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A review of the genus *Tropidophorus* (Squamata, Scincidae) from Vietnam with new species records and additional data on natural history

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Abstract

At present, eight species of the water skink genus *Tropidophorus* are recognized from Vietnam. We provide expanded species descriptions based on new collections and new distributional and natural history data of all Vietnamese water skinks. In addition, an identification key to the species of *Tropidophorus* from the Indochinese Peninsula is presented.

Introduction

The water skink genus *Tropidophorus* is characterized morphologically by having keeled scales and a superficial tympanum. *Tropidophorus* taxa are furthermore known to be closely associated with water and they have a live-bearing reproductive mode (Smith 1923, 1935; Taylor 1963; Hikida et al. 2002; Greer & Biswas 2004). The members of this genus range widely from Bangladesh through mainland Southeast Asia and southern China, southwards to Malaysia and Indonesia, as well as to the Philippines (Pope 1935; Smith 1935; Wen 1992; Ngo et al. 2000; Hikida et al. 2002; Chuaynkern et al. 2005; Ziegler et al. 2005; David & Ineich 2009; Nguyen et al. 2009). The Australian species *Tropidophorus queenslandiae* is now regarded to represent a distinct genus *Gnypetoscincus* (Wells & Wellington 1984; Cogger 1994). Since 2002, five new species have been described from the Indochinese Peninsula: *T. hangnam*, *T. latiscutatus*, and *T. matsuii* from Thailand, as well as *T. murphyi* and *T. noggei* from Vietnam (Hikida et al. 2002; Chuaynkern et al. 2005; Ziegler et al. 2005).

Our recent field work in Vietnam adds substantially to the morphological variation, distribution, and natural history of the water skinks. Therefore, we offer a review of *Tropidophorus* from this country.

Material and methods

Field surveys were conducted during a period of ten years (1998–2008) in different provinces of Vietnam: Ha Giang, Cao Bang, Lang Son, Quang Ninh, Bac Giang, Hai Duong, Phu Tho, Nghe An, Quang Binh, Quang Tri, Thua Thien–Hue, Quang Nam, Lam Dong, and Dong Nai. Specimens referred to in this paper are deposited in the collections of the American Museum of Natural History (AMNH); The Natural History Museum (BMNH), London; Institute of Ecology and Biological Resources (IEBR); Zoological Museum, Hanoi National University (HNUV); Vietnam National Museum of Nature (VNMN), Hanoi; Muséum d'histoire naturelle (MHNG), Geneva; Muséum National d'Histoire Naturelle (MNHN), Paris; Royal Ontario Museum (ROM), Toronto; Senckenberg Forschungsinstitut und Naturmuseen, Frankfurt am Main (SMF); Zoologisches Forschungsmuseum

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Morphological analysis. Measurements were taken with dial callipers to the nearest 0.1 mm. The following abbreviations were used: SVL: Snout-vent length, TaL: Tail length; SE: standard deviation; a.s.l.: above sea level. Scalation: nuchals: enlarged scales behind parietals, paravertebral scales: number of dorsal scales from posterior edge of parietals to a point above vent; ventrals in transverse rows: number of scales from first gular to precloacal scales, scale rows at position of 10th subcaudal on tail including subcaudal.

If voucher specimens were unavailable for examination, diagnoses of species were compiled from literature.

Taxonomic account

Genus *Tropidophorus* Duméril & Bibron, 1839

Diagnosis. According to Smith (1935), Taylor (1963), and Hikida et al. (2002) the following characters were selected for diagnosis of the genus: Palatine bones in contact in middle line of palate; pterygoids without teeth (or reduced to one or two teeth), in contact with each other anteriorly; palatal notch not reaching to level of centers of eyes; teeth conical; nostril in a single nasal; frontonasal single or divided; supranasal absent; prefrontals, frontoparietals and an interparietal present; lower eyelid scaly without disc; tympanum superficial; dorsal and lateral scales keeled; limbs pentadactyl with transverse subdigital lamellae. Greer & Biswas (2004) proposed an additional generic character: anterior and posterior corners of eyelids contained within a single, wrap-around scale.

Tropidophorus baviensis Bourret, 1939

Figures 1a, 3a

Type. Holotype: MNHN 1948.63.

Type locality. Mt. Ba Vi, Ha Tay Province (now Hanoi), Vietnam, altitude: 400 m a.s.l.

Common name. Bavi water skink.

Diagnosis. Upper head scales smooth; frontonasal undivided; prefrontals in contact with each other; loreals 2, anterior one usually divided; superciliaries 5–7, superciliary row nearly completed along the entire length of lateral edge of supraoculars; nuchals in 1–2 pairs; supralabials 6, fourth below the eye; infralabials 5; postmental undivided; midbody scales in 28–30 rows; 11 scale rows at position of tenth subcaudal on tail; paravertebral scales 47–69; ventrals in 44–49 transverse rows; 2 enlarged precloacals; subdigital lamellae 18–22 under fourth toe (Bourret 1939, 2009; Ngo et al. 2000; our own data).

Specimens examined. Five specimens: IEBR A.0744 (adult female), A.0753 (adult male), IEBR A.0754 (subadult), and ZFMK 87588 (adult female) collected by Hoang Ngoc Thao and Dau Quang Vinh, 17–23 December 2006, in Chau Quang Commune (19°20′42″ N, 105°09′03″ E), Quy Hop District, Nghe An Province; VNMN T-181 (adult male) collected by Nguyen Thien Tao in August 2008, within Xuan Son National Park, Thanh Son District, Phu Tho Province.

Description. Moderate-sized *Tropidophorus*, adult females: SVL 83.2–84.9 mm (n = 2); adult males: SVL 55.7–71.5 mm (n = 2); body strongly dorsoventrally depressed; head slightly longer than wide, swollen at the temples and distinctly set-off from neck.

Upper head scales smooth; snout obtuse, rostral partly visible from above, about 2 times wider than high; supranasal absent; frontonasal undivided, as long as wide; prefrontals in contact; frontal about 1 1/2 times longer than the distance to snout, in contact with 2 anterior supraoculars; supraoculars 4, the first longest, followed by a small postsupraocular; frontoparietals in contact medially, bordered by 2–3 posterior supraoculars; interparietal narrow posteriorly with a transparent spot; parietals large, narrowly in contact or separated by interparietal or a small scale posteriorly, posteriorly bordered by 4 scales on each side; nuchals in 1–2 pairs; nostril in single nasal; loreals 2, anterior one usually divided into 2 superposed scales, lower anterior loreal touched by first and second supralabials; preoculars 2, small; presuboculars 2; superciliaries 5–6, superciliary row nearly completed along the entire length of lateral edge of supraoculars; lower eyelid with 5–6 opaque scales, separated from supralabials by 1–2 rows of granular scales; supralabials 6, fourth longest and below the eye; a shallow groove on loreal-labial border, from nasal across subocular obliquely downward to the end of fourth supralabial; postocular single, small; postsuboculars 3–4, most lower one in contact with fourth and fifth supralabials; primary temporals 3; secondary temporals 3; tympanum superficial, ovoid; mental rounded anteriorly; postmental undivided, in contact with first infralabial; infralabials 5, first longest; chinshields in 3 pairs, first pair in contact medially, second pair separated by a small gular scale or touching in one point, and third pair separated by three scales.

Midbody scales in 28–30 rows; 11 scale rows at position of tenth subcaudal on tail; dorsal scales subequal to ventral scales, imbricate; scales on nuchal region feebly keeled; vertebral scale rows keeled but not widened, outer dorsal scale rows strongly keeled; paravertebral scales 47–49; lateral scales strongly keeled, straight backward; dorsal and lateral scales on tail distinctly keeled, strongly mucronate; ventral scales smooth, 44–49 transverse rows from first gular to precloacals; two enlarged precloacals, left one overlapped by right one in three specimens, right one overlapped by left one in one specimen (IEBR A.0744); postcloacal pores absent in both males and females; subcaudals enlarged, 2 times as broad as neighboring scales, smooth, the first divided; scales on forelimbs distinctly keeled, imbricate; those on hindlimbs keeled dorsally, smooth ventrally; subdigital lamellae smooth, numbering 13–15 under fourth finger and 18–21 under fourth toe.

Coloration (in alcohol). Head uniform brown, supralabials darker with some white spots; dorsum dark brown with cream markings forming irregular broken bands: 1–3 on neck, 6–8 on body, and 3–6 on tail; flanks dark brown with some light markings or spots;

venter cream; chin and lower tail with some darker marblings. Coloration in life see Figure 1a.

Distribution. *Tropidophorus baviensis* has been recorded from few localities in northern Vietnam: Lai Chau (Muong Te), Hanoi (Ba Vi), Ninh Binh (Cuc Phuong) (Bourret 1939, 2009; Tran et al. 1981; Bobrov 1993; Ngo et al. 2000; Hikida et al. 2002; Nguyen et al. 2009). Our new provincial records are for Phu Tho and Nghe An, with the latter being the southernmost record of this species from Vietnam, ca. 170 km from the type locality in Ba Vi National Park (Fig. 3a).

Natural history. The specimens were found at night time in rocky streams in montane evergreen forest. Two females that were collected in December 2006 contained yellowish eggs: IEBR A.0744 had four eggs (largest one: 11.8 mm in length, 7.4 mm in diameter), ZFMK 87588 had seven eggs (largest one: 10.6 mm in length, 6.8 mm in diameter). Ngo et al. (2000) noted that *Tropidophorus baviensis* were relatively abundant in October in the Ba Vi National Park.

***Tropidophorus berdmorei* (Blyth, 1853)**

Figures 1b, 3b

Type. The original description was based on a single specimen (Blyth, 1853). Smith (1923) mentioned 3 type specimens in the collection of Indian Museum, Calcutta.

Type locality. Mergui, Myanmar.

Common name. Berdmore's water skink.

Diagnosis. This species is characterized by the following characters (after Boulenger 1887; Smith 1923, 1935; Taylor 1963; Greer & Biswas 2004; Chuaynkern et al. 2005; Bourret 2009): moderate size, SVL of adults 76.28 ± 6.91 mm, $n = 24$ (Chuaynkern et al. 2005); upper head scales smooth; frontonasal undivided; prefrontals in contact with or separated from each other; parietals usually in contact posteriorly; loreals 2, anterior one usually divided; supraciliaries 8 and supraciliary row not completed along the entire length of lateral edge of supraoculars; nuchals in 2 pairs; supralabials 6, fourth below the eye; infralabials 5–7;

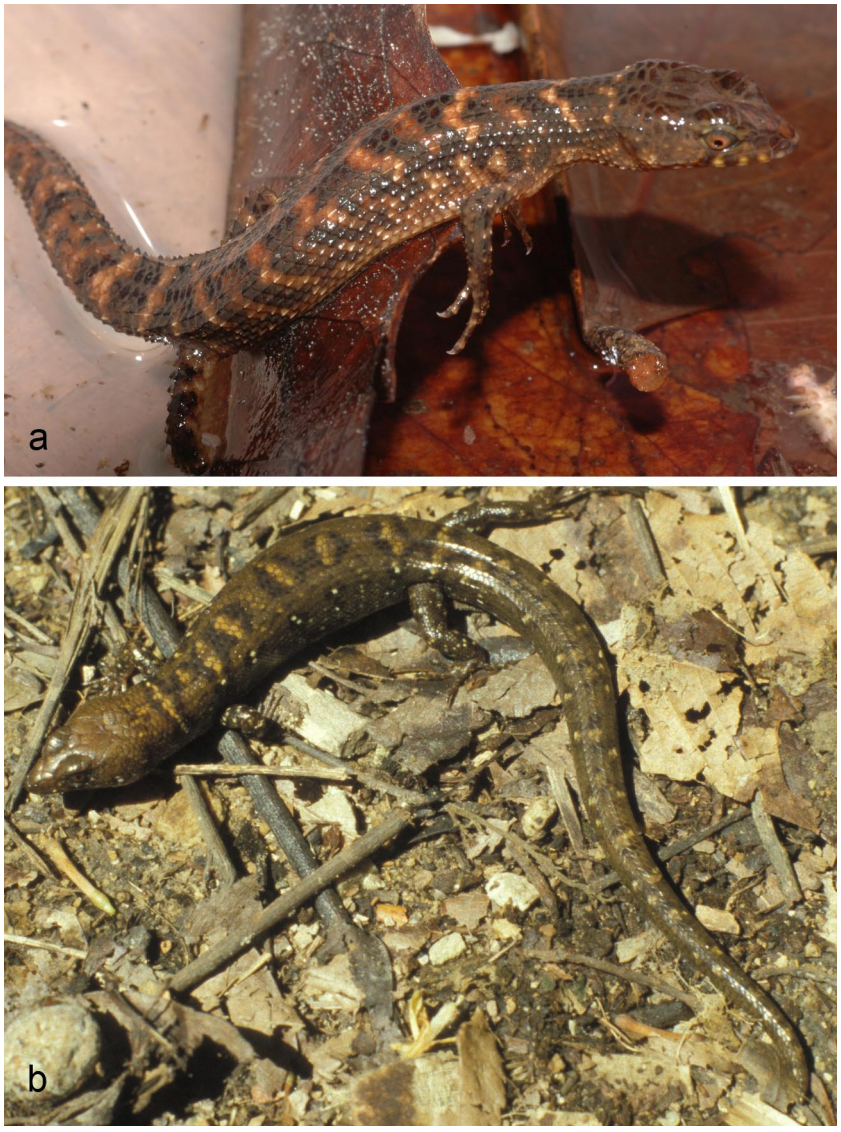

Figure 1. **a.** *Tropidophorus baviensis* (VNMN T-181) from Phu Tho Province, northern Vietnam, photograph Nguyen Thien Tao; **b.** *Tropidophorus berdmorei* from Thailand, photograph Gernot Vogel.

postmental undivided; midbody scales in 32–40 rows; dorsal scales smaller than ventrals; paravertebral scales 64; ventrals in 53 transverse rows; 2 enlarged precloacals; subdigital lamellae 22 under fourth toe. Coloration in life see Figure 1b.

Distribution. In Vietnam, *Tropidophorus berdmorei* is known from Lao Cai (Sa Pa), Bac Kan (Ngan Son), Son La (Moc Chau), Ninh Binh (Cuc Phuong), Nghe An (Pu Huong), Ha Tinh (Huong Son), Quang Tri (Dak Rong), Gia Lai (K Bang: So Pai, Chu Se) (Smith 1935; Tran et al. 1981; Bobrov 1998; Bourret 2009; Nguyen et al. 2009) (Fig. 3b). Elsewhere, this species has been recorded from China, Myanmar, and Thailand (Smith 1923, 1935; Taylor 1963; Hallermann et al. 2002; Bourret 2009).

Tropidophorus cocincinensis Duméril & Bibron, 1839

Figures 2a, 3c

Type. Holotype: MNHN 2847. Smith (1923) mentioned 3 type specimens: MNHN 2845–2847. However, the original description was obviously based on a single specimen (Duméril & Bibron 1839). The holotype is MNHN 2847 because it has a TL (179 mm) which is identical with the original description (Patrick David, Paris, per.-comm.).

Type locality. Cochinchina (now southern Vietnam) (Smith, 1935).

Common name. Cochinchinese water skink.

Diagnosis. Upper head scales striated; frontonasal undivided; prefrontals in contact with or separated from each other by a small scale; loreals 2, separated from supralabials by a series of small scales; superciliaries 6–8, superciliary row not completed along the entire length of lateral edge of supraoculars; nuchals in 1–3 pairs; supralabials 7, fifth below the eye; infralabials 6; postmental undivided; midbody scales in 30–33 rows; 13–14 scale rows at position of tenth subcaudal on tail; paravertebral scales 41–46; dorsal scales on tail distinctly keeled, two series of moderately elevated spines along middle of dorsal tail, being continuous with those on back; ventrals in 47–53 transverse rows; 2 enlarged precloacals; subdigital lamellae 18–21 under fourth toe (after Smith 1935; Bourret 2009; our own data).

Specimens examined. 38 specimens: IEBR 387–390, 393–395, 397, 400, 402, 411–413, 415, 417–418, 443, 445 (18 adult females), IEBR 391–392, 396, 398–399, 401, 403–404, 414, 416, 420, 441–442, 444 (14 adult males) collected by Ho Thu Cuc, 11–16 August 2001, in A So Commune, A Luoi District, Thua Thien–Hue Province (16°06.265′ N, 107°19.344′ E), altitude: ca. 800 m a.s.l.; IEBR 2258 (adult female) collected by Nikolai Orlov et al. on 26 April 2005, in Ban Cup, Huong Hoa District, Quang Tri Province (16°56.207′ N, 106°35.164′ E), altitude: 450 m a.s.l.; IEBR A.0815–A.0817 (adult males) collected in Tra Ve, Hong Tien Commune, Huong Tra District (16°15.282′ N, 107°26.976′ E), altitude: 150 m a.s.l., 17–18 August 2005, and IEBR A.0818 (adult male) collected in Khe Dau, Binh Thanh Commune, Huong Thuy District, Thua Thien–Hue Province (16°17.995′ N, 107°33.307′ E), altitude: 150 m a.s.l., on 8 September 2005, by Raoul Bain and Nguyen Quang Truong; IEBR 3125 (adult female) collected by Doan Van Kien, on 26 April 2006, in B'Halee, Tay Giang District, Quang Nam Province (16°00.312′ N, 107°31.189′ E), altitude: ca. 750 m a.s.l.

Description. Large-sized *Tropidophorus*, adult females: SVL 54.0–90.2 mm (mean ± SE 80.17 ± 8.95 mm, n = 20), TaL 93.1–107.7 mm (mean ± SE 106.1 ± 7.74 mm, n = 13); males: SVL 68.3–94.7 mm (mean ± SE 83.57 ± 7.75 mm, n = 18), TaL 92.4–122.9 mm (mean ± SE 105.78 ± 10.05 mm, n = 8); body slightly dorso-ventrally depressed; head longer than wide, swollen at the temples and distinctly set-off from neck.

Upper head scales strongly striated; snout obtuse; rostral partly visible from above, about 2 times wider than high; supranasals absent; frontonasal undivided, as long as wide; prefrontals in contact with or separated from each other by a small scale; frontal about 1 1/2 times longer than the distance to snout, in contact with first and second supraoculars; supraoculars 4, the first longest, followed by a small postsupraocular; frontoparietals in contact with each other medially and in contact with 2–3 supraoculars; interparietal with a small transparent spot; parietals large, in contact with or separated from each other by a small scale posteriorly, posteriorly bordered by 3–4 scales on each side; nuchals in 1–3 pairs (rarely absent); nostril in single nasal; loreals 2, separated from supralabials by a series of small scales; preocular single; presuboculars 2–3; superciliaries 6–7 (rarely 8), superciliary row not completed along the entire length of lateral edge of supraoculars; lower eyelid with 4–6 opaque scales, separated from supralabials by a row of granular scales; supralabials 7, fifth longest and below the eye; a shallow groove on loreal-labial border, from lower corner of nasal across subocular obliquely downward to the end of fifth supralabial; postocular single; postsuboculars 4–5; primary temporals 3–4; secondary temporals 4–5; tympanum superficial, ovoid; mental bordered by postmental and first infralabials; postmental undivided; infralabials 6, first anterior one smallest; 3 pairs of chinshields, first and second pairs in contact meadially, third pair separated from each other by 1–2 gular scales.

Midbody scales in 30–33 rows; 13–14 scale rows at position of tenth subcaudal on tail; dorsal scales subequal to ventral scales, imbricate; scales in nuchal region feebly keeled or keeled; vertebral scale rows keeled but not widened, outer dorsal scale rows keeled; paravertebral scales 41–46; lateral scales strongly keeled, straight backward, and strongly mucronate; dorsal and lateral scales on tail distinctly keeled, two series of moderately elevated spines along middle of dorsal tail, being continuous with those on back; ventral scales smooth, most outer row on each side feebly keeled, 47–53 transverse rows from first gular to precloacals; precloacals two (rarely three), enlarged, right one overlapped by left one or contrary; postcloacal pores present in males and usually absent in females; subcaudals enlarged, two times as broad as neighboring scales, smooth, usually divided from first to third; scales on forelimbs distinctly keeled, imbricate; those on hind limbs keeled dorsally, smooth ventrally; subdigital lamellae smooth,

numbering 12–15 under fourth finger and 18–21 under fourth toe.

Coloration (in alcohol). Head brown, supralabials cream with or without dark bars below eye, an yellow streak from lower corner of eye to tympanum; dorsum brown or reddish brown, light bands indistinct or absent; flanks dark brown with one or two rows of cream or yellow spots from behind tympanum to groin, upper spots smaller than lower ones in size; throat and venter cream; dark gray in posterior part of tail. For coloration in life see Figure 2a.

Variation. One specimen (IEBR 400) with frontonasal separated from prefrontals by a row of 3 small scales posteriorly. Frontonasal partly divided posteriorly in IEBR 391 (on left side) and in IEBR 403, 420 (on right side). Prefrontals in contact in 25 specimens, anteriorly separated by a small scale in 4 specimens (IEBR 388, 392, 399, 442), and completely separated from each other by a small scale in 7 specimens (IEBR 387, 389, 411, 413–414, 416, A.0816). Two specimens with 3 precloacals (IEBR 394, 403) and 36 specimens with 2 enlarged precloacals, right one overlapped by left one in 16 specimens, left one overlapped by right one in 20 specimens. Postcloacal pores present in all males and absent in all females except for IEBR 412.

Distribution. In Vietnam, *Tropidophorus cocincinensis* has been recorded from Quang Binh (Phong Nha–Ke Bang), Quang Tri (Huong Hoa), Thua Thien–Hue (A Luoi, Nam Dong), Da Nang (Son Tra), Quang Nam (Nam Giang, Tay Giang), Kon Tum (Kon Plong, Kon Tum) (Smith 1935; Bourret 1937; Ziegler et al. 2006a; Ho 2002; Bain et al. 2007; Nguyen et al. 2009) (Fig. 3c). Outside of Vietnam, this species has been known from Laos (Xe Kong) and Cambodia (Siem Riep) (Chuaynkern et al. 2005; Hartmann et al. 2009; Nguyen et al. 2009).

Natural history. The specimens were found during the day and at night time under and near by the rocks along the banks of forest streams. The males have two cream testes, 6.7–11.2 mm in length and 2.8–4.5 mm in width. Two females collected in April contained yellowish eggs: IEBR 2258 contained 6 eggs (largest one: 8.9 mm in length, 8.3 mm in diameter), IEBR 3125 had 7 eggs (largest one: 11.5 mm in length, 9.2 mm in diameter). Other females collected in August from A Luoi, Thua Thien–Hue Province, contained small follicles (about 1.5 mm in diameter).

Tropidophorus hainanus Smith, 1923

Figures 2b, 3d

Type. Holotype: BMNH 1946.8.9.10 (formerly 1924.5.22.8; Smith's collection number 6997).

Type locality. Ang Mao, near the Five Finger Mountain, Hainan, China, altitude 600 m a.s.l.

Common name. Hainan water skink.

Diagnosis. Upper head scales striated; frontonasal undivided; prefrontals usually separated from each other; nuchals absent or in 1 pair; loreals divided into 2 pairs; superciliaries 5–6, superciliary row usually not completed along the entire length of lateral edge of supraoculars; supralabials 6–7, fourth below eye; infralabials 5; postmental undivided; midbody scales in 29–34 rows; 13–15 scale rows at position of tenth subcaudal on tail; paravertebral scales 40–48; ventrals in 45–48 transverse rows; 2 enlarged precloacals; subdigital lamellae 15–20 under fourth toe (Smith 1923; Bourret 2009; our own data).

Specimens examined. Nine specimens: AMNH R-147123 (adult female) collected from Rao An, Huong Son District, Ha Tinh Province (18°20′47″ N, 105°14′10″ E), altitude: 870 m a.s.l., by Pham Duc Tien, on 9 May 1998; IEBR A.0711 (adult female) collected by Nguyen Quang Truong and Nguyen Truong Son, in May 1999, in Luc Son Commune, Luc Nam District, Bac Giang Province (21°12′ N, 106°39′ E), altitude: ca. 350 m a.s.l.; IEBR 505 (adult female), 563 (adult male) collected from the same locality as above by Nguyen Van Sang and Nguyen Quang Truong, 26–28 August 2001; IEBR 1219 (adult female) collected from Nam Xay Commune, Van Ban District, Lao Cai Province (21°58.731′ N, 104°01.403′ E), altitude: 1550 m a.s.l, by Nguyen Quang Truong, on 6 July 2002; IEBR A.0710 and ZFMK 84618 (adult males) collected from Huu Lien Commune, Huu Lung District, Lang Son Province (21°40′52″ N, 106°20′28″ E); altitude: c.a. 200 m a.s.l., by Doan Van Kien, in April 2004; IEBR A.73 (subadult) and ZFMK 84619 (adult male) collected from Na Chi Commune, Xin Man District, Ha Giang Province (22°31.641′ N, 104°28.803′ E); altitude: 270 m a.s.l., by Nguyen Quang Truong on 23 June 2005.

Description. Small-sized *Tropidophorus*, adult females: SVL 43.9–55.7 mm (mean ± SE 51 ± 6.26 mm, n = 3), TaL 54.1–55.6 mm (n = 2); adult males SVL 39.1–44.3 mm (mean ± SE 42.18 ± 2.17 mm, n = 5), TaL 45.2–54.2 mm (mean ± SE 50.9 ± 3.95 mm, n = 4); body dorso-ventrally depressed; head longer than wide, distinctly set-off from neck.

Upper head scales strongly striated; snout obtuse; rostral partly visible from above, about 2 times wider than high; supranasal absent; frontonasal undivided; prefrontals usually separated from each other; frontal about 1 1/2 times longer than the distance to snout, in contact with first and second supraoculars; supraoculars 4, the first longest, following by a small postsupraocular; frontoparietals in contact with each other medially and with 2–3 posterior supraoculars; interparietal with a small transparent spot; parietals large, in contact or separated by a small scale, posteriorly bordered by 3–5 scales on each side; nuchals absent or in 1 pair; nostril in single nasal; loreals divided into 2 pairs; preoculars 2; presuboculars 2; superciliaries 5–6, superciliary row usually not completed along the entire length of lateral edge of supraoculars; lower eyelid with 5–7 opaque scales, separated from supralabials by a row of granular scales; supralabials 6–7, fourth longest and below eye; a shallow groove on loreal-labial border, from lower corner of nasal across subocular obliquely downward to the end of fourth supralabial; postocular single; postsuboculars 4–5; primary temporals 3–4; secondary tem-

porals 4–5; tympanum superficial, oval; mental bordered by postmental and first infralabials; postmental undivided; infralabials five, first one longest; three pairs of chinshields, first pair in contact with each other meadially, second pair separated by a gular scale, and third pair separated by three scales.

Midbody scales in 30–34 rows; 13–15 scale rows at position of tenth subcaudal on tail; dorsal scales subequal to ventral scales; scales on nuchal region keeled; vertebral scale rows keeled but not widened, outer dorsal scale rows keeled; paravertebral scales 40–48; lateral scales strongly keeled, straight backward; dorsal and lateral scales on tail distinctly keeled, two median keels on tail base not continuous on back; ventral scales smooth, in 45–48 transverse rows; 2 enlarged precloacals, right one overlapped by left one; postcloacal pores absent in both sexes; subcaudals widened, about 2 times as broad as neighboring scales, smooth, first one usually divided; scales on forelimbs distinctly keeled, imbricate; those on hind limbs keeled dorsally, smooth ventrally; subdigital lamellae smooth, numbering 10–13 under fourth finger and 15–20 under fourth toe.

Coloration (in alcohol). Dorsal head brown, lighter in frontal region, loreal and supralabials dark brown with some small white spots; dorsum brown with indistinct light dark-edged cross bars, the first two in V-shaped form; upper part of flank dark brown with white spots; lower part grayish brown or gray; venter white cream, belly sometimes with dark longitudinal streaks; infralabial and throat with some dark marblings. For coloration in life see Figure 2b.

Variation. Body of the females usually wider than males; 1 specimen (ZFMK 84619) with prefrontals in contact; IEBR 563 with interparietal divided into 4 small scales and parietal divided into 2 scales on each side; parietals separated from each other posteriorly in 4 specimens (IEBR 505, 563, 1219 and A.0710); supraciliary row completed along the entire length of lateral edge of supraoculars in AMNH R-147123.

Distribution. In Vietnam, *Tropidophorus hainanus* has been recorded from Lai Chau (Muong Te), Lao Cai (Van Ban), Bac Kan (Ngan Son), Tuyen Quang, Phu Tho (Xuan Son), Vinh Phuc (Lang Cong, Tam Dao), Hanoi (Ba Vi), Bac Giang (Son Dong, Luc Nam), Hai Duong (Chi Linh), Nam Dinh (Giao Thuy), Ninh Binh (Cuc Phuong), Hoa Binh (An Lac, Tu Li), Ha Tinh (Huong Son), Quang Nam (Lam Ca), Dak Lak (Ea Kao), Dak Nong (Nam Da) (Bourret 1937; Bobrov 1993; Ziegler et al. 2006b; Bain et al. 2007; Nguyen et al. 2009) (Fig. 3d). These are new provincial records, Ha Giang ca. 650 km and Lang Son ca. 450 km westward from the type locality at Hainan Island. Else-

Figure 2. a. *Tropidophorus cocincinensis* (IEBR A.0815) from Thua Thien–Hue Province, central Vietnam, photograph Nguyen Quang Truong; **b.** *Tropidophorus hainanus* (IEBR A.0711) from Bac Giang Province, northern Vietnam, photograph Nguyen Quang Truong.

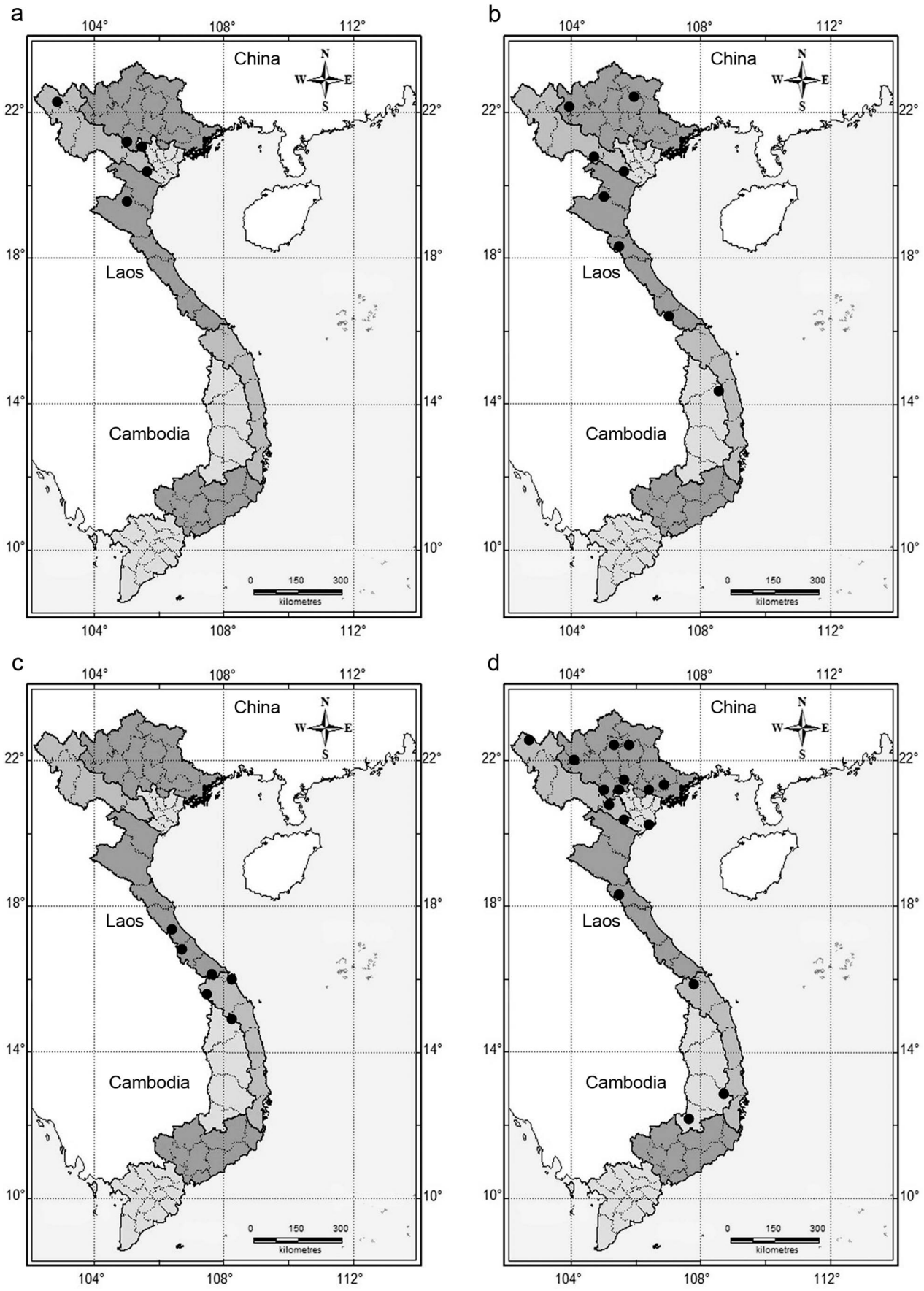

Figure 3. Distribution map of **a.** *Tropidophorus baviensis*, **b.** *T. berdmorei*, **c.** *T. cocincinensis,* and **d.** *T. hainanus* in Vietnam (●).

where, this species is known from Hainan Island, Guangxi, and Jiangxi in China (Pope 1935; Smith 1935; Zhao & Adler 1993).

Natural history. Specimens were found in the evening and at night time along the banks of streams. *Tropidophorus hainanus* can be found both in limestone forest (Tuyen Quang, Bac Kan, Lang Son, Phu Tho, Ninh Binh Provinces) and in montane evergreen forest (Lao Cai, Ha Giang, Bac Giang, Ha Tinh Provinces). The male (IEBR 563) has 2 cream testes, 4.3 mm in length and 2.2 mm in width. The female (AMNH R-147123) collected in May contained 4 yellowish eggs (7.6 mm in length). IEBR A.0711 and IEBR 505 had very small cream follicles.

Tropidophorus microlepis Günther, 1861

Figures 4a, 6a

Type. Holotype: BMNH 1946.8.20.85 (formerly 1860.8.28.21).

Type locality. Khao Sebab, Chantabun (now Chanthaburi), S. E. Siam, Thailand.

Common name. Small-scaled water skink.

Diagnosis. Upper head scales strongly striated; frontonasal undivided; prefrontals in contact with each other; loreals 2, separated from supralabials by a series of 4–5 small scales; superciliaries 5–7, superciliary row not completed along the entire length of lateral edge of supraoculars; supralabials 7, fifth below the eye; infralabials 6–7; postmental undivided; midbody scales in 28–32 rows; 13–14 scale rows at position of tenth subcaudal on tail; paravertebral scales 40–46; dorsal scales on tail distinctly keeled, two series of moderately elevated spines along middle of dorsal tail, not being continuous with those on back; ventral scales in 49–52 transverse rows; 3 enlarged precloacals; subdigital lamellae 20–22 under fourth toe (Smith 1935; Taylor 1963; Bourret 2009; our own data).

Specimens examined. Five specimens: IEBR A.0756 (adult female) collected by Nguyen Van Sang in May 2001 and ZFMK 88042 (adult male) collected by Peter Geissler on 29 July 2008, within Cat Tien National Park, Dong Nai Province (11°26′08″ N, 107°19′17″ E, altitude 200 m a.s.l.); IEBR A.0846 (adult female), IEBR A.0847 (adult male) collected by Phung My Trung, and HNUV VC 2 (adult male) collected by Vu Ngoc Thanh, in October 2008, within Vinh Cuu Nature Reserve, Dong Nai Province.

Description. Large size, adult females SVL 66.8–67 mm (n = 2), TaL: 88.1 mm; adult males SVL 63.8–68.5 mm (mean ± SE 66.7 ± 2.56 mm, n = 3); body slightly dorso-ventrally depressed; head triangular, longer than wide, swollen at the temples and distinctly set-off from neck.

Upper head scales strongly striated; snout obtuse, rounded anteriorly; rostral partly visible from above, about 2 times wider than high; supranasal absent; frontonasal undivided; prefrontals in contact with each other, and in contact with loreals, first supraocular, first superciliary, and frontal; frontal narrowing posteriorly, slightly longer than the distance to snout, in contact with prefrontals, first and second supraoculars and frontoparietals; supraoculars 4, followed by a small postsupraocular; frontoparietals in contact with each other medially and with 2–3 posterior supraoculars; interparietal narrow with a small transparent spot; parietals in contact with or separated from each other by a small scale, posteriorly bordered by 3–5 shields and scales on each side; nuchal scales absent or in 1 pair; nostril in single nasal; loreals 2, separated from supralabials by a series of 4–5 small scales; preocular single; presubocular 2–3; superciliaries 5–7, anterior two largest, superciliary row not completed along the entire length of lateral edge of supraoculars; lower eyelid with 4–5 opaque scales, separated from supralabials by 2 rows of granular scales; supralabials 7, fifth longest and below the eye, a shallow groove on loreal-labial border, from lower corner of nasal across subocular obliquely downward to the end of fifth supralabial; postocular single; postsuboculars 4; primary temporals 3–4; secondary temporals 5; tympanum superficial, ovoid; mental bordered by postmental and first infralabials; infralabials 6–7, first one very small; postmental undivided; 3 pairs of chinshields, first and second pairs in contact meadially, third pair separated from each other by 2–3 gular scales.

Midbody scales in 28–31 rows; 13–14 scale rows at position of tenth subcaudal on tail; dorsal scales on body subequal to ventral scales, imbricate; scales on nuchal region keeled; vertebral scale rows keeled but not enlarged, outer dorsal scale rows keeled, mucronate; paravertebral scales 40–46; lateral scales strongly keeled, straight backward, and strongly mucronate; dorsal and lateral scales on tail distinctly keeled, two series of moderately elevated spines along middle of dorsal tail, not being continuous with those on back; ventral scales smooth, in 49–52 transverse rows from first gular to precloacals; 3 enlarged precloacals; postcloacal pores 12–15 in males and absent in females; subcaudals smooth, about 2 times as broad as neighboring scales, usually divided from first to sixth; scales on forelimbs distinctly keeled, imbricate; those on hind limbs keeled dorsally, smooth ventrally; subdigital lamellae 12–14 under fourth finger and 20–22 under fourth toe.

Coloration (in alcohol). Head brown; supralabials cream with or without dark bars; an indistinct dark stripe from nostril to anterior corner of the eye and from behind the eye to tympanum; an yellow streak from lower corner of eye to tympanum; dorsum grayish brown, light bands indistinct or absent; flanks dark brown with a row of cream or yellow spots, running from behind tympanum to groin; throat and venter white cream; posterior part of tail gray. For coloration in life see Figure 4a.

Distribution. In Vietnam, *Tropidophorus microlepis* has been known from Son La (Moc Chau), Lam Dong (Lang Bian, Loc Chau), Dong Nai (Cat Tien) (Smith

Figure 4. a. *Tropidophorus microlepis* (IEBR A.0847) from Dong Nai Province, southern Vietnam, photograph Phung My Trung; **b.** *Tropidophorus murphyi* from Cao Bang Province, northern Vietnam, photograph Nikolai Orlov.

1935; Bobrov & Ho 1993; Bobrov 1995; Nguyen & Ho 2002; Nguyen et al. 2009). Here we present the first record of the species for Vinh Cuu Nature Reserve (Fig. 6a). Elsewhere, it is reported from Laos, Cambodia, and Thailand (Taylor 1963; Chuaynkern et al. 2005; Stuart et al. 2006).

Natural history. Specimens were found at night time along the banks of streams. The females (IEBR A.0756, A.0846) contained small yellow follicles.

Tropidophorus murphyi Hikida, Orlov, Nabhitabhata & Ota, 2002

Figures 4b, 6b

Type. Holotype: ROM 41227.

Type locality. Quang Thanh Village, Nguyen Binh District, Cao Bang Province, northern Vietnam (22°37′43 N, 105°54′46 E), altitude 700–750 m a.s.l.

Common name. Murphy's water skink.

Diagnosis. According to Hikida et al. (2002) and our own data, this species is characterized by a large size, adult males SVL 62.4–85.1 mm (n = 3), TaL: 101 mm (holotype, tail tip lost) (Hikida et al. 2002); adult females SVL 79.3–95.6 mm (n = 2), TaL 106.5–110.4 (n = 2); body strongly depressed; upper head scales smooth; frontonasal undivided; prefrontals in contact; parietals not in contact posteriorly; loreals 2, anterior one usually divided; supraciliaries 5–8, supraciliary row completed along the entire length of lateral edge of supraoculars; supralabials 6; infralabials 5–6, first one longest; postmental undivided; midbody scales in 30–32 rows; paravertebral scales 55–67; ventrals in 55–56 transverse rows (in the two paratypes); 2 enlarged precloacals; 12–13 scale rows at position of tenth subcaudal; 20–25 subdigital lamellae on fourth toe. For coloration in life see Figure 4b.

Specimens examined. Two females: ROM 41225, 41229 (paratypes).

Distribution. This species is currently known only from the type locality in Cao Bang Province, northern Vietnam (Hikida et al. 2002; Nguyen et al. 2009) (Fig. 6b).

Natural history. The large female (ROM 41225) contained 5 yellowish eggs (largest one: 9.6 mm in length and 6.8 mm in width), another one (ROM 41229) had small follicles.

Tropidophorus noggei Ziegler, Vu & Bui, 2005

Figures 5a, 6c

Type. Holotype: ZFMK 83668.

Type locality. Cha Noi, Phong Nha–Ke Bang National Park, Quang Binh Province, Vietnam.

Common name. Nogge's water skink.

Diagnosis. Large-sized *Tropidophorus*: adult females SVL 94.9–110.2 mm (mean ± SE 101.27 ± 5.66 mm, n = 6), TaL 82.5 mm (n = 1); adult males SVL 101–101.8 mm (n = 2), TaL: 121–104.5 mm (n = 2); body strongly depressed; upper head scales smooth; frontonasal undivided; prefrontals in contact or separated; parietals usually not in contact with each other posteriorly; loreals 2; supraciliaries 2–5, supraciliary row usually completed along the entire length of lateral edge of supraoculars (rarely not completed); supralabials 6; infralabials 4–5; postmental undivided; midbody scales in 22–24 rows; paravertebral scales 40–49; precloacals 2, enlarged; 9–10 scale row at position of tenth subcaudal; 18–20 subdigital lamellae under fourth toe (after Ziegler et al. 2005, 2007). For coloration in life see Figure 5a.

Specimens examined. Beside the examination of one male and two females of the type series (ZFMK 83668, 83669, VNUH 18605.1), additional morphological data derived from four females (PNNP 111, 112, 174, 175) deposited in the collection of the Phong Nha–Ke Bang National Park and from another male deposited in the Muséum d'histoire naturelle, Geneva (MHNG 2683.99).

Distribution. This species is currently known only from type locality in Quang Binh Province, central Vietnam (Ziegler et al. 2005, 2007; Nguyen et al. 2009) (Fig. 6c).

***Tropidophorus sinicus* Boettger, 1886**

Figures 5b, 6d

Type. Holotype: SMF 15750.

Type locality. Ding-hu-shan (now Mt. Dinghushan), Canton, Guangdung (now Guangdong), China.

Common name. Chinese water skink.

Diagnosis. Upper head scales distinctly striated; frontonasal divided by a longitudinal suture; prefrontals in contact or separated; loreals 2, anterior one undivided; superciliaries 5–6, superciliary row not completed along the entire length of lateral edge of supraoculars; supralabials 6, fourth below the eye; infralabials 5–6; postmental divided; midbody scales in 28–30 rows; 13–14 scale rows at position of tenth subcaudal on tail; paravertebral scales 44–49; ventral scales in 48–57 transverse rows; 2 enlarged precloacals; subdigital lamellae 17–20 under fourth toe (Smith 1935; Bourret 2009; our own data).

Specimens examined. 11 specimens: IEBR A.0759 (subadult male) collected by Ho Thu Cuc et al. in May 1998, in Quang Thanh Commune, Nguyen Binh District, Cao Bang Province (22°37′43″ N, 105°54′46″ E), altitude: 700–750 m a.s.l.; IEBR 501–502, 502a (adult females), and IEBR 503 (adult male) collected by Nguyen Van Sang and Nguyen Quang Truong, 20–30 August 2001, in Luc Son Commune, Luc Nam District, Bac Giang Province (21°12′ N, 106°39′ E), altitude: 350 m a.s.l.; IEBR A.0810 (subadult) collected by Nguyen Quang Truong and Pham The Cuong on 3 April 2008, in Thuong Yen Cong Commune, Uong Bi, Quang Ninh Province (21°08.282′ N, 106°43.403′ E), altitude: 240 m a.s.l.; IEBR A.0811 (adult female) collected by Nguyen Quang Truong on 4 April 2008, in Hoang Hoa Tham Commune, Chi Linh District, Hai Duong Province (21°14′ N, 106°29′ E), altitude: 200 m a.s.l.; IEBR 3642 (adult female) collected in Thanh Luan Commune (21°09.773′ N, 106°49.296′ E), altitude: 450 m a.s.l.; IEBR 3662 (adult male), IEBR 3663, 3667 (adult females) collected in Thanh Son Commune, Son Dong District, Bac Giang Province (21°11.102′ N, 106°42.479′ E), altitude: 300 m a.s.l., by Nguyen Quang Truong et al., 9–11 April 2008.

Description. Moderate-sized *Tropidophorus*: adult females: SVL 55.2–66.8 mm (mean ± SE 64.51 ± 5.04 mm, n = 7), TaL 61–84.5 mm (mean ± SE 70.8 ± 9.07 mm, n = 5); males SVL 54.3–60.4 mm (mean ± SE 57.35 ± 4.31 mm, n = 2), TaL 73–74 mm (mean ± SE 73.5 ± 0.71 mm, n = 2); body dorso-ventrally depressed; head triangular, longer than wide, swollen at the temples and distinctly set-off from neck.

Figure 5. a. *Tropidophorus noggei* (ZFMK 83668) from Quang Binh Province, central Vietnam, photograph Thomas Ziegler; **b.** *Tropidophorus sinicus* (IEBR 3662) from Bac Giang Province, northern Vietnam, photograph Nguyen Quang Truong.

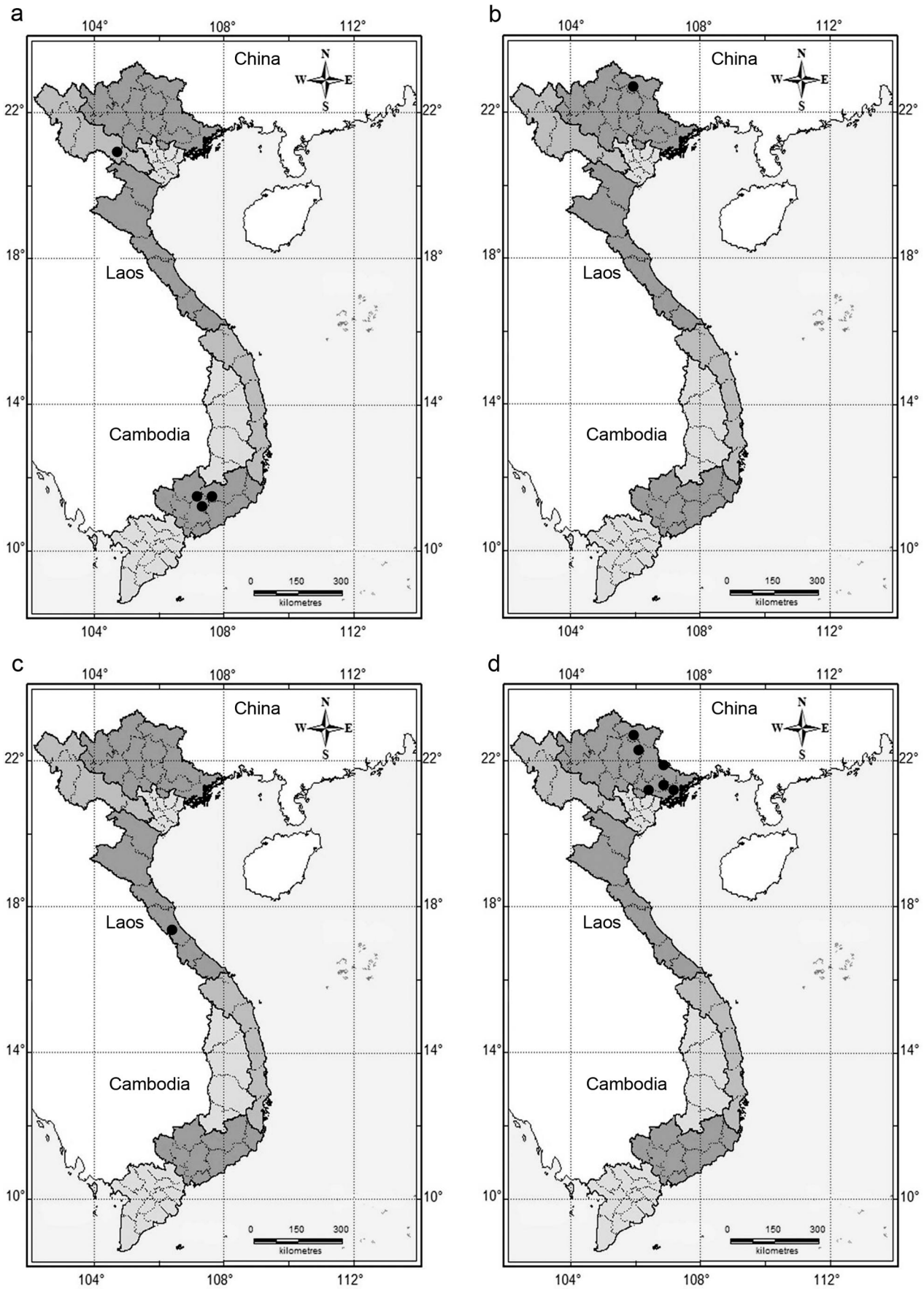

Figure 6. Distribution map of **a.** *Tropidophorus microlepis,* **b.** *T. murphyi,* **c.** *T. noggei*, and **d.** *T. sinicus* in Vietnam (•).

Upper head scales distinctly striated; snout obtuse, rounded anteriorly; rostral partly visible from above, about 2 times wider than high; supranasals absent; frontonasal divided by a longitudinal suture; prefrontals usually in contact or separated by a small scale, and in contact with loreals, first supraocular, first superciliary, and frontal; frontal narrowing posteriorly, as long as the distance to snout, in contact with prefrontals, first and second supraoculars, and frontoparietals; supraoculars 4, the third widest, followed by a small postsupraocular; frontoparietals subequal to prefrontals, in contact with each other medially, and with 2–3 posterior supraoculars; interparietal narrow with a small transparent spot; parietals in contact or separated by a small scale posteriorly, posteriorly bordered by 4–5 shields and scales on each side; nuchal scales absent; nostril in single nasal; loreals 2, anterior loreal undivided, touching first supralabial; preocular single; presuboculars 2–3; superciliaries 5–6, superciliary row not completed along the entire length of lateral edge of supraoculars; lower eyelid with 4–6 opaque scales, separated from supralabials by 1–2 rows of granular scales; supralabials 6, fourth longest and below the eye, a shallow groove on loreal-labial border, from lower corner of nasal across subocular obliquely downward to the end of fourth supralabial; postocular single; postsuboculars 4–5; primary temporals 3–4; secondary temporals 3–4; tympanum superficial, ovoid; mental bordered by postmentals and first infralabials; infralabials 5–6, first one longest; postmental divided; 3 pairs of chinshields, first pair in contact meadially, second pair separated by a gular scale, and third pair usually separated by 3 scales.

Midbody scales in 28–30 rows; 13–14 scale rows at position of tenth subcaudal on tail; dorsal scales on body subequal to ventral scales, imbricate; scales on nuchal region keeled; vertebral scale rows keeled but not widened, outer dorsal scale rows distinctly keeled; paravertebral scales 44–49; lateral scales strongly keeled, straight backward; dorsal and lateral scales on tail distinctly keeled; ventral scales smooth, in 48–57 transverse rows; 2 enlarged precloacals, right one overlapped by left one or conversely; postcloacal pores absent in both males and females; subcaudals enlarged, about 2 times as broad as neighboring scales, smooth, usually divided from first to fifth; scales on forelimbs distinctly keeled, imbricate; those on hind limbs keeled dorsally, smooth vetrally; subdigital lamellae smooth, numbering 12–14 under fourth finger and 17–20 under fourth toe.

Coloration (in alcohol). Dorsal head uniform dark brown; supralabials black or dark brown with some small white flecks; dorsum brown with large pale yellow bars (one on neck, 3–6 on body, and 2–5 on tail), light bars indistinct on posterior part of tail; flanks brown and some light markings or spots; venter white cream with some darker marblings on throat and under tail. For coloration in life see Figure 5b.

Variation. Three specimens (IEBR 502a, A.0758, A.0810) with prefrontals separated from each other by a small scale; parietals in contact posteriorly in three specimens (IEBR 3667, A.0759, A.0810).

Distribution. In Vietnam, *Tropidophorus sinicus* has been reported from Cao Bang (Nguyen Binh), Bac Kan (Ngan Son), and Lang Son (Mau Son) (Bourrert 1937; Bobrov 1995; Hikida et al. 2002; Nguyen et al. 2009). Herein, we present new records for Bac Giang, Hai Duong, and Quang Ninh Provinces, ca. 700 km from type locality in Guangdong Province (Fig. 6d). Outside of Vietnam, this species is known from Guangxi, Guangdong, and Hong Kong in southern China (Pope 1935; Smith 1935; Zhao & Adler 1993; Karsen et al. 1998).

Natural history. Specimens were found at night time (19:00–23:00) along the banks of rocky streams in mixed secondary forest of bamboo and wooden trees in Yen Tu Mountains. This species is viviparous (Karsen et al. 1998). The male (IEBR 3662) had 2 white testes (4.1 mm in length and 2.1 mm in width). Four females collected in April 2008 (IEBR 3642, 3663, 3667, and A.0811) had 4–9 yellowish eggs, 5.5–8.8 mm in length and 4.3–4.8 mm in width. Three females (IEBR 501, 502 and 502a) that were collected at the end of August contained small follicles.

Discussion

The genus *Tropidophorus* is a skink group with a high level of local endemism, with 15 of 27 species being restricted to a single country (Greer & Biswas 2004; Chuaynkern et al. 2005; Ziegler et al. 2005; Honda et al. 2006) (Fig. 7). Among the eight species recorded from Vietnam, three species are endemic to the country, viz. *Tropidophorus baviensis*, *T. murphyi*, and *T. noggei*. However, the skink fauna of Vietnam is still imperfectly studied, especially in montane forests in upland areas. Except for two new species of *Tropidophorus* discovered by Hikida et al. (2002) and Ziegler et al. (2005), three other new skink species were described from the country in last five years: *Sphenomorphus cryptotis*, *S. devorator* (Darevsky et al. 2004), and *Leptoseps tetradactylus* (Darevsky & Orlov 2005). Therefore, further studies are necessary not only to increase the knowledge of the lizard diversity in the region but also to clarify the distribution range of recently described species, especially those with only limited distribution or that were recorded from nearby national borders such as *T. guangxiensis*, *T. murphyi*, and *T. noggei*. A key to the species of *Tropidophorus* known from the Indochinese Peninsula is given below. In the key provided by Chuaynkern et al. (2005), *T. baviensis* was erroneously considered as a member of a group with rugose upper head scales.

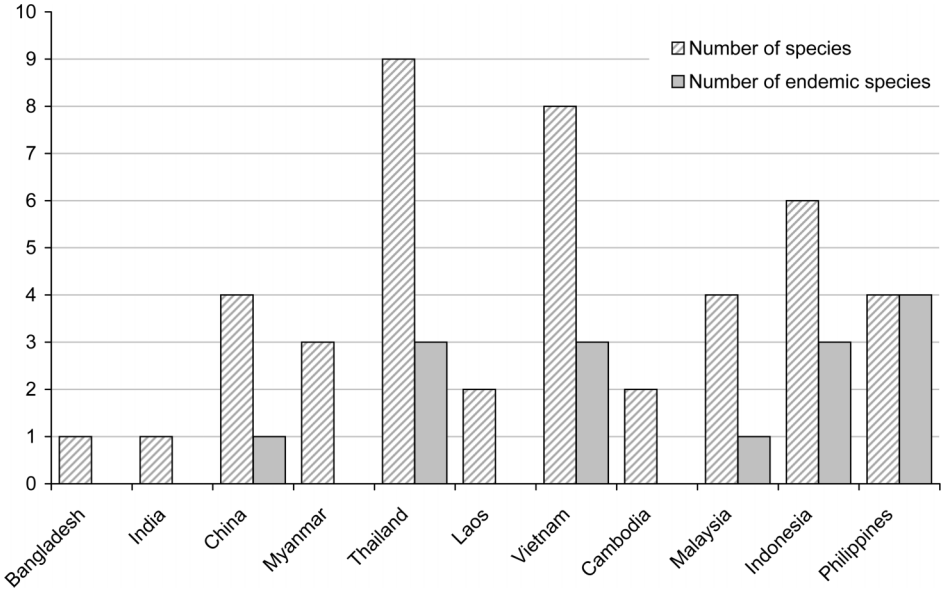

Figure 7. Species diversity and endemism in the genus *Tropidophorus.*

Key to the species of *Tropidophorus* from Indochinese Peninsula

(after Smith 1935; Taylor 1963; Wen 1992; Hikida et al. 2002; Greer & Biswas 2004; Chuaynkern et al. 2005; Ziegler et al. 2005, 2007; Bourret 2009 and data presented herein)

1a.	Upper head scales smooth	2
1b.	Upper head scales striated	9
2a.	Supraciliary row completed along the entire length of lateral edge of supraoculars	3
2b.	Supraciliary row not completed along the entire length of lateral edge of supraoculars	7
3a.	Frontonasal divided; midbody scales in 34 rows	*matsuii*
3b.	Frontonasal undivided; midbody scales in 22–32 rows	4
4a.	Midbody scales in 22–24 rows; 9–10 scale rows at position of 10th subcaudal	*noggei*
4b.	Midbody scales in 28–32 rows; 11–15 scale rows at position of 10th subcaudal	5
5a.	Vertebral scale rows two times broader than neighboring scales	*latiscutatus*
5b.	Vertebral scale rows subequal in size to neighboring scales	6
6a.	Midbody scales in 28–30 rows; 11 scale rows at position of 10th subcaudal	*baviensis*
6b.	Midbody scales in 30–32 rows; 12–13 scale rows at position of 10th subcaudal	*murphyi*
7a.	Frontonasal divided	*laotus*
7b.	Frontonasal undivided	8
8a.	Midbody scales in 28–31 rows; one loreal; subcaudals divided on whole tail	*hangnam*
8b.	Midbody scales in 32–40 rows; two loreals, anterior one usually divided; subcaudals not divided on whole tail	*berdmorei*
9a.	Frontonasal undivided	10
9b.	Frontonasal divided	13
10a.	Four loreals; prefrontals separated	*hainanus*
10b.	Two loreals; prefrontals usually in contact	11
11a.	Loreals in contact with supralabials; six supralabials; four infalabials	*robinsoni*
11b.	Loreals separated from supralabials by a series of small scales; seven supralabials; 6–7 infralabials	12
12a.	Two precloacals; two series of elevated spines along middle of dorsal tail being continuous with those on back	*cocincinensis*
12b.	Three precloacals; two series of elevated spines along middle of dorsal tail not being continuous with those on back	*microlepis*
13a.	34–38 midbody scale rows; four loreals	*thai*
13b.	28–30 midbody scale rows; two loreals	14
14a.	6–8 supralabials; postmental undivided	*guangxiensis*
14b.	6 supralabials; postmental divided	*sinicus*

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