, without discs, subarticular tubercles small; relative length of toes I<II<III<V<IV; tibio-tarsal articulation reaching to the eye. Skin granulate on dorsum and flanks containing 10 irregular rows of elongate ridges; ventral side of body smooth; supratympanic fold distinct.

Coloration in life: Dorsum olive green with dark blotches; upper lip with irregular dark bars; dorsal surface of limbs with dark bands; ventral surface cream; gular region with dark marbling; lower part of flanks with dark marbling (determination after Bourret 1942; Taylor 1962; Ziegler 2002).

Ecological notes. The specimen was found at ca. 21:00 on the bank of a small stream. The surrounding habitat was mixed secondary karst forest, composed of medium and small hardwoods, shrubs and vines.

Distribution. In Vietnam, this species has been reported from the entire country. Elsewhere, this species is known from China, Taiwan, Myanmar, Laos, Thailand, Cambodia and Malaysia (Nguyen et al. 2009).

***Limnonectes bannaensis* Ye, Fei & Xie, 2007**
(Fig. 3g, h)

Specimens examined. One female (IEBR 3859: SVL 80.6 mm), and two adult males (IEBR 3861: SVL 66.2 mm, IEBR 3867: SVL 69.5 mm) collected by T.Q. Nguyen et al. on 15 October 2011, at an elevation of 476 m asl.; and four adult males (IEBR 3888: SVL 65.5 mm, IEBR 3889: SVL 60 mm, IEBR 3890: SVL 64 mm, IEBR 3899: SVL 92 mm) collected by T.Q. Nguyen et al. on 13 April 2012, at an elevation of 544 m asl.

Morphological characters. Head large, flattened, wider than long (HL 21.5–36.0 mm, HW 22.8–37.5 mm); snout round, longer than eye diameter (SL 7.9–10.3 mm, ED 7.1–8.4 mm); canthus rostralis indistinct; loreal region oblique and slightly concave; nostril closer to tip of snout than to eye (EN 4.6–6.6 mm, NS 4.1–4.9 mm); internarial distance broader than interorbital distance and upper eyelid (IND 4.2–6.0 mm, IOD 4.0–5.2 mm, UEW 3.8–5.0 mm); tympanum hidden; vomerine teeth present; tongue bifurcated posteriorly; lower jaw with two tooth-like processes; males without vocal sacs. Arms short, fingers free of webbing, tips of fingers obtuse or slightly swollen, relative length of fingers II<IV<I<III; subarticular tubercles on fingers and toes large; hind limbs short; toes short, fully webbed; tips of toes dilated into small discs; relative length of toes I<II<III<V<IV; subarticular tubercles large; inner metatarsal tubercle large, outer metatarsal tubercle absent; tibio-tarsal articulation reaching to the eye. Skin above and below smooth; small and homogenous tubercules on the leg and foot; supratympanic fold present.

Coloration in life: Dorsum reddish brown to greyish brown, mostly with dark mottling or marbling; sometimes with light vertebral stripe; lower region of flanks lighter; limbs with dark transversal bands; ventral surface cream, ventral side of limbs darker; throat, pectoral region, belly and outer edges of limbs with dark mottles (determination after Ye et al. 2007; McLeod 2010; McLeod et al. 2015).

Ecological notes. The specimens were found between 19:30 and 23:00 on the bank of a small stream. The surrounding habitat was mixed secondary karst forest, composed of medium and small hardwoods, shrubs and vines.

Distribution. In Vietnam, this species was reported from Lao Cai Province in the North to Dong Nai and Kien Gi-

ang provinces in the South. Elsewhere, this species is known from China, Myanmar and Laos (Nguyen et al. 2009; McLeod 2010).

Remarks: McLeod (2010) stated that *Limnonectes kuhlii* (Tschudi, 1838) is a complex of cryptic species. The "true" *L. kuhlii* is known only from the type locality in Java, Indonesia, and specimens identified as *L. kuhlii* from China and Vietnam should be assigned to *L. bannaensis*.

Ranidae

***Hylarana guentheri* (Boulenger, 1882)** (Fig. 4a)

Specimens examined. One adult male (IEBR 3838: SVL 49.7 mm) collected by T.Q. Nguyen et al. on 17 October 2011, at an elevation of 544 m asl.; and one adult male (IEBR 3939: SVL 76.6 mm) collected by T.Q. Nguyen et al. on 10 April 2012, at an elevation of 459 m asl.

Morphological characters. Head longer than wide (HL 19.2–29.1 mm, HW 16.3–24.2 mm); snout pointed, strongly projecting; canthus rostralis distinct; loreal region moderately oblique, concave; nostril closer to tip of snout than to eye (EN 4.5–6.4 mm, NS 3.9–5.3 mm); internarial distance broader than interorbital distance and upper eyelid (IND 4.9–6.9 mm, IOD 4.4–6.2 mm, UEW 3.6–4.6 mm); tympanum distinct (TD 4.0–5.8 mm); vomerine teeth present; tongue notched posteriorly; males with vocal sacs. Fingers slender and rather long, free of webbing, finger tips swollen; relative length of fingers II<IV<I<III; subarticular tubercles large; tips of toes dilated into small discs, with a median groove; relative length of toes I<II<III<V<IV; webbing formula I1/2-2II1/2-2III1-3IV3-1V; subarticular tubercles small; inner metatarsal tubercle present, outer metatarsal tubercle very small; tibio-tarsal articulation reaching nearby tip of snout. Skin above and below smooth; dorsolateral fold distinct; supratympanic fold prominent.

Coloration in life: Dorsal surface of head and body light brown to reddish brown, uniform or with dark brown spots; lateral head and flanks with a dark line, bordering the dorsolateral fold; tympanum dark brown or reddish; limbs with brown crossbars, back of thighs yellow with black mottles; ventral surface white or yellow, throat or chest speckled with brown (determination after Bourret 1942; Ziegler 2002).

Ecological notes. One specimen was found between 19:00 and 21:00 on the bank of a small stream, another one was found near the cave entrance. The surrounding habitat was mixed secondary karst forest, composed of medium and small hardwoods, shrubs and vines.

Distribution. This is a common species in lowland areas of Vietnam. Elsewhere, the species has been reported from China, Taiwan, Myanmar and Laos (Nguyen et al. 2009).

***Odorrana bacboensis* Bain, Lathrop, Murphy, Orlov & Ho, 2003** (Fig. 4b)

Specimens examined: Three adult females (IEBR A.2015.82: SVL 101.1 mm, IEBR 3886: SVL 103 mm, IEBR A.2015.83: SVL 93.2 mm) collected by T.Q. Nguyen et al. on 10 April 2012, at an elevation of 459 m asl.

Morphological characters. Head longer than wide (HL 37.1–39.7 mm, HW 32.5–35.9 mm); snout obtusely round in dorsal view, projecting beyond lower jaw, round in profile; canthus rostralis distinct; nostril lateral, closer to tip of snout than to eye (NS 7.3–7.6 mm, EN 8.8–9.2 mm); snout length greater than eye diameter longer than eye (SL 16.1–17.4 mm, ED 10.6–12.0 mm); interorbital distance narrower than internarial distance but broader than upper eyelid (IOD 10.5–11.3 mm, IND 11.1–12.3 mm, UEW 6.9–8.6 mm); tympanum distinct, half of eye diameter (TD 5.4–6.1 mm, ED 10.6–12.0 mm); vomerine teeth present; tongue notched posteriorly. Fingers free of webbing; relative length of fingers II<I<IV<III; finger discs larger than those of toes, with circummarginal groove; toes fully webbed; relative length of toes I<II<III<V<IV; outer metatarsal tubercle absent; inner metatarsal tubercle large, flat; tibio-tarsal articulation reaching to tip of snout. Dorsal skin smooth; flanks with tubercles; supratympanic fold present; dorsolateral fold absent; dorsal surface of limbs smooth; throat, chest, belly and ventral surface of thighs smooth.

Coloration in life: Dorsum brown to dark brown, with tiny, irregular, black blotches; flanks brown, with some large black spots; throat, chest and belly white (determination after Bain et al. 2003; Wang et al. 2015).

Ecological notes. The specimens were found between 19:00 and 23:00 on the bank of a rocky stream inside a cave. The surrounding habitat was mixed secondary karst forest, composed of medium and small hardwoods, shrubs and vines.

Distribution. In Vietnam, this species has been reported from Lao Cai, Tuyen Quang, Bac Kan, Nghe An provinces (Nguyen et al. 2009). This is the first record of *O. bacboensis* from Cao Bang Province. Elsewhere, the species has been reported from China (Wang et al. 2015).

***Odorrana graminea* (Boulenger, 1900)** (Fig. 4c, d)

Specimens examined. Five adult females (IEBR A.2015.80: SVL 85 mm, IEBR 3887: SVL 90 mm, IEBR 3891: SVL 91 mm, IEBR A 2015.81: SVL 94 mm, IEBR 3892: SVL 92 mm) and eight adult males (IEBR 3893: SVL 51.1 mm, IEBR 3894: SVL 47.3 mm, IEBR A 2015.79: SVL 50 mm, IEBR 2015.78: SVL 45 mm, IEBR 3895: SVL 45 mm, IEBR 3896: SVL 43 mm, IEBR 3898: SVL 46 mm, IEBR 3897: SVL 48 mm) collected by T.Q. Nguyen et al. in April and May 2012, at elevations between 428 and 594 m asl.

Fig. 4. a) *Hylarana guentheri*, b) *Odorrana bacboensis*, c and d) *O. graminea*, e) *O. lipuensis*, f and g) *O. mutschmanni,* h) *Gracixalus waza.* Photos: C.T. Pham and H.T. An.

Morphological characters. Males smaller than females (SVL 42–53 mm in males, SVL 78–100 mm in females); head longer than wide (HL 30.2–38.1 mm, HW 27.7–34.1 mm in females, HW 14.8–16.4 mm, HL 16.7–18.7 mm in males); snout round, longer than eye (SL 12.5–15.7 mm, ED 9.1–10.8 mm in females, SL 7.0–7.8 mm, ED 5.9–6.8 mm in males); canthus rostralis distinct; interorbital distance wider than internarial distance and upper eyelid (IOD 8.3–9.8 mm, IN 9.5–11.1 mm, UEW 6.5–7.3 mm in females, IOD 4.5–4.8 mm, IN 5.1–5.8 mm, UEW 3.8–4.4 mm in males); pupil round; tympanum distinct, approximately half of eye diameter (TD 4.5–5.6 mm, ED 9.1–10.5 mm in females, TD 3.7–3.9 mm, ED 5.9–6.8 in males); vomerine teeth present; tongue cordiform, deeply notched posteriorly; males with vocal sacs. Fingers free of webbing; relative length of fingers II<I<IV<III; finger discs larger than those of toes, with circummarginal groove; toes fully webbed; relative length of toes I<II<III<V<IV; outer metatarsal tubercle absent; inner metatarsal tubercle elongate; tibio-tarsal articulation reaching beyond tip of snout. Dorsal skin smooth, flank with tubercles; supratympanic fold distinct; dorsolateral fold absent.

Coloration in life: Dorsum green with or without black spots; lateral sides of head and flanks brownish grey; lips white; hind limbs with distinct dark bars; webbing dark grey; ventral surface whitish (determination after Bourret 1942; Bain et al. 2003).

Ecological notes. The specimens were found between 19:00 and 23:00 on the bank of a rocky stream. The surrounding habitat was mixed secondary karst forest composed of medium and small hardwoods, shrubs and vines.

Distribution. In Vietnam, this species has been reported from Bac Kan, Lang Son, Vinh Phuc and Lam Dong provinces (Nguyen et al. 2009). This is the first record of *O. graminea* from Cao Bang Province. Elsewhere, the species has been reported from China (Nguyen et al. 2009).

***Odorrana lipuensis* Mo, Chen, Wu, Zhang & Zhou, 2015** (Fig. 4e)

Specimens examined. Two adult males (IEBR A.2015.63: SVL 48.1 mm, IEBR A.2015.64: SVL 49.8 mm) collected by T.Q. Nguyen et al. on 21 May 2012, at an elevation of 669 m asl.; three adult females (IEBR A.2015.65: SVL 60.1 mm, IEBR A.2015.66: SVL 58.5 mm, IEBR A.2015.67: SVL 59.5 mm) collected by C.T. Pham et al. on 7 June 2014, at an elevation of 532 m asl.

Morphological characters. Males smaller than females (SVL 48.1–49.8 mm in males, 58.5–60.1 mm in females); head longer than wide (HL 18.9–19.5 mm, HW 16.8–17.3 mm in males; HL 21.8–23.2 mm, HW 20.2–21.5 mm in females); snout obtusely rounded in dorsal view, projecting beyond lower jaw, round in profile; nostril lateral, closer to the tip of snout than to eye (NS 3.5–3.6 mm, EN 4.2–4.4 mm in males; NS 4.0–4.3 mm, EN 5.4–5.7 mm in females); canthus rostralis distinct; pupil horizontally oval; loreal region slightly concave and oblique; snout length greater than eye diameter (SL 7.6–7.7 mm, ED 6.8–6.9 mm, in males; SL 9.2–9.5 mm, ED 7.3–7.5 mm in females); interorbital distance wider than internarial distance and upper eyelid (IOD 5.6–5.6 mm, IND 5.2–5.3 mm, UEW 4.5–4.7 mm in males; IOD 7.0–7.2 mm, IND 6.3–6.6 mm, UEW 4.8–5.2 mm in females); tympanum distinct, round, smaller than eye diameter (TD 4.2–4.3 mm in males; TD 5.4–5.7 mm in females); vomerine teeth in two oblique ridges; tongue deeply notched posteriorly; males without vocal sacs; females contained creamy yellow eggs, without black poles. Forelimbs robust; tips of fingers expanded into discs with circummarginal grooves; relative length of fingers II<I<IV<III; inner metatarsal tubercle oval, elongate; outer metatarsal tubercle small; nuptial pads present in males. Hindlimbs long; tips of toes expanded into discs with circummarginal grooves; width of disc of toe IV smaller than that of finger III; relative length of toes I<II<III<V<IV; webbing formula I0-1/4II0-1/2III0-3/4IV3/4-0V; inner metatarsal tubercle elongate; outer metatarsal tubercle absent; tibio-tarsal articulation reaching to tip of snout. Dorsal surface of head and body smooth; tiny spinules on flanks, upper edge of eyelid; anterior and posterior edge of tympanum; supratympanic fold weakly developed; dorsolateral fold absent; throat, chest, belly and ventral surface of thigh smooth.

Coloration in life: Iris black, surrounded by golden network; dorsum and upper part of flanks moss-green with brown mottles; dorsal surface of fore and hindlimbs moss-green with dark brown cross bars; upper lip with dark brown bars; throat, chest and belly cream with dark brown mottles (determination after Mo et al. 2015).

Ecological notes. The specimens were found between 19:30 and 23:00. Two juveniles were found on trees, about 0.2–0.5 m above the ground, near the entrance of caves, on October 18th, 2011. Two males and five juveniles were found on trees, ca. 1.0-1.5 m above the ground, near cave entrances, in April and May 2012. Three females were found on trees, ca. 0.3-0.5 m above the water surface, near a pool from the waterfall of a rocky stream, in June 2014. The surrounding habitat was secondary karst forest, composed of medium and small hardwoods, shrubs and vines

Distribution. This species was originally described from China by Mo et al. (2015) and recently recorded from Vietnam by Pham et al. (2016a).

Remarks: The Vietnamese specimens of *O. lipuensis* differ from the type specimens from China in having larger sized females (SVL 58.5–60.1 mm *versus* 51.1–55.4 mm in the Chinese specimens) and a smaller ratio of TD/ED (0.68 in males and 0.63 in females *vs*. 0.73 in males and 0.69 in females from China, respectively) (see Mo et al. 2015).

***Odorrana mutschmanni* Pham, Nguyen, Le, Bonkowski & Ziegler, 2016** (Fig. 4 f, g)

Specimens examined. One adult male (IEBR 3724: SVL 91.6 mm) collected by T.Q. Nguyen et al. on 15 April 2012, one adult female (IEBR 3725: SVL 108.7 mm) and four adult males (IEBR 3726: SVL 85.8 mm, IEBR 3727: SVL 89.0 mm, IEBR 3728: SVL 90.1 mm, IEBR 3729: SVL 86.9 mm) collected by T.Q. Nguyen et al. on 16 April 2012, two adult males (ZFMK 97329: SVL 90.4 mm, ZFMK 97330: SVL 91.6 mm) collected by H.T. An et al. on 3 May 2012, one adult female (IEBR 3730: SVL 109.6 mm) collected by C.T. Pham et al. on 10 June 2014, one adult male (IEBR 3723: SVL 85.9 mm) and one adult female (IEBR 3731: SVL 110.1 mm) collected by T.Q. Nguyen on 22 April 2015, at an elevation of 447 m asl.

Morphological characters. Size large (SVL 85.9–91.6 mm in males, 108.7–110.1 mm in females); head longer than wide (HL 33.5–36.5 mm, HW 28.9–31.7 mm in males, HL 41.2–43.5 mm, HW 38.7–41.1 mm in females); snout round anteriorly in dorsal view; projecting beyond lower jaw; nostril lateral, closer to the snout tip than to eye (NS 6.2–7.2 mm, EN 7.1–8.1 mm in males, NS 8.4–8.8 mm, EN 9.1–9.7 mm in females); canthus rostralis distinct; loreal region slightly concave and oblique; snout length greater than eye diameter (SL 13.3–15.8 mm, ED 9.9–11.1 mm in males, SL 17.2–17.9 mm, ED 12.1–12.8 mm in females); internarial distance wider than interorbital distance and upper eyelid (IND 9.9–11.5 mm, IOD 7.8–10.3 mm, UEW 6.6–7.3 mm in males, IND 12.4–12.7 mm, IOD 10.7–11.5 mm, UEW 8.4–8.7 mm in females); tympanum distinct, round, 70% of eye diameter; vomerine teeth in two oblique ridges; tongue cordiform, deeply notched posteriorly; males without vocal sacs. Tips of fingers expanded into discs, with circummarginal grooves; relative length of fingers II<I<IV<III; finger webbing rudimental; outer metatarsal tubercle small; finger I with nuptial pad, elongate in males; tips of toes expanded into discs, with circummarginal grooves; width disc of toe IV narrower than that of finger III; relative length of toes I<II<III<V<IV; webbing formula I0-0II0-0III0-1/2IV1/2-0V; inner metatarsal tubercle elongate; outer metatarsal tubercle absent; tibio-tarsal articulation reaching to tip of snout. Dorsal surface of head and anterior part of body smooth; posterior part of body and flanks with tubercles; spinules present on lateral sides of body, anterior and posterior edge of tympanum; supratympanic fold present; dorsolateral fold absent; dorsal surface of limbs granular; throat, chest, belly and ventral surface of thigh smooth.

Coloration in life: Iris black; dorsum green with dark brown spots; lateral side of head and flanks greyish brown with dark brown spots; lips with dark bars; tympanum dark brown; spinules on flank ivory; dorsal surface of fore and hindlimbs greyish brown with dark crossbars; throat and chest grey; ventral surface of fore and hindlimbs and belly with large dark brown spots, edged in white, forming a network; toe webbing dark brown (determination after Pham et al. 2016c).

Ecological notes. The specimens were found between 19:00 and 23:00 around a water pool. Most of specimens were found on rock boulders, ca. 0.5–1.0 m above the ground, few frogs were in the water. The surrounding habitat was secondary karst forest of medium and small hardwoods mixed with shrubs and vines.

Distribution. The species was recently described from Cao Bang Province and is currently known only from its type locality in Vietnam (Pham et al. 2016c).

Rhacophoridae

***Gracixalus waza* Nguyen, Le, Pham, Nguyen, Bonkowski & Ziegler, "2012" 2013** (Fig. 4h)

Specimens examined. Five adult females (IEBR 3840: SVL 34 mm, IEBR 3841: SVL 32 mm, IEBR 3842: SVL 34 mm, IEBR 3843: SVL 35 mm, IEBR 3844: SVL 31 mm); seven adult males (IEBR 3845: SVL 33 mm, IEBR 3846: SVL 32.5 mm, IEBR 3847: SVL 32 mm, IEBR 3848: SVL 33 mm, IEBR 3849: SVL 31 mm, IEBR 3850: SVL 34 mm, IEBR 3851: SVL 30 mm), and two subadults (IEBR 3852: SVL 24.2 mm, IEBR 3853: SVL 25 mm) collected by T.Q. Nguyen et al. in April and May 2012, at elevations between 462 and 655 m asl.

Morphological characters. Head as long as wide (HL 10.5–13.9 mm, HW 10.9–14.2 mm), convex above; snout round anteriorly from dorsal view, slightly protruding, its length (SL 4.8–6.4 mm) longer than horizontal diameter of eye (ED 4.0–5.5 mm); canthus rostralis round, loreal region oblique, concave; interorbital region flat, broader than upper eyelid (IOD 3.1–4.2 mm, UEW 2.7–3.8 mm), as broad as internarial distance (IND 3.2–4.1 mm); nostril round, closer to tip of snout than to the eye (NS 2.2–3.0 mm, EN 3.2–4.0 mm); pupil oval, horizontal; tympanum distinct (TD 1.8–2.6 mm), round, half of the eye diameter; pineal ocellus absent; spinules on upper eyelid absent; vomerine teeth absent; choanae small, oval; tongue cordate, deeply notched posteriorly; males with a pair of vocal sacs at base of jaw. Arm short, about half of hand length; fingers free of webbing; relative length of fingers I<II<IV<III; tips of fingers with well-developed discs with distinct circum-marginal grooves; subarticular tubercles distinct, blunt, round; nuptial pads prominent, oval; outer palmar tubercle divided into two; relative length of toes I<II<III≤V<IV; tips of toes with well-developed discs with distinct circum-marginal grooves; webbing formula I1-11/3II1/2-2III1-2IV2-1V; subarticular tubercles distinct; inner metatarsal tubercle small; outer metatarsal absent; tibio-tarsal articulation reaching to tip of snout. Dorsal surface of head and body smooth; posterior part of tympa-

num, flank and lateral sides of limbs with small, flattened granules; dorsolateral folds absent; supratympanic fold distinct; throat and chest smooth, belly and ventral surface of thigh granular; dermal appendage at vent absent.

Coloration in life: Background of dorsal surface of head, body and limbs greyish green to moss-green; a dark brown, blotched pattern between eyes bifurcating into two bands continuing posteriorly on the back; a dark stripe present in the middle of posterior part of dorsum. Forelimb, dorsal parts of thigh, tibia, and foot moss-green with some dark brown bands; throat and chest white with dark brown marbling; belly immaculate white (determination after Nguyen et al. 2013a).

Ecological notes. The specimens were found between 19:00–23:30 on leaves and a limestone cliff, about 0.3–1.2 m above the ground, near the cave entrances and in the valleys surround by limestone cliffs, relatively far from water sources. The surrounding habitat was secondary forest consisting of medium and large hardwoods, shrub and liane.

Distribution. In Vietnam, this species has been only reported from Cao Bang Province (Nguyen et al. 2013a).

***Kurixalus bisacculus* (Taylor, 1962)** (Fig. 5a)

Specimens examined. One adult female (IEBR 3854: SVL 34 mm), and eight adult males (IEBR 3855: SVL 28 mm, IEBR 3856: SVL 29 mm, IEBR 3857: SVL 28.5 mm, IEBR 3858: SVL 30 mm, IEBR 3860: SVL 31 mm, IEBR 3862: SVL 31 mm, IEBR 3863: SVL 31 mm, IEBR 3864: SVL 31 mm) collected by T.Q. Nguyen in April and May 2012, at elevations between 352 and 669 m asl.

Morphological characters. Head longer than wide (HL 10.0–14.8 mm, HW 9.4–14.1 mm); snout pointed anteriorly, longer than eye (SL 4.5–6.0 mm, ED 3.6–4.4 mm); nostril closer to tip of snout than to eye (NS 2.0–2.8 mm, EN2.6–3.1 mm); interorbital distance wider than internarial distance (IOD 3.4–4.4 mm, IND 2.7–3.6, mm); tympanum distinct, smaller than eye (TD 1.9–2.6 mm, ED 3.6–4.4 mm); vomerine teeth in two ridges, arising near inner edges of choanae; males with vocal sacs. Fingers free of webbing, tips of fingers with enlarged discs; relative length of fingers I<II<IV<III; toes webbed, webbing formula I2/3-1II1/4-1III1/4-1IV1-1/4V; relative length of toes I<II<III<V<IV; inner metatarsal tubercle small; outer metatarsal absent; tibio-tarsal articulation reaching between eye and tip of snout. Some scattered flat tubercles on the head, eyelids, and occiput, sparse on dorsum, more dense and larger on flanks, fine granules on rump; chin granular, chest nearly smooth; venter and lower part of sides granular.

Coloration in life: Dorsal head and body light or reddish brown with green marking, occiput with a dark green marking in triangular shape; tympanum brownish; chin cream with dark spots; throat, chest, venter, and underside of limbs cream (determination after Taylor 1962; Yu et al. 2010).

Ecological notes. The specimens were found between 19:00 and 23:30 on leaves, about 0.5–1.5 m above the ground, near cave entrances and water rivulets. The surrounding habitat was secondary forest consisting of medium and large hardwoods, shrub and liane.

Distribution. Yu et al. (2010) stated that the distribution of *K. bisacculus* extends from Vietnam over Thailand, Cambodia, North and Central Laos to the South of China.

***Polypedates megacephalus* Hallowell, 1861** (Fig. 5b)

Specimens examined. One adult male (IEBR 3865: SVL 62.0 mm) and one adult female (IEBR 3866: SVL 80.0 mm) collected by T.Q. Nguyen et al. in April and May 2012, at elevations between 461 and 669 m asl.

Morphological characters. Head longer than wide (HL 21.7–30.8 mm, HW 19.8–28.6 mm); vomerine teeth present; snout pointed, longer than eye (SL 10.5–13.9 mm, ED 8.3–10.2 mm); canthus rostralis distinct, slightly concave; loreal region vertical; nostrils closer to tip of snout than to eye (EN 6.8–9.1 mm, NS 3.2–4.4 mm); interorbital distance wider than internarial distance and upper eyelid (IOD 7.4–8.8 mm, IND 5.4–6.4 mm, UEW 6.4–7.3 mm); tympanum distinct, approximately half of eye diameter (TD 4.4–5.3 mm); vomerine teeth present; tongue notched posteriorly; external vocal sacs absent. Fingers free of webbing; relative length of fingers I<II<IV<III; tips of finger with enlarged discs; relative length of toes I<II<III<V<IV; webbing formula I1-1II1/4-11/2III1/2-2IV2-1/4V; subarticular tubercles present; outer metatarsal tubercle present; tibio-tarsal articulation reaching to tip of snout. Dorsal skin and upper part of flanks smooth; lower part of flank, belly and ventral surface thighs granular; supratympanic fold present.

Coloration in life: Dorsum beige yellow or brown, with dark blotches; an X-shaped pattern present on neck; limbs with dark transverse bars; dark brown stripe bordering supratympanic fold from eye beyond arm; flanks sometimes with few dark brown spots; back of thighs with large white spots; belly yellowish white (determination after Ziegler et al. 2006; Kuraishi et al. 2012).

Ecological notes. The specimens were found between 19:00 and 21:00, on tree branches near a water pool, about 1.5–3 m above the ground. The surrounding habitat was secondary karst forest of small hardwoods mixed with shrubs and vines.

Distribution. In Vietnam, this species was reported from Lang Son Province in the North southwards to Quang Binh Province. Elsewhere, the species is known from China, Myanmar, Laos, Cambodia and Thailand (Nguyen et al. 2009; Kuraishi et al. 2012).

Fig. 5. a) *Kurixalus bisacculus*, b) *Polypedates megacephalus*, c) *P. mutus*, d) *Rhacophorus dennysi*, e) *R. kio*, f) *R. maximus*, g) *Theloderma asperum*, h) *T. corticale*. Photos: C.T. Pham, T.Q. Nguyen, and H.T. An.

***Polypedates mutus* (Smith, 1940)** (Fig. 5c)

Specimens examined. One adult female (IEBR 3868: SVL 63.9 mm) collected by T.Q. Nguyen et al. on 18 October 2011, at an elevation of 620 m asl.; and one adult female (IEBR 3869: SVL 68.4 mm) collected by T.Q. Nguyen et al. on 8 April 2012, at an elevation of 606 m asl.

Morphological characters. Head longer than wide (HL 23.3–24.3 mm, HW 22.0–22.8 mm); snout pointed, longer than eye (SL 10.2–10.7 mm, ED 7.8–8.1 mm); canthus rostralis distinct, slightly concave; loreal region vertical; nostrils closer to tip of snout than to eye (EN 6.5–6.8 mm, NS 3.3–3.8 mm); interorbital distance wider than internarial distance and upper eyelid (IOD 7.8–8.1 mm, IND 5.3–5.6 mm, UEW 5.8–6.0 mm); tympanum distinct, approximately half of eye diameter (TD 4.5–4.8 mm); vomerine teeth present; tongue notched posteriorly. Fingers free of webbing; relative length of fingers I<II<IV<III; tips of finger with enlarged discs; relative length of toes I<II<III<V<IV; webbing formula I1-1II1/4-11/2III1/2-2IV2-1/4V; subarticular tubercles present; outer metatarsal tubercle present; tibio-tarsal articulation reaching to tip of snout. Dorsal skin and upper part of flanks smooth; lower part of flanks, belly and ventral surface of thighs granular; supratympanic fold present.

Coloration in life: Dorsum beige yellow or brown, without dark blotches; limbs with dark transverse bars; brown stripe bordering supratympanic fold from eye to arm; back of thigh with small white spots; belly yellowish white (determination after Ziegler et al. 2006; Kuraishi et al. 2012).

Ecological notes. The specimens were found between 19:00 and 20:00, on tree branches near a water pool, about 1.5–3 m above the ground. The surrounding habitat was secondary karst forest of small hardwoods mixed with shrubs and vines.

Distribution. This is a widespread species in Vietnam. Elsewhere, the species has been reported from China, Myanmar, Laos, Cambodia and Thailand (Nguyen et al. 2009; Kuraishi et al. 2012).

***Rhacophorus dennysi* (Blanford, 1881)** (Fig. 5d)

Specimens examined. One adult female (IEBR 3870: SVL 94 mm) collected by T.Q. Nguyen et al. on 5 May 2012, at an elevation of 481 m asl.; one adult male (IEBR 387: SVL 63.9 mm) collected by T.Q. Nguyen et al. on 9 May 2012, at an elevation of 497 m asl.

Morphological characters. Head broader than long (HW 22.6–31.5 mm, HL 21.5–30.8 mm); nostril oval, closer to tip of snout than to eye (NS 5.1–6.1 mm, EN 6.4–8.3 mm); interorbital distance wider than internarial distance and upper eyelid (IOD 7.7–10.7 mm, IND 6.7–8.5 mm, UEW 5.7–7.5 mm); tympanum round, smaller than eye diameter (TD 3.9–5.5 mm, ED 7.6–9.5 mm); vomerine teeth present; tongue notched behind; the male without external vocal sacs. Tips of fingers with enlarged discs; relative length of fingers I<II<IV<III; webbing formula I1-1II1/4-11/4III1/2-1/2IV; tips of toes with enlarged discs; relative length of toes I<II<III<V<IV; toes completely webbed; subarticular tubercles present; inner metatarsal tubercle present; outer metatarsal tubercle absent; nuptial pad present in male; tibio-tarsal articulation reaching between eye and tip of snout. Dorsum and flanks smooth; belly and ventral surface of thighs granular; supratympanic fold distinct.

Coloration in life: Dorsum green with white-gray blotches; fringe on outer edge of outer finger, forearm and foot brightly colored; lower part of flanks and ventral surface whitish, in part dark speckled; gular region green anteriorly; webbing of fingers and toes grayish (determination after Ziegler 2002; Fei et al. 2010).

Ecological notes. The specimens were found between 19:00 and 20:00, on tree branches near a water pool in a rice field, about 1–2 m above the ground. The surrounding habitat was secondary karst forest of small hardwoods mixed with shrubs and vines.

Distribution. In Vietnam, this species has been reported from Cao Bang Province in the North southward to Quang Binh Province. Elsewhere, the species has been reported from China, Myanmar and Laos (Nguyen et al. 2009).

***Rhacophorus kio* Ohler & Delorme, 2006** (Fig. 5e)

Specimens examined. Five adult males (IEBR 3872: SVL 74 mm, IEBR 3873: SVL 69 mm, IEBR 3874: SVL 72 mm, IEBR 3875: SVL 67 mm, IEBR 3876: SVL 69 mm), and one adult female (IEBR 3877: SVL 85 mm) collected by T.Q. Nguyen et al. in April and May 2012, at elevations between 447 and 532 m asl.

Morphological characters. Head broader than long (HW 22.8–28.5 mm, HL 24.1–30.1 mm); nostril oval, closer to tip of snout than to eye (NS 5.2–5.9 mm, EN 6.3–7.1 mm); interorbital distance wider than internarial distance and upper eyelid (IOD 7.8–11.4 mm, IND 6.1–8.0 mm, UEW 5.1–6.0 mm); tympanum round, smaller than eye diameter (TD 4.3–5.2 mm, ED 7.9–8.9 mm); vomerine teeth present; tongue notched posteriorly; males without external vocal sacs. Tips of fingers and toes enlarged into discs, relative length of fingers I<II<IV<III; webbing formula I1-1II0-0III0-0IV; relative length of toes I<II<III<V<IV; toes fully webbed; inner metatarsal tubercle present; outer metatarsal tubercle absent; tibio-tarsal articulation reaching to the eye. Dorsum smooth; ventral side of belly and thighs and lower part of flanks ganular; fringes on outer edge of forearm well developed; supratympanic fold distinct; dermal appendage above vent present.

Coloration in life: Dorsal surface of head, body and upper part of flanks green with small white spots; lower part of flanks dark brown with yellow spots; a distinct black

spot in armpit; throat, chest, belly and lower part of thighs yellow (determination after Ohler & Delorme 2006).

Ecological notes. The specimens were found between 20:00 and 22:00, on tree branches near a water pool, about 2–4 m above the ground. The surrounding habitat was secondary karst forest of small, medium and large hardwoods mixed with bamboo, shrub and liane.

Distribution. In Vietnam, this species has been reported from Lao Cai Province in the North southwards to Gia Lai Province. Elsewhere, the species has been reported from India, China, Laos, Thailand and Cambodia (Nguyen et al. 2009).

***Rhacophorus maximus* Günther, 1858** (Fig. 5f)

Specimen examined. One adult male (IEBR 3878: SVL 73.1 mm) collected by T.Q. Nguyen on 22 April 2015, at an elevation of 526 m asl.

Morphological characters. Head broader than long (HW 26.5 mm, HL 25.4 mm); nostril oval, closer to eye than to tip of snout (NS 6.3 mm, EN 5.7 mm); interorbital distance wider than internarial distance and upper eyelid (IOD 8.5 mm, IND 7.9 mm, UEW 5.9 mm); tympanum round, smaller than eye diameter (TD 4.4 mm, ED 8.3 mm); vomerine teeth present; tongue notched behind; the male without external vocal sacs. Tips of fingers with enlarged discs; relative length of fingers I<II<IV<III; webbing formula I1-1II1/4-1III1/2-1/2IV; tips of toes with enlarged discs; relative length of toes I<II<III<V<IV; toes fully webbed; subarticular tubercles present; inner metatarsal tubercle present; outer metatarsal tubercle absent; nuptial pad present; tibio-tarsal articulation reaching between eye and tip of snout. Dorsum smooth; belly, ventral surface of thighs, and lower part of flank ganular; supratympanic fold distinct.

Coloration in life: Dorsal surface of head and body uniformly green; a narrow white stripe present along the flanks; ventral surface cream (determination after Anders & Rai 2002; Hecht et al. 2013).

Ecological notes. The specimen was found at ca. 20:00, on tree branches near a water pool, about 4 m above ground. The surrounding habitat was secondary karst forest of medium and large hardwoods, shrub and liane.

Distribution. In Vietnam, this species has been reported from Bac Giang, Dien Bien, and Thanh Hoa provinces (Nguyen et al. 2009; Nguyen et al. 2015; Pham et al. 2016a). This is the first record of *R. maximus* from Cao Bang Province. Elsewhere, the species has been reported from India, China and Thailand (Nguyen et al. 2009; Luu et al. 2014).

***Theloderma asperum* (Boulenger, 1886)** (Fig. 5g)

Specimens examined. One adult female (IEBR 3879: SVL 28.5 mm) collected by T.Q. Nguyen et al. on 16 October 2011, at an elevation of 544 m asl.; one adult male (IEBR 3880: SVL 29.5 mm) collected by T.Q. Nguyen on 12 April 2012, at an elevation of 526 m asl.; one adult male (IEBR 3881: SVL 26 mm) collected by T.Q. Nguyen et al., on 2 May 2012, at an elevation of 601 m asl.; and one adult male (IEBR 3882: SVL 29.8 mm) collected by C.T. Pham et al., on 8 June 2014, at an elevation of 586 m asl.

Morphological characters: Head longer than wide (HL 10.59–11.81 mm, HW 11.73–12.01 mm); snout round, longer than eye (SL 4.1–5.1 mm, ED 3.9–4.6 mm); canthus rostralis indistinct; loreal region slightly concave; nostril closer to tip of snout than to eye (NS 1.05–1.48 mm, EN 2.61–2.71 mm); interorbital distance wider than internarial distance and upper eyelid (IOD 3.1–3.7 mm, IND 2.5–2.8 mm, UEW 2.3–2.4 mm); tympanum distinct (TD 2.4–2.5 mm); vomerine teeth absent; tongue notched behind; males without external vocal sacs. Fingers free of webbing, tips of fingers with enlarged discs; relative length of fingers I<II< IV<III; tips of toes enlarged into round discs; webbing formula I0-1II0-1III1/4-11/4IV1-0V; relative length of toes I<II<III<V<IV; inner metatarsal tubercle present, small; tibio-tarsal articulation reaching to tip of snout. Skin on dorsum and flanks with granular tubercles; throat and chest smooth; venter granular; supratympanic fold absent.

Coloration in life: Dorsal surface greyish brown with large white blotches on head, loreal region, anterior part of dorsum, upper part of flanks and hip; hind limbs with dark transverse bars; head with short brown stripe between eyes; ventral surface blackish with white marbling; iris pinkish brown (determination after Bourret 1942; Taylor 1962; Neang & Holden 2008).

Ecological notes. Two specimens were found between 19:00 and 23:00 in a tree hole, about 0.5-1.0 m above the ground, and two other ones were found on leaves near a cave entrance. The surrounding habitat was secondary karst forest of small, medium and large hardwoods, shrub and liane.

Distribution. In Vietnam, this species has been reported from Lai Chau and Lao Cai provinces in the North southwards to Lam Dong and Dong Nai provinces. Elsewhere, the species has been reported from India, China, Myanmar, Laos, Thailand, Cambodia and Malaysia (Nguyen et al. 2009).

***Theloderma corticale* (Boulenger, 1903)** (Fig. 5h)

Specimens examined: One adult female (IEBR 3883: SVL 54.1 mm) collected by T.Q. Nguyen et al. on 1 May 2012, at an elevation of 484 m asl.; one adult female (IEBR 3884: SVL 67 mm), and one adult male (IEBR 3885: SVL 69 mm) collected by T.Q. Nguyen et al. on 6 May 2012, at an elevation of 537 m asl.

Morphological characters: Head wider than long (HL 20.8–28.1 mm, HW 21.5–28.9 mm); snout longer than eye

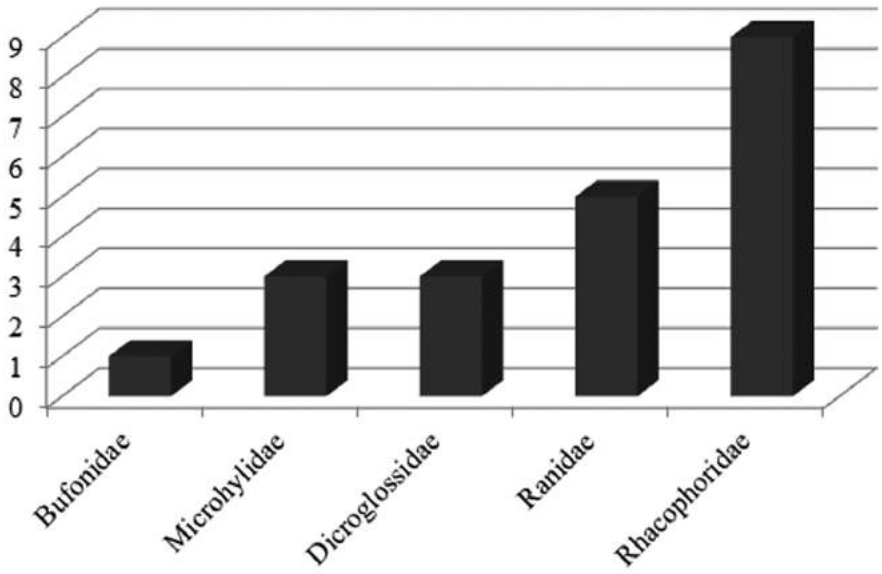

Fig. 6. Species richness of the amphibian families from Ha Lang forests, Cao Bang Province.

diameter (SL 18.8–12.3 mm; ED 6.4–7.3 mm); canthus rostralis round; loreal region concave; interorbital distance wider than internarial distance and upper eyelid (IOD 7.2–9.2 mm, IND 4.2–5.3 mm, UEW 4.5–5.8 mm); nostril closer to tip of snout than to eye (NS 2.7–3.5 mm; EN 6.5–8.2 mm); tympanum oval (TD 4.2–5.6mm); vomerine teeth present; tongue notched posteriorly; the male without external vocal sacs. Fingers free of webbing; relative length of fingers I<II<IV<III; tips of fingers and toes enlarged into round discs; webbing formula I0-1/2II0-1III0-1IV1-0V; relative length of toes I<II<III<V<IV; subarticular tubercles present; inner metatarsal tubercle present; outer metatarsal tubercle absent; tibio-tarsal articulation reaching between eye and tip of snout. Dorsal surface of head, body and limbs covered with tubercles or warts of different sizes; ventral skin with small tubercles; supratympanic fold absent; nuptial pad present in the male.

Coloration in life: Dorsum green marbled with reddish brown spots; flanks yellow, mottled or marbled with black; dark brown bars present on upper surface of fore and hind limbs; ventral surface yellow with green marbling (determination after Inger et al. 1999; Orlov et al. 2006).

Ecological notes. The specimens were found between 21:00 and 23:00, on leaves next to a forest path. The surrounding habitat was secondary karst forest of small, medium and large hardwoods, shrub and liane.

Distribution. This species is currently known only from Vietnam, from Ha Giang and Cao Bang provinces in the North southwards to Quang Binh Province (Nguyen et al. 2009; Luu et al. 2013).

DISCUSSION

A total of 21 species of amphibians were recorded from the Ha Lang District, Cao Bang Province. Rhacophoridae and Ranidae were the two most species-rich families with nine and five recorded species, respectively (Fig. 6). Three species, *Odorrana bacboensis*, *O. graminea*, and *Rhacophorus maximus*, are recorded for the first time from Cao Bang Province. Among the reported species, three species, *Odorrana mutschmanni*, *Gracixalus waza*, and *Theloderma corticale*, are currently known only from Vietnam. Remarkably, the karst forest of Ha Lang District also harbors several threatened species, comprising one species (*Rhacophorus kio*) listed as Vulnerable in the IUCN Red List (2016) and two species (*R. kio* and *Theloderma corticale*) listed as Endangered in the Red Data Book of Vietnam (2007). Although the karst forest in Ha Lang District harbors a considerable number of endemic and rare species, its biodiversity is currently threatened due to quarrying for cement and road construction, expanding agriculture, and illegal timber logging (Pham et al. 2016c). Additional surveys are required to obtain further data about the actual biodiversity of this karst forest. The establishment of a new protected area should be seriously considered in order to protect the remaining karst forests and their unique biodiversity in Cao Bang Province.

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REFERENCES

Anders C, Rai KR (2002) *Rhacophorus maximus* Günther, 1859 "1858".Pp. 337–340 in: Schleich HH & Kästle W (eds) Amphibians and Reptiles of Nepal: Biology, Systematics, Field Guide, ARG GanterVerlag KG

Bain RH, Nguyen TQ (2004) Three new species of narrow-mouth frog (Genus: *Microhyla*) from Indochina, with comments on *Microhyla annamensis* and *Microhyla palmipes*. Copeia 3: 507–524

Bain RH, Lathrop A., Murphy RW, Orlov NL, Ho CT (2003) Cryptic species of a cascade frog from Southeast Asia: Taxonomic revisions and descriptions of six new species. American Museum Novitates 3417: 1–60

Bain RH, Stuart BL, Nguyen TQ, Che J, Rao DQ (2009) A new *Odorrana* (Amphibia: Ranidae) from Vietnam and China. Copeia 2: 348–362

Bourret R (1942) Les Batraciens de l'Indochine. Institut Océanographique de l'Indochine. Hanoi, Vietnam

David P, Nguyen TQ, Nguyen TT, Jiang K, Chen TB, Teynié A, Ziegler T (2012) A new species of the genus *Oligodon* Fitzinger, 1826 (Squamata: Colubridae) from northern Vietnam, southern China and central Laos. Zootaxa 3498: 45–62

Fei L, Ye C, Jiang J (2012) Colored Atlas of Chinese Amphibians. Sichuan Publishing House of Science & Technology, Sichuan

Frost DR (2017) *Amphibian Species of the World: an on-line reference. Version 6.0*. American Museum of Natural History, New York, USA. Available from http://research.amnh.org/herpetology/amphibia/ (accessed on 24 January 2017)

Guo P, Liu Q, Wen T, Xiao R, Fang M, Zhong GH, Nguyen TQ, Zhu F, Jadin RC, Li C (2016) Multilocus phylogeny of the Asian Lance-headedpitvipers (Squamata, Viperidae, *Protobothrops*). Zootaxa 4093: 382–390

Hecht V, Pham CT, Nguyen TT, Nguyen QT, Bonkowski M & Ziegler T (2013) First report on the herpetofauna of Tay Yen Tu Nature Reserve, northeastern Vietnam. Biodiversity Journal 4: 507–552

Inger RF, Orlov NL, Darevsky I (1999) Frogs of Vietnam: A report on new collection. Fieldiana: Zoology 92: 1–46

IUCN (2016) The IUCN Red List of Threatened Species. Version 2016.4. http://www.iucnredlist.org. Accessed on 10 June 2016

Kuraishi N, Matsui M, Hamidy A, Belabut DM, Ahmad N, Panha S, Sudin A, Yong HS, Jiang JP, Ota H, Ho TT, Nishkawa K (2012) Phylogennetic and taxonomic relationships of the *Polypedates leucomystax* complex (Amphibia). Zoologica Sripta 42: 54–70

Luu VQ, Calame T, Nguyen TQ, Ohler A, Bonkowski M, Ziegler T (2014) First records of *Gracixalus supercornutus* (Orlov, Ho and Nguyen, 2004) and *Rhacophorus maximus* Günther, 1858 from Laos. Herpetology Notes 7: 419–423

Luu VQ, Nguyen TQ, Pham CT, Dang KN, Vu TN, Miskovic S, Bonkowski M, Ziegler T (2014) No end in sight? Further new records of amphibians and reptiles from PhongNha-Ke Bang National Park, Quang Binh Province, Vietnam. Biodiversity Journal 4: 285–300

Manthey U, Grossmann W (1997) Amphibien und Reptilien Südostasiens. Natur & Tier Verlag, Münster

Mcleod DS (2010) Of least concern? Systematics of a cryptic species complex: *Limnonectes kuhlii* (Amphibia: Anura: Dicroglossidae). Molecuar Phylogenetics and Evolution 56: 991–1000

McLeod DS, Kurlbaum S, Hoang NV (2015) More of the same: a diminutive new species of the *Limnonectes kuhlii* complex from northern Vietnam (Anura: Dicroglossidae). Zootaxa 3947: 201–214

Mo Y, Chen W, Wu H, Zhang W, Zhou S (2015) A new species of *Odorrana* inhabiting complete darkness in a karst cave in Guangxi, China. Asian Herpetological Research 6: 11–17

Neang T, Holden J (2008) A field guide to the amphibians of Cambodia. Fauna and Flora International. Phompenh

Nguyen TQ, Le MD, Pham CT, Nguyen TT, Bonkowski M, Ziegler T (online: 2012/printed 2013a) A new species of *Gracixalus* (Amphibia, Anura, Rhacophoridae) from northern Vietnam. Organisms Diversity & Evolution 13: 203–214.

Nguyen TQ, Lehmann T, Le MD, Duong TH, Bonkowski M, Ziegler T (2013b) A new species of *Hemiphyllodactylus* (Reptilia: Gekkonidae) from northern Vietnam. Zootaxa 3736: 89–98

Nguyen TQ, Pham CT, Le DT, Nguyen BV, Nguyen SLH (2015) Diversity of tree frogs (Amphibia: Anura: Rhacophoridae) from Dien Bien Province. Pp. 954–959 in: Proceedings of the sixth National Scientific Conference on Ecology and Biological Resources. Agriculture Publishing House, Hanoi

Nguyen TQ, Wang YY, Yang YH, Lehmann T, Le MD, Ziegler T, Bonkowski M (2013c) A new species of the *Gekko japonicus* group (Squamata: Sauria: Gekkonidae) from the border region between China and Vietnam. Zootaxa 3652: 501–518

Nguyen SV, Ho CT, NguyenTQ (2009) Herpetofauna of Vietnam. Edition Chimaira, Frankfurt am Main

Ohler A, Delorme M (2006) Well known does not mean well studied: morphological and molecular support for existence of sibling species in the Javanese gliding frog *Rhacophorus reinwardtii* (Amphibia, Anura). Comptes Rendus Biologies 329: 86–97

Orlov NL, Dutta S, Ghate H, Kent Y (2006) New species of *Theloderma* from Kon Tum province (Vietnam) and Nagaland state (India) (Anura: Rhacophoridae). Russian Journal of Herpetology 13: 135–154

Orlov NL, Sergei A, Nguyen TT (2009) Two new species of genera *Protobothrops* Hogeet Romano-Hoge, 1983 and *Viridovipera* Malhotra et Thorpe, 2004 (Ophidia: Viperidae: Crotalinae) from karst region in northeastern Vietnam. Part I. Description of a new species of *Protobothrops* genus.Russian Journal of Herpetology16: 69–82

Pham CT, Nguyen TQ, Bernades M, Nguyen TT, Ziegler T (2016a) First records of *Bufo gargarizans* Cantor, 1842 and *Odorrana lipuensis* Mo, Chen, Wu, Zhang & Zhou, 2015 (Anura: Bufonidae, Ranidae) from Vietnam. Russian Journal of Herpetology 23: 103–107

Pham CT, Nguyen TQ, Hoang CV, Ziegler T (2016b) New records and an updated list of amphibians from Xuan Lien Nature Reserve, Thanh Hoa Province, Vietnam. Herpetology Notes 9: 31–41

Pham CT, Nguyen QT, Le MD, Bonkowski M, Ziegler T (2016c) A new species of *Odorrana* (Amphibia: Anura: Ranidae) from Vietnam. Zootaxa 4084: 421–435

Taylor EH (1962) The amphibian fauna of Thailand. University of Kansas Science Bulletin 63: 265–599

Tran K, Ho CT, Nguyen SV, Pham T (2007) Reptiles and Amphibians. Pp. 219–276 + 8pls in: Dang TN, Tran K, Dang HH, Nguyen C, Nguyen TN, Nguyen YH, Dang DT (Eds.) Vietnam Red Data Book, Part 1. Animals. Publishing House for Science and Technology, Hanoi

Wang YY, Lau MN, Yang JH, Chen GL, Liu ZY, Pang H, Liu Y (2015) A new species of the genus *Odorrana* (Amphibia: Ranidae) and the first record of *Odorrana bacboensis* from China. Zootaxa 3999: 235–254

Ye CY, Fei L, Xie F, Jiang JP (2007) A new Ranidae species from China – *Limnonectes bannanensis* (Ranidae: Anura). Zoological Research 28: 545–550

Yu G, Zhang M, Yang J (2010) A species boundary within the Chinese *Kurixalus odontotarsus* species group (Anura: Rhacophoridae): New insights from molecular evidence. Molecular Phylogenetics and Evolution 56: 942–950

Ziegler T (2002) Die Amphibien und Reptilien eines Tieflandfeuchtwald-Schutzgebiets in Vietnam. Natur & Tier Verlag, Münster

Ziegler T, Ohler A, Vu TN, Le QK, Nguyen TX, Dinh TH, Bui TN (2006) Review of the amphibian and reptile diversity of PhongNha -Ke Bang Nationnal Park and adjacent areas, central Truong Son, Vietnam. Pp. 247–262 in: Proceeding of the 13th Congress of the Societas Europaea Herpetologica

