

A review of the genus *Sphenomorphus* Fitzinger, 1843 (Squamata: Scincidae) in southern Vietnam, with additional data on *S. sheai* and *S. tridigitus*

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ABSTRACT

Introduction: Among 14 species of forest skinks (genus *Sphenomorphus*) in Vietnam, seven were recorded from southern part of the country. Shea's forest skink, *S. sheai*, was described from Kon Tum Plateau based on a single female. Similarly, the tridigital forest skink, *S. tridigitus*, was also described based on a single putrid and desiccated specimen found dead on a road in Bach Ma; specimens collected recently in Laos did not fully agree with the original description. Hence, additional specimens from type localities of both poorly known species are necessary to discern their morphological variation. In addition, little is known about hemipenis and distribution of the other forest skinks in southern Vietnam. Our study seeks to (1) confirm the occurrence of all known species in the area and access their distributions, (2) provide additional morphological data on poorly known *S. sheai* and *S. tridigitus*, and (3) describe hemipenial structure of known species. **Methods:** We analyzed the morphology of 47 specimens of forest skink collected from southern Vietnam to identify species. Scales were observed and counted under a zoom stereo microscope and measurements were taken with a digital caliper. **Results:** Analyses confirmed the occurrence of seven species of *Sphenomorphus* in southern Vietnam, including *S. annamiticus*, *S. buenloicus*, *S. indicus*, *S. maculatus*, *S. sheai*, *S. tridigitus*, and *S. yersini*. New specimens of *S. sheai* had one enlarged anterior temporal and eight or nine lamellae under fourth toe, which differed from the original description. Additional specimens of *S. tridigitus* from the type locality verified that the holotype has 20 mid-body scale rows and first supralabial and nasal fused, but they differed from the holotype in having upper temporal overlapped or overlapping the lower one. Fieldwork discovered 20 new localities for all seven species. The hemipenes of four species involved those with symmetric and asymmetric lobes. **Conclusion:** We confirm the occurrence of seven species of *Sphenomorphus* in southern Vietnam with 20 additional distribution records. Hemipenial structures of known species form two groups. New specimens of *S. sheai* and *S. tridigitus* differ slightly from the holotypes.

Key words: *Sphenomorphus sheai*, *Sphenomorphus tridigitus*, forest skink, new record, hemipenis

INTRODUCTION

With 112 species, *Sphenomorphus* Fitzinger¹ is one of the most diverse genera of the family Scincidae. The genus has a wide distribution extending from India throughout Southeast Asia and associated islands to Australia²⁻⁴. The following morphological characters diagnose the genus: lower eyelid scaly, supranasals absent, prefrontals present, parietals in contact behind interparietal, tympanum usually sunk, dorsal scales usually smooth, medial pair of precloacals enlarged, inner precloacals overlapping outer ones, hind limbs with five digits, and symmetrical or asymmetrical forked hemipenis². Nguyen *et al.*⁵ recorded 11 species of *Sphenomorphus* in Vietnam, including *S. bachoensis*, *S. buenloicus*, *S. cryptotis*, *S. indicus*, *S. maculatus*, *S. mimicus*, *S. stellatus*, *S. tetradactylus*, *S.*

tonkinensis, *S. tridigitus*, and *S. tritaeniatus*, and provided a key to the species in Vietnam and China. Subsequently, Nguyen *et al.*^{6,7} added *S. incognitus* from Bac Giang Province and described the new species, *S. sheai*, from the border area between Quang Ngai and Kon Tum provinces. Nguyen *et al.*² described another new species, *S. yersini*, from Khanh Hoa Province. Uetz *et al.*³ added *S. malayanum* into the faunal list of Vietnam based on the checklist of Bobrov⁸. However, Bobrov & Semenov⁹ removed this species from the Vietnamese herpetofauna, and when reviewing *Sphenomorphus* in Vietnam and describing new species, Nguyen *et al.*^{5,7} did not include it. Recently, *S. annamiticus* was resurrected for the populations in southern Vietnam and *S. stellatus* was reported to be restricted to Peninsular Malaysia⁴. Therefore, Vietnam has 14 species of *Sphenomorphus*.

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Seven species of *Sphenomorphus*, including *S. annamiticus*, *S. buenloicus*, *S. indicus*, *S. maculatus*, *S. sheai*, *S. tridigitus*, and *S. yersini*, occur in southern Vietnam from Bach Ma-Hai Van Mountains southward. Most of these species are documented from a series of specimens^{2,10}, but two are the most poorly known species of skinks in Vietnam. *Sphenomorphus sheai* was described from the female holotype only⁷ and, hence, more samples are necessary to assess its morphological variation. Similarly, *S. tridigitus* was described from a single specimen collected at Bach Ma, Thua Thien-Hue Province¹¹. The second specimen was reported from Bolaven Plateau, Champasak Province, Laos¹², and subsequently Greer *et al.*¹³ updated the description and corrected original errors based on this specimen. However, the Laotian sample differs from the holotype by having only 18 mid-body scale rows instead of 20. Heatwole & Stuart¹⁴ collected 73 specimens of this skink from Bolaven Plateau, Champasak Province, Laos. This large collection agreed with the redescription of Greer *et al.*¹³ including discrepancies. However, the number of mid-body scale rows remains unclarified. In Vietnam, Bain *et al.*¹⁵ recorded two specimens (IEBR 73 & 74) from Ngoc Linh, Quang Nam Province that agreed with the redescription of Greer *et al.*¹³. These samples have a frontonasal, two widely separated prefrontals, fusion of nasal and first “infralabial” (it should be “supralabial”) scales, and 18 and 20 mid-body scale rows¹⁶. Because the holotype was in a poor state of preservation having been found dead on a road¹³ and the additional specimens collected out of the type locality do not fully agree with the original description, more specimens from Bach Ma (type locality) are necessary to clarify the status of this skink.

Our recent field surveys in southern Vietnam yielded additional specimens of *S. sheai* near its type locality, *S. tridigitus* from its type locality, and all other congeners from southern Vietnam. Therefore, we review the species of *Sphenomorphus* in southern Vietnam and provide additional data on the morphology of *S. sheai* and *S. tridigitus*.

MATERIAL AND METHODS

A total of 47 specimens deposited in the Institute of Tropical Biology Collection of Zoology (ITBCZ, Vietnam Academy of Science and Technology, Ho Chi Minh City) were examined. Scales were observed and counted on the right side under a zoom stereo microscope at 7X–45X (Akeiyo, Hong Kong). Measurements were also taken on the right side with a digital caliper (Exploit 150 mm, China) to the nearest 0.1 mm. Elevation (above sea level – a.s.l.) was measured

using GPS Garmin 64S (Taiwan). Common English and Vietnamese names followed Nguyen *et al.*^{2,7,17}. The following morphological characters modified from Nguyen *et al.*^{2,7} were used: snout-vent length (SVL) measured from the tip of the rostral to the vent; tail length (TaL) measured from the vent to the tip of tail; axilla-groin length (AxGnL) measured from the posterior margin of the forelimb insertion to the anterior margin of the hind limb insertion; snout to forelimb length (SnForeL) measured from the anterior margin of the forelimb insertion to the tip of the rostral; head length (HL) measured from the posterior margin of parietal to the tip of the rostral; head width (HW) measured at the widest portion of the temporal region; supralabials (SL); infralabials (IL); loreals; supraoculars (SO); enlarged temporals (L/U – the lower secondary temporal overlapping the upper one, U/L – the upper secondary temporal overlapping the lower one); nuchal (pair); midbody scale rows (MBS) counted as the number of longitudinal scale rows encircling the body at a point midway between the limb insertions; paravertebral scale rows (ParaVert) counted as the number of scales in a line from the parietal scales to a point on the dorsum opposite the vent; ventral scale rows (Ven) counted as a row of scales between the postmentals and the cloacal plate; enlarged cloacal plate (L/R – the left plate overlapping the right one, R/L – the right plate overlapping the left one); subcaudal scales (SC) counted as a row of subcaudals between the vent and the tip of tail (paired + single plate); and lamellae beneath the fourth toe (Toe IV) counted from the first scale whose posterior margin extending into the body of the foot. Values of paired characters were recorded in order of left and right. Nomenclature for head shields followed Smith¹⁰, Ouboter¹⁸, and Greer¹³.

RESULTS

Examination of our 47 specimens confirmed the occurrence of seven species of the genus *Sphenomorphus* in southern Vietnam as follows:

Sphenomorphus annamiticus (Boettger, 1901)

Starry forest skink, thằn lằn phê-nô trung bộ (Figure 1F).

Type locality: “Phuc-Son in Annam” (now Phuoc Son District in Quang Nam Province)¹⁹.

Specimens examined (n = 2). ITBCZ 883, male, Ta Kou, Ham Thuan Nam Dist., Binh Thuan Prov., 242 m a.s.l.; ITBCZ 352, juvenile, Lo Go-Xa Mat, Tan Bien Dist., Tay Ninh Prov.



Figure 1: Skinks of genus *Sphenomorphus* in southern Vietnam. (A) *S. tridigitus* (ITBCZ 5307) from top of Bach Ma Mountains, Phu Loc Dist., Thua Thien-Hue Prov.; (B) *S. maculatus* (ITBCZ 6057) from Phu Quoc Island, Kien Giang Prov.; (C) *S. yersini* (ITBCZ 5685) from Hon Ba, CamLam Dist., Khanh Hoa Prov.; (D) *S. sheai* (ITBCZ 4563) from Tram Lap Forest, K'Bang Dist., Gia Lai Prov.; (E) *S. indicus* (ITBCZ 6835) from Nam Nung, Dak Glong Dist., Dak Nong Prov.; (F) *S. annamiticus* (ITBCZ 883) from Ta Kou, Ham Thuan Nam Dist., Binh Thuan Prov.; and (G) *S. buenloicus* (ITBCZ 6027) from Tram Lap Forest, K'Bang Dist., Gia Lai Prov.

Diagnosis. Relatively large-sized skink (SVL up to 65 mm); depressed limbs overlap; rostral convex, in broad contact with the frontonasal; prefrontals separated from one another; no supranasals; four large supraoculars; two or three pairs of nuchals; ear oval, without or with short projecting lobules; dorsal scale rows enlarged, 22 mid-body scale rows, all smooth; two enlarged precloacal shields; limbs well developed, pentadactyl, and 18 or 19 lamellae beneath fourth toe. These characters agree with the previous descriptions^{4,19}.

Distribution. In southern Vietnam, *S. annamiticus* has been recorded from the following provinces: Kon Tum: Chu Mon Ray, Kon Plong; Quang Nam: Phuoc Son; Lam Dong: Da Lat^{10,17,20}; Binh Thuan: Ta Kou; and Tay Ninh: Lo Go-Xa Mat [this study].

Natural history. All specimens were collected at night under rotting leaf layer near the trail in ever-green forest.

***Sphenomorphus buenloicus* Darevsky & Nguyen, 1983**

Buonloui forest skink, thần lằn phê-nô buồn lười (Figure 1G).

Type locality: "Buon-Loi, Dalai Kontum Province" (now Buon Luei, K'Bang District, Gia Lai Province), Vietnam²¹.

Specimens examined (n = 4). ITBCZ 4357, female, Tram Lap Forest, 1263 m a.s.l., ITBCZ 6027, male, Tram Lap Forest, 1197 m a.s.l., and ITBCZ 5060, female, Dak Rong, 1311 m a.s.l., K'Bang Dist., Gia Lai Province (Prov.); ITBCZ 6832, female, Song Thanh,

Nam Giang Dist., Quang Nam Prov., 361 m a.s.l.

Diagnosis. Relatively small size (SVL up to 56 mm); depressed limbs overlap; prefrontals in contact with each other; four supraoculars; parietals shields contacting behind interparietal; one enlarged anterior temporal, two posterior temporals, the lower scale overlapping the upper one; no enlarged dorsal scale rows, 32–34 mid-body scale rows, all smooth; two enlarged precloacal shields; limbs well developed, pentadactyl, 16–19 lamellae beneath fourth toe; hemipenis smooth, forked at the middle point of its length with two developing lobes and the outer lobe is slightly longer than the inner one. These characters agree with the previous descriptions^{2,21}.

Distribution. In southern Vietnam, *S. buenloicus* has been recorded from the following provinces: Gia Lai: Buon Luoi²¹, Kon Chu Rang, Kon Ka Kinh²², Tram Lap, Dak Rong [this study]; Kon Tum: Kon Plong^{5,17}, Chu Mom Ray^{20,22}; and Quang Nam: Song Thanh [this study].

Natural history. All specimens were collected at night and in daytime, under rotting leaf layer in evergreen forest.

Sphenomorphus indicus (Gray, 1853)

Indian forest skink, thần lằn phê-nô ấn độ (Figure 1E).

Type locality: Sikkim, Himalayas, India²³.

Specimens examined (n = 10). ITBCZ 5195 & 5205, Bach Ma, Phu Loc Dist., Thua Thien-Hue Prov., 1000–1300 m a.s.l.; ITBCZ 6833, female, Ba Na, Da Nang City, 1477 m a.s.l.; ITBCZ 6834, female, Song Thanh, Nam Giang Dist., Quang Nam Prov., 361 m a.s.l.; ITBCZ 4262 & 4568, Tram Lap, K'Bang Dist., Gia Lai Prov.; ITBCZ 2811, male, 1507 m a.s.l., ITBCZ 5689, Juv., 867 m a.s.l., ITBCZ 5696, juv., 1510 m a.s.l., Hon Ba, Cam Lam Dist., Khanh Hoa Prov.; ITBCZ 6835, female, Nam Nung, Dak Glong Dist., Dak Nong Prov., 865 m a.s.l.

Diagnosis. Large-sized skink (SVL up to 90 mm); depressed limbs overlap; rostral convex, in broad contact with the frontonasal; prefrontals always separated from one another; no nuchals; four large supraoculars; ear oval, no projecting lobules; no enlarged dorsal scale rows, 30–38 mid-body scale rows, all smooth; two enlarged precloacal shields; limbs well developed, pentadactyl, 16–22 lamellae beneath fourth toe; hemipenis smooth, forked at about half of its length with two long lobes. These characters agree with the previous description¹⁰. Data on hemipenis are new.

Distribution. In southern Vietnam, *S. indicus* has been recorded from the following provinces: Thua

Thien-Hue: Bach Ma; Da Nang: Ba Na¹⁷, [this study]; Quang Nam: Song Thanh [this study]; Quang Ngai: Son Ha, Ba To²⁴; Kon Tum: Kon Plong¹⁷; Gia Lai: Tram Lap [this study]; Dak Lak: Chu Yang Sin¹⁷; Dak Nong: Nam Nung; Khanh Hoa: Hon Ba [this study]; and Dong Nai: Cat Tien¹⁷.

Natural history. All specimens were collected at night and in daytime, under rotting leaf layer in evergreen forest and in daytime near the road on top of mountains.

Sphenomorphus maculatus (Blyth, 1853)

Spotted forest skink, thần lằn phê-nô đốm (Figure 1B).

Type locality: Asám (now Assam, India)²⁵.

Specimens examined (n = 16). ITBCZ 6836 & 6837, females, Chu Yang Sin, Krong Bong Dist., Dak Lak Prov., 480 m a.s.l.; ITBCZ 5780, female, Tan Nghia, Ham Tan Dist., Binh Thuan Prov., 100 m a.s.l.; ITBCZ 1221–1224, Ta Kou, Ham Thuan Nam Dist., Binh Thuan Prov., 54 m a.s.l.; ITBCZ 6284–6287, Ba Den, Duong Minh Chau Dist., Tay Ninh Prov., 365 m a.s.l.; ITBCZ 528, Chua Chan, Xuan Loc Dist., Dong Nai Prov., 473 m a.s.l.; ITBCZ 6348, female, Nui Dinh, Tan Thanh Dist., Ba Ria-Vung Tau Prov., 304 m a.s.l.; ITBCZ 6056–6058, males, Phu Quoc Island, Kien Giang Prov., 66 m a.s.l.

Diagnosis. Medium-sized skink (SVL up to 62 mm); depressed limbs overlap; rostral concave, in broad contact with the frontonasal; prefrontals rather small, separated from one another; no nuchals; five supraoculars, first longest, fifth smallest; ear without projecting lobules; 38–42 mid-body scale rows, all smooth; dorsal scales larger than lateral ones; two enlarged precloacal shields; limbs well developed, pentadactyl, 16–22 lamellae beneath fourth toe; hemipenis smooth, forked at the middle point of its length with two long lobes. These characters agree with the previous description¹⁰. Data on hemipenis are new.

Distribution. In southern Vietnam, *S. maculatus* has been recorded from the following provinces: Dak Lak: Chu Yang Sin [this study]; Lam Dong: Da Lat¹⁷; Binh Thuan: Tan Nghia, Ta Kou [this study]; Dong Nai: Cat Tien¹⁷, Chua Chan [this study]; Tay Ninh: Ba Den; Ba Ria-Vung Tau: Nui Dinh [this study]; and Kien Giang: Hon Thom¹⁷, Phu Quoc [this study].

Natural history. All specimens were collected at night and in daytime under rotting leaf layer or rocky area in evergreen, semi-deciduous or disturbed forests and in hilly habitats near resident area.

***Sphenomorphus sheai* Nguyen, Nguyen, Devender, Bonkowski & Ziegler, 2013**

Shea's forest skink, thằn lằn phê-nô shea (Figure 1D). Type locality: border area between Quang Ngai and Kon Tum provinces, Vietnam⁷.

Specimens examined (n = 3). ITBCZ 4563, 4564, and 6036, sex unknown, Tram Lap, K'Bang Dist., Gia Lai Prov., 997 m a.s.l.

Diagnosis. Small-sized skink (SVL up to 34.6 mm); limbs short, pentadactyl, depressed limbs separated from each other; rostral concave, in broad contact with the frontonasal; prefrontals separated from one another; enlarged nuchals in two pairs; four, rarely three, supraoculars; supralabials six, the sixth largest, the first fused with nasal; infralabials five; primary temporal one; secondary temporals two, the lower scale overlapping the upper one; external ear openings absent; 20 mid-body scale rows, all smooth; paravertebral scales 54–58, slightly larger than lateral ones; two enlarged precloacal shields, the left shield overlapping the right one; 8 or 9 lamellae beneath fourth toe; tail longer than snout-vent length (TaL/SVL = 1.6), 88 transversally enlarged subcaudals; dorsolateral light stripe present on neck, shoulder, and anterior part of dorsum. Detailed morphological characters for the additional samples were showed in Table 1. These characters essentially agree with the original description⁷.

Distribution. In southern Vietnam, *S. sheai* has been recorded from the following provinces: Quang Ngai-Kon Tum border⁷ and Gia Lai: Tram Lap [this study].

Natural history. All specimens were collected at night under rotting leaf layer in evergreen forests.

***Sphenomorphus tridigitus* (Bourret, 1939)**

Tridigital forest skink, thằn lằn phê-nô ba ngón (Figure 1A).

Type locality: Bach Ma, Thua Thien-Hue Province¹¹.

Specimens examined (n = 6). ITBCZ 5229, 5306 (gravid female), 5307, and 5308, Bach Ma, Phu Loc Dist., Thua Thien-Hue Prov., 1300 m a.s.l.; ITBCZ 7278 & 7288, females, Ngoc Linh, Dak Glei Dist., Kon Tum Prov., 1825 m a.s.l.

Diagnosis. Small-sized skink (SVL up to 47.2 mm); limbs short, depressed limbs separated, hindlimb pentadactyl, forelimb tridactyl; rostral concave, in broad contact with the frontonasal; prefrontals separated from one another; enlarged nuchals in two or three pairs; four supraoculars; supralabials six, the sixth largest, the first fused with nasal; infralabials five; primary temporal one; secondary temporals two, the lower scale overlapping or overlapped by the upper one; external ear openings absent; 20 mid-body

scale rows, all smooth; paravertebral scales 51–63, slightly larger than lateral ones; two enlarged precloacal shields; seven or eight lamellae beneath fourth toe; tail longer than snout-vent length (TaL/SVL = 1.6), 87 transversally enlarged subcaudals; a dorsolateral black stripe extending continuously from posterior margin of eye to tail base. Detailed morphological characters for the additional samples were showed in Table 1. These characters essentially agree with the original and additional descriptions of the holotype^{11,13}.

Distribution. In southern Vietnam, *S. tridigitus* has been recorded from the following provinces: Thua Thien-Hue: Bach Ma Mountains¹¹, [this study]; Quang Nam: Ngoc Linh^{5,15}; Kon Tum: Ngoc Linh [this study].

Natural history. All specimens were collected in the morning under leaf litter in mixed evergreen and pine forests around the Bach Ma summit and in evergreen forest in Ngoc Linh.

***Sphenomorphus yersini* Nguyen, Nguyen, Nguyen, Orlov & Murphy, 2018**

Yersin's forest skink, thằn lằn phê-nô yersin (Figure 1C).

Type locality: Hon Ba, Cam Lam, Khanh Hoa, Vietnam².

Specimens examined (n = 6). ITBCZ 5685, male, 1162 m a.s.l., ITBCZ 5686, female and ITBCZ 5684, male, 932 m a.s.l., Hon Ba, Cam Lam Dist., Khanh Hoa Prov.; ITBCZ 6838, male, Chu Yang Sin, Krong Bong Dist., Dak Lak Prov., 802 m a.s.l.; ITBCZ 6839, male, ITBCZ 6840, female, Nam Nung, Dak Glong Dist., Dak Nong Prov., 829 m a.s.l.

Diagnosis. Small-sized skink (SVL up to 56 mm); depressed limbs overlap; rostral convex, in broad contact with the frontonasal; prefrontals in broad contact with or just touching one another; no nuchals; four, rarely five, supraoculars; ear oval, no projecting lobules; no enlarged dorsal scale rows, 32–34 mid-body scale rows, all smooth; two enlarged precloacal shields; limbs well developed, pentadactyl, 18–20 lamellae beneath fourth toe hemipenis smooth, deeply forked, asymmetrical with a long lobe and another short. These characters essentially agree with the original description².

Distribution. In southern Vietnam, *S. yersini* has been recorded from the following provinces: Khanh Hoa: Hon Ba²; Dak Lak: Chu Yang Sin; and Dak Nong: Nam Nung [this study].

Natural history. All specimens were collected at night under rotting leaf layer in evergreen forest.

Table 1: Measurements (in mm) and scalation of *Sphenomorphus tridigitus* and *S. sheai* from southern Vietnam. See Material and Methods for abbreviations. reg. = regenerated tail; l = left side; r = right side

Taxon	Sphenomorphus tridigitus						Sphenomorphus sheai					
	ITBCZ 5229	ITBCZ 5306	ITBCZ 5307	ITBCZ 5308	ITBCZ 7278	ITBCZ 7288	ITBCZ 4563	ITBCZ 4564	ITBCZ 6036			
Voucher												
SVL	36.2	42.9	32.0	36.0	47.2	47.2	33.2	34.6	34.3			
TaL	56.7	reg.	reg.	reg.	reg.	reg.	reg.	reg.	56.4			
HL	5.7	6.5	5.5	6.0	7.0	6.8	5.2	5.3	5.5			
HW	4.2	4.9	3.8	4.4	5.0	4.9	3.5	3.6	3.5			
AxGnL	20.0	26.9	17.2	20.7	29.2	28.8	20.0	20.3	19.7			
SnForeL	11.2	11.2	10.1	12.6	14.1	13.5	10.3	10.3	10.3			
MBS	20	20	20	20	20	20	20	20	20			
ParaVert	53	56	51	51	56	63	58	54	56			
Ven	53	56	53	52	55	58	57	56	56			
SL	6	6	6	6	6	6	6	6	6			
IL	5	5	5	5	5	5	5	5	5			
Loreal	1	1	1	1	1	1	1	1	1			
Temporal	1+2, L/U (l), U/R (r)	1+2, L/U	1+2, U/L	1+2, L/U	1+2, U/L	1+2, U/L	1+2, L/U	1+2, L/U	1+2, L/U			
SO	4	4	4	4	4	4	4	4(l), 3(r)	4			
Nuchal	3	2	2	2	2	3	2	2	2			
Cloacal	2, R/L	2, L/R	2, R/L	2, L/R	2, R/L	2, L/R	2, L/R	2, L/R	2, L/R			
Toe IV	8	8	8	8 (l)	8	7	9	9	9			
SC	2+87	1+37+	1+20+	1+17+	1+30+	1+48+	1+34+	1+38+	1+88			

DISCUSSION

Taxonomic notes. *Sphenomorphus stellatus* was described under the name *Lygosoma stellatum* based on samples collected from Larut Hills, Perak, West Malaysia²⁶. One year later, Boettger¹⁹ described *Lygosoma annamiticum* (= *Sphenomorphus annamiticus*) from “Phuc-son in Annam” (now Phuoc Son, Quang Nam). Smith¹⁰ supposed that *S. annamiticus* was a junior synonym of *S. stellatus* based on a specimen collected from Da Lat. However, *S. annamiticus* was recently resurrected for the populations in southern Vietnam based on molecular and morphological evidences and *S. stellatus* was reported to be restricted to Peninsular Malaysia⁴. Our specimens agree with the descriptions of *S. annamiticus*^{4,19}.

Vassilieva *et al.*²⁷ recorded *Sphenomorphus* cf. *buenloicus* from Lam Dong, Dong Nai, Ba Ria-Vung Tau, and Tay Ninh provinces, and subsequently Neang & Poyarkov²² reported *S. buenloicus* from Lam Dong (Loc Bac) and Dong Nai (Cat Tien) provinces. However, Nguyen *et al.*² recently described *Sphenomorphus yersini* from Khanh Hoa and the key differences between *S. buenloicus* and *S. yersini* involve DNA sequences and morphology of the hemipenes. Hemipenes of the samples from Chu Yang Sin (Dak Lak) and Nam Nung (Dak Nong) are similar to those of *S. yersini*. Hence, further molecular studies are necessary to clarify if the previous records^{22,26} are *S. buenloicus*, *S. yersini*, or other taxa, and if *S. buenloicus* occurs in Gia Lai-Kon Tum Plateau and adjacent areas while *S. yersini* distributes in Lang Bian Plateau and its vicinity.

Sphenomorphus sheai was described from a single specimen⁷ and additional data from new specimens essentially agree with the original description. However, some characters differ from those of the holotype, including enlarged anterior temporal (1 vs. 2), loreal (1 vs. 2), paravertebral scales (54–58 vs. 53), and lamellae under toe four (8 or 9 vs. 6).

Some characters and variation differ between the Laotian specimen¹³ and samples from the type locality of *S. tridigitus*. The specimen from Laos has six pairs of subcaudals basally while the specimens from Bach Ma bear only one or two pairs. The samples from Bach Ma have from 51 to 56 paravertebral scale rows, which is greater than in the specimen from Laos (50). Uetz *et al.*³ noted that *S. tridigitus* differs from most of its congeners by having the upper temporal scale overlapping the lower one. This statement may have originated from Greer *et al.*¹³. However, additional material from the type locality reveals variation. In our four specimens from the type locality, only one

(ITBCZ 5307) has the upper temporal scale overlapping the lower one, two (ITBCZ 5306 & 5308) have the lower temporal scale overlapping the upper one, and the remainder (ITBCZ 5229) has the upper temporal scale overlapping the lower one on the right and opposite condition on the left. The significant difference between specimens from Laos and Bach Ma involves the number of mid-body scale rows. All examined specimens from the type locality as well as the holotype have 20 mid-body scale rows while sample from Laos has 18 rows only. Two additional samples from Ngoc Linh essentially agree with those from Bach Ma and, thus, they also differ from the Laotian specimen in having 20 mid-body scale rows. Given this invariability of mid-body scale rows (20 vs. 18), further molecular study should be done to clarify if populations from Bach Ma, Ngoc Linh, and Laos are distinct taxa.

New records of distribution. In total, we report 20 new locations in southern Vietnam for all seven species. The new records for each species are as follows: *S. annamiticus*: Ta Kou and Lo Go-Xa Mat; *S. buenloicus*: Tram Lap, Dak Rong, and Song Thanh; *S. indicus*: Song Thanh, Tram Lap, Nam Nung, and Hon Ba; *S. maculatus*: Chu Yang Sin, Tan Nghia, Ta Kou, Chua Chan, Ba Den, Nui Dinh, Phu Quoc; *S. sheai*: Tram Lap; *S. tridigitus*: Ngoc Linh; and *S. yersini*: Chu Yang Sin and Nam Nung. In general, these skinks trend to have wide distributions.

Hemipenis. Among seven species of *Sphenomorphus* in southern Vietnam, the hemipenes of two were described previously^{2,21} (*S. buenloicus* and *S. yersini*) and we add descriptions for *S. indicus* and *S. maculatus*. The organs can be divided into two groups. The first group has symmetrical hemipenes each with two long lobes. This form occurs in *S. indicus* and *S. maculatus*. The second group has asymmetrical hemipenes with the two lobes being different in length, as found in *S. buenloicus* and *S. yersini*. The hemipenes of *S. annamiticus*, *S. sheai*, and *S. tridigitus* remain unknown.

Main limitations of this study. Herein, we use only morphological data to access the taxonomic status of species of *Sphenomorphus* in southern Vietnam. All recorded species seem to have wide distributions and, therefore, further molecular studies should be done to clarify if cryptic species exist in the area. In addition, specimens of *S. tridigitus* from Laos were not examined in this study. Hence, it is still in doubt if this species is endemic to Vietnam or occurs in both Vietnam and Laos. Molecular study is necessary to clarify if populations in the two countries are distinct taxa or conspecific.

Among seven species of *Sphenomorphus* in southern Vietnam, four are known their hemipenial structures. Further surveys need to collect more adult males of the three remaining species and others to obtain a comprehensive understanding of the hemipenial morphology of all species of *Sphenomorphus*.

CONCLUSION

We confirm the occurrence of seven skinks of the genus *Sphenomorphus* in southern Vietnam, including *S. annamiticus*, *S. buenloicus*, *S. indicus*, *S. maculatus*, *S. sheai*, *S. tridigitus*, and *S. yersini* and provide 20 new distributional records. In term of morphological characters, the newly collected specimens of *S. sheai* have one enlarged anterior temporal and eight or nine lamellae under fourth toe, which differs from the original description. Additional specimens of *S. tridigitus* from type locality in Bach Ma have 20 mid-body scale rows, first supralabial and nasal fused, and upper temporal overlapped or overlapping the lower one. Hemipenis of known species form two groups, one with symmetrical long lobes and the other with asymmetrical lobes.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTION

Manh V. Le and Sang N. Nguyen designed this study, collected and analyzed data, and wrote the manuscript; Luan T. Nguyen, Ba D. Vo, Vu D.H. Nguyen, and R. W. Murphy collected data and gave comments on the manuscript.

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