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A new species of the genus *Oligodon* Fitzinger, 1826 (Squamata: Colubridae) from coastal southern Vietnam

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Abstract

A new species of the genus *Oligodon* from the coastal area of Binh Chau–Phuoc Buu Nature Reserve, Ba Ria–Vung Tau Province, southern Vietnam, is described. *Oligodon arenarius* **sp. nov.** is distinguishable from all other species by the unique combination of the following characters: medium size; 17 dorsal scale rows; 6–8 maxillary teeth, the posterior three being enlarged; head scalation lacking a loreal but usually including a presubocular; divided nasal; two postoculars; 131–144 ventrals; 36–60 subcaudals; unforked hemipenis, without spines or obvious papillae; sexual dimorphism displayed in the number of subcaudals (36–40 in females, 58–60 in males) and a relative tail length, tails being quite long in males (TaL/TL = 0.26-0.28) and moderate in females (TaL/TL = 0.13-0.17); head coloration pattern including ocular band, temporal bands and chevron-shaped mark on nape; dorsal coloration without distinct pattern, uniform or with dark speckling; ventrals pinkish in life, immaculate. To date, this species appear to be endemic to Vietnam.

Key words: Oligodon arenarius sp. nov., Ba Ria-Vung Tau Province, southern Indochina, taxonomy, sexual dimorphism, natural history

Introduction

The kukri snakes, or the colubrid snakes of the genus *Oligodon* Fitzinger, 1826, which currently numbers 74 valid species (Uetz & Jiri Hošek, 2015), have a wide distribution throughout tropical and subtropical Asia, including the Sunda Islands and the Philippines. In all, 22 species of the genus occur in Indochina, 19 of which are known from Vietnam (David *et al.* 2008ab, Nguyen *et al.* 2009, Das 2010, Green 2010, Neang *et al.* 2012, David *et al.* 2012, Vassilieva *et al.* 2013), where these medium-sized, mostly terrestrial snakes are encountered in various habitats from montane and lowland tropical forests to coastal dunes.

Given the impressive diversity of kukri snakes, it is not surprising that the ongoing investigations of the herpetofauna of Vietnam are revealing new species, even in areas that are quite popular for tourism and that are considered scientifically well studied.

During field surveys in Binh Chau–Phuoc Buu Nature Reserve in Ba Ria–Vung Tau Province, Vietnam, we collected, in the coastal resort zone, several specimens of a snake species obviously belonging to the genus *Oligodon* but not fitting any diagnosis of known species. A close examination of the specimens and the comparison of their external morphological traits and hemipenial morphology with those of other *Oligodon* species revealed that they display a unique combination of characters that differs significantly from all described taxa. Herein they are assigned to a new species, which is described below.

Material and methods

Herpetological surveys in Binh Chau–Phuoc Buu Nature Reserve were undertaken from 7 to 18 November 2010, from 7 to 14 November 2011, from 6 to 13 July 2012, and from 11 to 17 November 2014.

All collected specimens were photographed after capture, and subsequently fixed and stored in 70% ethanol. Morphological characters and morphometric ratios considered to be of taxonomic importance within Oligodon (see Smith 1943, David et al. 2008ab, 2012, Green et al. 2010) were used for species determination. Scale counts and measurements were taken under a Leica EZ4 dissecting microscope using a digital caliper. The ventral count methodology used in this study followed Dowling (1951). Maxillary teeth were counted by pushing back the soft tissue with a preparation pin. The hemipenes in one adult male were forcedly everted and photographed before the preservation of the specimen. The following measurements and counts were taken: anterior dorsal scale row count (ASR, number of dorsal scale rows at neck, approximately one HL behind head); midbody dorsal scale row count, same as dorsal scale row count DSR (MSR, number of dorsal scales at a position corresponding to the midpoint of the ventral scale row, VEN/2); posterior dorsal scale row count (PSR, number of dorsal scale rows before vent); supralabial scales (SL); infralabial scales (IL); teeth (number of maxillary teeth); preocular scales (PreOc); presubocular scales (PrSbOc); postocular scales (PostOc); temporal scales (Temp); ventral scales (VEN); subcaudal scales (SC); total length (TL, from snout to tail tip); snout – vent length (SVL); tail length (TaL); ratio of tail length to total length (TaL/TL); head width (HW); head length (HL, from snout tip to jaw angles); head height (HH); interorbital distance (IO); eye diameter (ED, horizontal); snout length (SnL, from the tip of rostral to the anterior margin of eye); eye-nostril distance (EN, from anterior edge of orbit to posterior edge of nostril); internarial distance (IN). Differing symmetric characters are given in left / right order.

The types and referred material are stored in the herpetological collections of the Zoological Museum of Moscow State University (ZMMU) in Moscow, Russia, and in the Vietnam National Museum of Nature (VNMN) in Hanoi, Vietnam.

For comparison, voucher specimens of diverse *Oligodon* species encountered in Vietnam were examined (see Appendix).

The diagnosis of the genus *Oligodon* and morphological characters chosen for comparison were taken from the following sources: Günther (1873), Wall (1909, 1910), Venning (1914), Smith (1943), Campden-Main (1970), Deuve (1970), Pauwels *et al.* (2002), David *et al.* (2008ab), Green (2010), Green *et al.* (2010), Orlov *et al.* (2010), Geissler *et al.* (2011), David *et al.* (2012), David & Vogel (2012), Neang *et al.* (2012), Neang & Hun (2013), Vassilieva *et al.* 2013.

Species description

Oligodon arenarius sp. nov.

Holotype. ZMMU R-14503 (field ID ZMMU ABV–00813), adult male from Binh Chau–Phuoc Buu Nature Reserve, Xuen Moc District, Ba Ria–Vung Tau Province, southern Vietnam (Fig. 1), coordinates 10°29'46"N, 107°27'54"E, elevation 5 m a.s.l., collected by Anna B. Vassilieva on 14 November 2014.

Paratypes. ZMMU R-14002 (field ID ZMMU NAP-03137), adult male from type locality: Binh Chau–Phuoc Buu Nature Reserve, Xuen Moc Disctrict, Ba Ria–Vung Tau Province, southern Vietnam (10°32'18"N, 107°28'37"E, 43 m a.s.l.), collected on 8 November 2010 by Anna B. Vassilieva; ZMMU R-14002 (field ID ZMMU NAP-03138), adult female from type locality (10°29'50"N, 107°27'58"E, 5 m a.s.l.) collected on 9 November 2010 by Anna B. Vassilieva; VNMN 04724 (field ID NAP-03884), adult female from type locality, environs of the resort Ho Coc (10°29'54"N, 107°28'08"E; 8 m a.s.l.), captured on 10 July 2012 by local people and collected by Anna B. Vassilieva and Nikolay Poyarkov; ZMMU R-14504, adult female from type locality (10°29'41"N, 107°27'46"E; 7 m a.s.l.), collected on 16 November 2014 by Anna B. Vassilieva.

Diagnosis. The species is allocated to the genus *Oligodon* based on the following characters considered to be diagnostic for the genus (Smith, 1943): posterior maxillary teeth strongly enlarged and compressed; palatine teeth well developed or vestigial; head short, not distinct from neck, usually displaying a specific coloration pattern; head scalation complete or reduced; eye moderate, with rounded pupil; rostral scale enlarged, extending on to the upper surface of the snout and partly separating the internasals; body cylindrical; scales smooth; ventrals rounded or obtusely keeled laterally; subcaudals paired.

The new species is distinguishable from other species of the genus by a combination of the following features: (1) medium size in adults (TL 336–389 mm); (2) 17(19)–17–15 dorsal scale rows; (3) 6–8 maxillary teeth, the

posterior three being enlarged; (4) head scalation lacking a loreal but including a presubocular (except one specimen), (5) nasal divided; (6) two postoculars; (7) 131–144 ventrals; (8) 36–60 subcaudals (36–40 in females, 58–60 in males); (9) anal plate entire; (10) tail quite long for the genus in males (TaL/TL = 0.26-0.28) and moderate in females (TaL/TL = 0.13-0.17); (11) unforked hemipenes without spines; (12) head coloration pattern including ocular band, temporal bands and chevron-shaped mark on nape; (13) dorsal coloration without specific pattern, uniform or with dark speckling; (14) ventrals pinkish in life, immaculate; (15) iris bicolored with silvery upper third and dark brown lower two thirds.



FIGURE 1. The type locality and known distribution of *Oligodon arenarius* **sp. nov.** (marked by red triangle) in Binh Chau–Phuoc Buu Nature Reserve, southern Vietnam.



FIGURE 2. Holotype *Oligodon arenarius* **sp. nov.** (ZMMU R-14503, field ID ABV-00813) in preservative; (A) dorsal view, (B) ventral view. Photos by V. Trounov.

Description of holotype. Main morphometric characters are given in Table 1.

Body (Fig. 2) cylindrical, rather robust, tail long for the genus (TaL/TL = 0.26), slender, with acuminated tip; shallow artificial groove caused by the temporary (removed) ligature is seen at the base of tail; head (Fig. 3) short (HL/SVL = 0.04), ovoid in dorsal view, somewhat triangular in profile view, faintly distinct from neck, somewhat depressed dorsoventrally; snout narrowed, triangle with blunt tip; snout tip strongly extending beyond the lower jaw; large oval nostril piercing the central part of nasal; eye rather small, approximately 0.17 times the head length; pupil rounded.

Dentition. Maxillary teeth: 8 functional teeth on the right and 7 on the left side, the posterior three teeth being strongly enlarged, slightly curved posteriorly, dagger-shaped; no distinct gap before the enlarged teeth. Palatine dentition well developed.

Body scalation. Dorsal scale rows 17-17-15, all smooth; outermost dorsal scale row slightly enlarged; 134 ventrals, obtusely keeled laterally; preventrals absent; anal plate entire; 58 subcaudals, all paired; terminal caudal scale forming an acuminated tail cap.

Head scalation. In lateral view (Fig. 3A), head scalation comprising a subrectangular nasal, pierced by large nostril and divided almost vertically by a prominent suture running through the posterior half of nostril; single rectangular preocular, slightly higher than wide, separated from nasal by the lateral part of the prefrontal; single small subrectangular presubocular; two small postoculars, almost equal in size; eight supralabials: dorsally, I in contact with nasal, II in contact with nasal and prefrontal, III in contact with prefrontal and presubocular, IV in contact with presubocular and eye, V in contact with eye, VI in contact with lower postocular and anterior temporal, the largest VII in contact with anterior temporal, VIII in contact with lower posterior temporal; 1+2 temporals, the anterior one subrectangular, elongated and narrow, the upper posterior smoothly pentagonal, approximately equal to the anterior one, elongated, the lower posterior the smallest, rhomboid. In dorsal view (Fig. 2B), head scalation comprising a rostral, two internasals, two prefrontals, two supraoculars, a frontal, and two parietals. Rostral large, wider than high, extending on to the dorsal surface of the snout and inserting deeply between internasals. Internasals wider than long, narrowing and slightly curving back towards the median suture. Prefrontals large, pentagonal, approximately 1.5 times wider than internasals, curving down laterally to the loreal area; lateral portions of prefrontals contacting posteriorly with the upper preocular and ventrally with the II-III supralabials. Supraoculars large, elongated, widening posteriorly, approximately half as wide as long. Frontal large, smoothly hexagonal, slightly longer than wide, posterior angle rather acute. Parietals irregularly pentagonal, slightly longer and wider than frontal, bordered laterally by the first and the upper second temporals and posteriorly by four small scales; no enlarged nuchal scales present. In ventral view (Fig. 2C), nine infralabials on the left and seven on the right side, III+IV and VII+VIII being fused on the right side; I medially in contact with each other and rostrally with mental, II-V in contact with two enlarged chin shields; mental small, triangular; two enlarged, elongated chin shields, the anterior pair being approximately twice longer than the posterior pair along the midline.



FIGURE 3. Holotype *Oligodon arenarius* **sp. nov.** head view (in preservative) and head scalation; (A) lateral view, (B) dorsal view, and (C) ventral view. Photos and drawings by V. Trounov.



FIGURE 4. Hemipenis of the holotype *Oligodon arenarius* **sp. nov.,** (A) everted, before preservation, (B) in preservative. Photos by A. Vassilieva.



FIGURE 5. Life coloration of the holotype *Oligodon arenarius* **sp. nov.**: (A) total view in situ, (B) portrait view, (C) dorsal coloration, (D) ventral coloration. Photos by V. Trounov.

Hemipenis (Fig. 4). Hemipenis rather short, the partly everted organ hardly reaching IV subcaudals; unforked, without spines or obvious papillae, proximal part with smooth surface, distal part with flat and smooth circular folds.

Coloration. In life (Fig. 5AC), dorsal coloration pale sandy-gray, with slightly more saturated yellowish tint on 4-5 upper dorsal and vertebral scale rows; all dorsal scales scattered with minute dark brown spots. Some dorsal scales (except of three lowerest rows on each side) edged by dark brown forming a diffuse speckled or dashed pattern on dorsum. On nape two pairs of irregular dark spots formed by brown-colored halves of 2-3 scales are most visible along the paravertebral zone. Dark speckling less conspicuous on the caudal part of dorsum. On tail, small brownish speckles fuse into two very faint diffuse lines along two adjacent vertebral scales rows edging a slightly paler vertebral line. Ventrals immaculate; gular and anterior ventral scales creamy-white, belly salmonpink with more intensive coloration caudally. Subcaudals salmon-pink in the anterior part of the tail, gradually whitening toward the tail tip. Head (Fig. 3AB, 5B) ground coloration sandy-gray with yellowish tint on snout; supralabials slightly paler. Darker head pattern include a faintly visible brown crescent-shaped interocular band partly covering the internasals, prefrontals, supraoculars and frontal scales; the anterior margin of the interocular bar diffuse, the posterior rather clear, edged with dark brown; two diffuse brown markings on the posterior part of each supraocular; short brown oblique subocular stripe extending from the lower margin of each orbit towards the mouth and covering parts of V and VI supralabials; brown oblique temporal bars with sharp, dark-edged anterior end and diffuse posterior one, starting close to the anterior margins of parietals and running down towards the neck just behind the jaw angle; large arrow-shaped chevron, brown with clear darker edges, extending from the center of frontal and medial part of parietals to the occiput and nape, reaching the second paraventral scale row on each side laterally. Iris bicolor, with silvery upper third and dark brown lower two thirds; tongue pinkish-red (Fig. 5B).

In preservative (Fig. 2AB, 3A–C), all brown and yellow tints fade and turn slightly to gray or cream. Ventral surface yellowish-cream, very faint small grayish spots are visible in the middle of the anterior subcaudals and along the lateral margins of the posterior ventrals.

Description and variation of the paratype series. The most important characters of the four other available specimens, all considered paratypes, are given in Table 1.

TABLE 1. Pholi	dosis (A)	and other	. morpho.	logical i	features ()	B) of the	type ser	ies of C	ligodon	arenarı	ius sp.	nov.				
А																
Specimen	ASR	MSR	PSR	SL	IL Te	eeth	Nasal	Anal	PreOc	PrSt	00c	PostOc	Ten	ıp VEN	SC	SL contacting eye
R-14002	17	17	15	7	6		D	ы						131	60	IV
R-14002	19	17	1 ک	×	/L 6	9	C	ŢŢ	1	1		2/1	1+2	142	40	IV_V
	2		2	þ	` 8/	9	1	1	1	-		2	1+2	1	2	-
VNMN 04724	17	17	15	8	6		D	Щ						143	36	IV-V
					/L	7			1	ou		2	1+2			
R-14503	17	17	15	×	8/9 ^^	r	D	ц	-	-		ç	-	134	58	IV-V
R-14504	19	17	15	8	ہ 9	_	D	Щ	-	-		4	7+1	144	37	IV-V
					/9	7			1	-		7	1+2			
В																
Specimen	Sex	TL	SVL	TaL	TaL/TI	MH	HL	HH	IO	ED	SnL	EN I	N Do	rsal coloration		
R-14002	male	355.0	257.0	98.0	0.28	8.6	10.6	6.9	4.7	1.8	4.5	2.1 2	.6 sar	ldy-orange with	out clear	speckling
R-14002	female	336.0	286.0	50.0	0.15	8.1	10.1	6.3	4.9	1.9	4.0	2.1 2	.9 sat spe	urated orange w sckling	ith evenl	y distributed black
VNMN 04724	female	372.0	318.0	54.0	0.17	10.1	11.3	7.9	5.6	1.7	4.9	2.4 3	.8 yel spe	lowish-gray wi ckling, short pa	th evenly travertebi	distributed black al streaks on neck
R-14503 holotype	male	351.0	260.0	91.0	0.26	8.9	10.3	6.7	4.8	1.8	4.1	1.9 3	.1 sar nec	ldy-gray with fa sk	uint dark s	speckling, clearer on
R-14504	female	389.0	340.0	49.0	0.13	10.7	11.2	6.8	5.1	1.9	4.6	2.3 3	.7 gra pai	y with yellowis avertebral rows	h vertebr of dark s	al line and discrete speckles

FIGURE 6. Variation in life coloration of *Oligodon arenarius* **sp. nov.**: (A) male paratype ZMMU R-14002, (B) female paratype ZMMU R-14002, (C) female paratype VNMN 04724, (D) female paratype ZMMU R-14504 in situ (while swallowing a frog). Photos by V. Trounov (A,B), N. Poyarkov (C) and A. Vassilieva (D).

Morphological characters mostly agree with those described for the holotype with few exceptions.

Body proportions. Relative tail length differs significantly in the male paratype (TaL/TL 0.28) and female paratypes (average TaL/TL 0.15, three specimens).

Dentition. 6–8 functional maxillary teeth in all specimens, the posterior three being strongly enlarged and dagger-shaped; palatine dentition well developed.

Body scalation. All scales are smooth, small, ovoid; first and second rows slightly enlarged, the vertebral row does not differ in size from other median dorsal rows; ASR varies 17/19, MSR and PSR are equal in all specimens, 17 and 15, respectively. Ventrals obtusely keeled laterally, 131 in one male (134 in the holotype), 142–144 in three females; anal plate entire, subcaudals paired, 60 in one male (58 in the holotype), 36–40 in females.

FIGURE 7. Natural habitats of *Oligodon arenarius* sp. nov.: (A) coastal dunes, (B) light dipterocarp forest. Photos by A. Vassilieva.

Head scalation. Generally as for holotype. In all specimens the nasal is divided through the nostril by a suture; loreal absent, preocular single, presubocular present in three specimens (and in the holotype) and absent on both sides in one specimen (VNMN 04724); two postoculars present with one exception (ZMMU R-14002 male), when the asymmetrical condition is observed (2/1). Eight supralabials (VI and V contacting eye) with one exception (ZMMU R-14002 male), when the IV supralabial (occupying the place of VI and V supralabials of other

specimens) is unusually large and the single to contact the eye. Nine infralabials in all paratypes. No variability observed in temporal scales.

Coloration in life. Dorsal background coloration varies from sandy-orange (ZMMU R-14002 male, Fig. 6A) to orange (ZMMU R-14002 female, Fig. 6B), yellowish-gray (VNMN 04724, Fig. 6C) or gray (ABV-00814, Fig. 6D); orange or yellow tint always being more saturated on the dorsum (sometimes forming a faint and diffuse vertebral line, as in female paratype ZMMU R-14504) and gradually turning paler to lower flanks. Blackish or dark brown speckles on dorsum are almost absent (ZMMU R-14002 male) or quite numerous and evident, evenly dispersed (VNMN 04724) or forming two more discrete paravertebral rows (ZMMU R-14504). On neck these dark speckles are always more discrete and may form two short paravertebral streaks (VNMN 04724), on tail they may fuse into faint paravertebral lines (ZMMU R-14504).

Head pattern similar in all specimens, including faintly visible intraocular band and more clear brown-colored temporal bars and chevron. Ventrals and subcaudals immaculate in all specimens, in paratype female ABV-00814 salmon-pink as in holotype; vital belly coloration for other paratypes was not documented.

In preservative, coloration fades slightly, especially the orange and yellow tints, which change to beige. Ventrals and subcaudals creamy-white or ivory.

Distribution. To date known only from the type locality (Binh Chau–Phuoc Buu Nature Reserve).

Habitat and natural history. Four specimens (ZMMU R-14002 female, VNMN 04724, ZMMU R-14503, ZMMU R-14504) were collected in the coastal area along the Loc An–Binh Chau secondary road. The landscape comprises gently sloping low sand dunes covered with more or less sparse trees or high bushes (Fig. 7A), including *Buchanania siamensis* (Anacardiaceae), *Casuarina equisetifolia* (Casuarinaceae), *Blachiaja trophifolia*, *Suregada multiflora* (Euphorbiaceae) and *Randia dasycarpa* (Rubiaceae), with the locally present herbs *Pandanus odoratissimus* (Pandanaceae), *Vitex rotundifolia* (Verbenaceae), *Spinifex littoreus* (Poaceae) and *Ipomoea pescaprae* (Convolvulaceae). The area's natural character has been severely degraded by human activities, and most of the coastal area is occupied by resorts or private homes.

One specimen (ZMMU R-14002 male) was collected approximately 4 km from the seacoast, on the edge of a lowland forest (Fig. 7B), where open sandy areas are present and the co-dominant species are *Dipterocarpus chartaceus*, *Shorea roxburghii*, *S. siamensis* (Dipterocarpaceae), *Melanorrhoea laccifera* (Anacardiaceae) and *Irvingia malayana* (Irvingiaceae), with *Melaleuca cajuputi* (Myrtaceae) dominating in seasonally wet areas. The natural character of the area has been profoundly altered by selective logging and cattle pasturing.

All specimens were collected on the ground. They were active during the day (one specimen) or after dark (20:00–22:00, three specimens). In attempts to avoid capture two of the specimens dived into the loose sand and moved swiftly under the sand layer, reappearing on the surface after 1.5–2 m. The specimen ZMMU R-14504 was found while in the process of swallowing an adult microhylid frog *Microhyla pulchra* (Hallowell). The digestive tract of other specimens contained some amounts of sand, implying that they foraged on the ground.

In the Binh Chau–Phuoc Buu Nature Reserve, *Oligodon arenarius* **sp. nov.** coexists with other *Oligodon* species: *O. deuvei* (data of A. Vassilieva and N. Poyarkov), as well as *O. fasciolatus* and one unidentified *Oligodon* sp. (Nguyen & Hoang 2013).

Etymology. The new species name is an adjective in the nominative case, masculine gender, derived from the Latin word "arena" meaning "sand", "sandy land". The name is intended to reflect the evident preference by the new species for sandy coastal habitats and the snake's remarkable ability to plunge into the sand and move under it.

Comparisons. Oligodon arenarius **sp. nov.** differs from all other species of the genus by the unique combination of the following characters: 17 DSR, the absence of a loreal scale, unforked hemipenis without spines or obvious papillae, the absence of a specific dorsal coloration pattern (blotches, crossbars or longitudinal lines) and the expressed sexual dimorphism in the relative tail length and number of subcaudals.

The absence of a loreal is a rather rare feature in kukri snakes. In particular, among the 22 *Oligodon* species known from Indochina, this element of head scalation is consistently absent in only three species: *O. annamensis* Leviton (Vietnam, Cambodia), *O. catenatus* (Blyth) (Vietnam, Thailand, Myanmar) and *O. lacroixi* Angel et Bourret (Vietnam, China); also, two Indochinese species occurring in Vietnam, *O. mouhoti* (Boulenger) and *O. macrurus* (Angel), lack the loreal scale facultatively. *Oligodon arenarius* **sp. nov.** differs from them by the following features: from *O. annamensis*, *O. catenatus* and *O. lacroixi*, by a greater DSR count (17 vs. 13, 13 and 15, respectively); usually present presubocular; 8(7) supralabials vs. 6(5), 6 and 5, respectively; 9(8) infralabials vs. 6, 7 and 6, respectively; a lesser number of ventrals (131–144 vs. 148–170, 179–212 and 162–178, respectively)

and a dorsal coloration pattern (uniform or with dark speckling vs. thin light crossbars in *O. annamensis*, chained vertebral line in *O. catenatus* and four indistinct longitudinal lines in *O. lacroixi*); additionally, *Oligodon arenarius* **sp. nov.** differs from *O. annamensis* and *O. lacroixi* by a greater number of subcaudals (58–60 vs. 44–46 in males, 36–40 vs. 30 in females of *O. annamensis*, 29–34 in *O. lacroixi*) and from *O. catenatus* and *O. lacroixi* by an entire anal plate instead of divided one; *Oligodon arenarius* **sp. nov.** differs from *O. mouhoti* by a longer tail in males (0.26–0.28 vs. 0.17–0.19) and a greater number of subcaudals in males (58–60 vs. 39–43), as well as by dorsal coloration features (vertebral stripe and two large dark blotches on tail in *O. mouhoti*) and the hemipenial morphology (see below); from *O. macrurus*, by a relatively shorter tail in males (TaL/TL 0.26–0.28 vs. 0.34–0.37, calculated after the data of Geissler *et al.* 2011, or 0.31 in one specimen, P. David, pers. comm.), a markedly lesser number of subcaudals in males (58–60 vs. 139–145) and the hemipenial morphology (see below).

Oligodon arenarius **sp. nov.** also differs from many congeners by its hemipenial morphology (unforked hemipenis devoid of spines and papillae). In particular, it differs from all the members of the informal *O. taeniatus* group (sensu Smith 1943, David *et al.* 2008b) with Indochinese distribution, namely *O. taeniatus* (Günther), *O. pseudotaeniatus* David, Vogel & Van Rooijen, *O. deuvei* David, Vogel & Van Rooijen, *O. barroni* (Smith), *O. moricei* David, Vogel & Van Rooijen and *O. mouhoti* discussed above, which possess deeply forked hemipenes. Additionally, *Oligodon arenarius* **sp. nov.** differs from them externally by the dorsal coloration (all members of the *O. taeniatus* group possessing vertebral stripes or blotches) and by the following characters: from *O. taeniatus*, by 17 vs. 19 DSR and a greater subcaudals count in males (58–60 vs. 38–48); from *O. deuvei*, by a slightly lesser ventrals count (131–134 vs. 140–147 in males, 142–144 vs. 147–155 in females) and a greater subcaudals count in males (58–60 vs. 36–47); from *O. barroni*, by a relatively longer tail in males (0.26–0.28 vs. 0.17–0.19), a greater subcaudals count in males (58–60 vs. 28–35) and the immaculate belly coloration; from *O. moricei*, by a lesser ventrals count (131–144 vs. 175), 6–8 maxillary teeth vs. 12 and a usually present presubocular.

Oligodon arenarius sp. nov. also differs by its hemipenial morphology from all the members of the informal Oligodon cyclurus group (sensu Smith 1943, David et al. 2008a, Green et al. 2010). The species of Oligodon cyclurus group are distributed in Indochina, China and India, and possess deeply forked hemipenes without spines but sometimes with papillae; these features were documented for O. cattienensis Vassilieva, Geissler, Galoyan, Poyarkov, Van Devender & Böhme, O. chinensis (Günther), O. cyclurus (Cantor), O. fasciolatus (Günther), O. formosanus (Günther), O. juglandifer (Wall), O. kampucheaensis Neang, Grismer & Daltry, O. ocellatus (Morice), O. saintgironsi David, Vogel & Pauwels, and O. macrurus (discussed above). Additionally, from the species of the Oligodon cyclurus group occurring in Indochina, Oligodon arenarius sp. nov. differs externally by the dorsal coloration features (all members of the Oligodon cyclurus group except O. macrurus possess blotches, reticulation or crossbars) and by the following characters: from O. cattienensis, by the immaculate belly and a lesser ventrals count (131–144 vs. 167–178); from O. chinensis, by a much lesser ventrals count (131–144 vs. 170–206); from O. fasciolatus, by DSR 17 vs. 21–23 and by a lesser ventrals count (131–144 vs. 147–210); from O. formosanus, by DSR 17 vs. 19 and a lesser ventrals count (131–144 vs. 154–189); from O. kampucheaensis, by DSR 17 vs. 15 and a lesser ventrals count (131-144 vs. 165); from O. ocellatus, by DSR 17 vs. 19, a relatively longer tail in males (TaL/TL 0.26–0.28 vs. 0.11–0.14) and a greater subcaudals count (58–60 vs. 32–44 in males, 36–40 vs. 26–33 in females); from O. saintgironsi, by a lesser ventrals count (131-144 vs. 166-184), a lesser subcaudals count in females (36–40 vs. 53) and a relatively longer tail in males (TaL/TL 0.26–0.28 vs. 0.19–0.20).

From the members of the informal *Oligodon cinereus* group (sensu Smith 1943, Green *et al.* 2010, David *et al.* 2011, 2012, Neang *et al.* 2012), which are distributed in Indochina, China, India, Andaman and Nicobar islands, and are characterized by the unforked hemipenes, not spinose but with papillae, *Oligodon arenarius* **sp. nov.** differs by the absence of a loreal (present in all group members except *O. melanozonatus* Wall from India) and by the following features: from *O. cinereus* (Günther), by a lesser ventrals count (131–144 vs. 155–186) and by the dorsal coloration pattern (from all subspecies having blotches, reticulations or crossbars except the uniformly colored *O. c. cinereus*); from *O. albocinctus* (Cantor), by a lesser ventrals count (131–144 vs. 177–207) and by the dorsal coloration pattern (light crossbars in *O. albocinctus*); from *O. inornatus* (Boulenger), by DSR 17 vs. 15 and a lesser ventrals count (131–144 vs. 171–174); from *O. joynsoni* (Smith), by a lesser ventrals count (131–144 vs. 186–195) and the dorsal coloration pattern (blotches and reticulated crossbars in *O. joynsoni*); from *O. maculatus* (Taylor), by

a lesser ventrals count (131–144 vs. 156–164) and the dorsal coloration pattern (dark blotches in *O. maculatus*); from *O. melanozonatus*, by a lesser ventrals count (131–144 vs. 171–173) and the dorsal coloration pattern (black-edged or black crossbars in *O. melanozonatus*); from *O. nagao* David, Nguyen, Nguyen, Jiang, Chen, Teynié & Ziegler, by a lesser ventrals count (131–144 vs. 184–193), a relatively longer tail in males (TaL/TL 0.26–0.28 vs. 0.14–0.15) and the dorsal coloration (butterfly-shaped blotches in *O. nagao*); from *O. splendidus* (Günther), by DSR 17 vs. 21, a single pair of both prefrontals and internasals (up to four pairs of each in *O. splendidus*), a lesser ventrals count (131–144 vs. 169–193) and the dorsal coloration (large spots on dorsum in *O. splendidus*); from *O. woodmansoni* (Sclater), by 8(7) supralabials vs. 6, a lesser ventrals count (131–144 vs. 180–190) and pale belly coloration (dark brown with white edges in *O. woodmansoni*).

The members of the informal *O. dorsalis* group (sensu Smith 1943) are distributed in Indochina, India, Nepal and Myanmar; the species with documented hemipenial morphology are characterized by unforked and usually spinose hemipenes. From all congeners belonging to this group, except *O. lacroixi* and *O. catenatus* discussed above, *Oligodon arenarius* **sp. nov.** differs by the dorsal coloration (longitudinal stripes or crossbars in all members of the *O. dorsalis* group) and an entire anal plate vs. divided, as well as by the following features of the pholidosis: from *O. dorsalis* (Gray & Hardwicke), by DSR 17 vs. 15, the absence of a loreal and a lesser ventrals count (131–144 vs. 162–188); from *O. eberhardti* Pellegrin, by DSR 17 vs. 13, 8(7) supralabials vs. 6 and a lesser ventrals count (131–144 vs. 165–191); from *O. erythrogaster* Boulenger, by a lesser ventrals count (131–144 vs. 163–186); from *O. hamptoni* Boulenger, by DSR 17 vs. 15, 8(7) supralabials vs. 5 and a lesser ventrals count (131–144 vs. 160–175); from *O. mcdougalli* Wall, by DSR 17 vs. 13 and a lesser ventrals count (131–144 vs. 199).

In the species of the informal *O. torquatus* group (sensu Smith 1943, Green *et al.* 2010) with the distribution in India, Myanmar and Thailand, hemipenes are unforked with apical papillae. *Oligodon arenarius* **sp. nov.** differs from the species of this group by the dorsal coloration features (longitudinal stripes in the *O. torquatus* group except *O. planiceps*), an entire anal plate vs. divided and additionally by the following external features: from *O. cruentatus* (Günther), by a lesser ventrals count (131–144 vs. 148–173); from *O. planiceps* Boulenger, by DSR 17 vs. 13, 8(7) supralabials vs. 5(4), a greater subcaudals count (36–60 vs. 22–27) and the immaculate ventrals (ventrals with paired dark blotches in *O. planiceps*); from *O. theobaldi* (Günther), by the absence of a loreal and a lesser ventrals count (131–144 vs. 164–180); from *O. torquatus* (Boulenger), by DSR 17 vs. 15 and the absence of a loreal.

In the species of the informal *O. venustus–O. taeniolatus* group (sensu Smith 1943, Green *et al.* 2010) with distribution in India, Sri Lanka, Afghanistan, Pakistan, Nepal and Bangladesh, hemipenes are unforked and spinose. *Oligodon arenarius* **sp. nov.** differs from the species of this group by the absence of spines on the hemipenis, the dorsal coloration pattern (crossbars or longitudinal stripes or blotches in all species of the *O. venustus–O. taeniolatus* group), an entire anal plate vs. divided, and the following external characters: from *O. affinis* Günther, by the immaculate belly (with black subrectangular spots in *O. affinis*); from *O. arnensis* (Shaw), by a lesser ventrals count (131–144 vs. 164–202); from *O. brevicauda* Günther, by the presence of internasals, DSR 17 vs. 15, a lesser ventrals count (131–144 vs. 158–173) and a greater subcaudals count (36–60 vs. 25–29); from *O. calamarius* (Linnaeus), by the absence of a loreal and a greater subcaudals count (31–144 vs. 154); from *O. melaneus* Wall, by DSR 17 vs. 15, 9(8) infralabials vs. 4 and a lesser ventrals count (131–144 vs. 152–160); from *O. sublineatus* Duméril, Bibron & Duméril, by DSR 17 vs. 15 and the absence of a loreal; from *O. taeniolatus* (Jerdon), by DSR 17 vs. 15, the absence of a loreal and a lesser ventrals count (131–144 vs. 158–218); from *O. travancoricus* Beddome, by a lesser ventrals count (131–144 vs. 154–155); from *O. venustus* (Jerdon), by the immaculate belly (with large black spots in *O. venustus*).

From other species of the genus, which are not clearly assigned to any specific groups of species, *Oligodon arenarius* **sp. nov.** differs by the following characters: from *O. ancorus* (Girard) (the Philippines), by the dorsal coloration (large dorsal spots in *O. ancorus*), the absence of a loreal and a lesser ventrals count (131–144 vs. 147–173); from *O. annulifer* (Boulenger) (Malaysia: Borneo), by the dorsal coloration (crossbands in *O. annulifer*), DSR 17 vs. 15 and the absence of a loreal; from *O. bitorquatus* Boie (Indonesia), by the dorsal coloration (red and yellow dots in *O. bitorquatus*) and the immaculate belly (with black spots in *O. bitorquatus*); from *O. booliati* Leong & Grismer (Peninsular Malaysia), by the dorsal coloration (crossbands in *O. booliati*) and 9(8) infralabials vs. 7; from *O. everetti* Boulenger (Malaysia and Indonesia), by DSR 17 vs. 15 and the absence of a loreal; from *O. forbesi* (Boulenger) (Indonesia), by the absence of a loreal, a lesser ventrals count (131–144 vs. 150–170) and the

immaculate belly (ventrals with brown spots in O. forbesi); from O. jintakunei Pauwels, Wallach, David & Chanhome (Thailand), by the dorsal coloration (crossbars in O. jintakunei), DSR 17 vs. 15, an entire anal plate and a lesser ventrals count (131-144 vs. 189); from O. kheriensis Achardji & Ray (Nepal and India), by the absence of a loreal and a lesser ventrals count (131–144 vs. 196); from O. lungshenensis Zheng & Huang (China), by DSR 17 vs. 15, 8(7) supralabials vs. 6, 9(8) infralabials vs. 6 and a lesser ventrals count (131–144 vs. 163–179); from O. meverinkii (Steindachner) (the Philippines and Malaysia), by the absence of a loreal and a lesser ventrals count (131-144 vs. 154-169); from O. modestus Günther (the Philippines), by DSR 17 vs. 15, 8(7) supralabials vs. 6 and a lesser ventrals count (131-144 vs. 158-176); from O. nikhili Whitaker & Dattatri (India), by DSR 17 vs. 15, the dorsal coloration (longitudinal stripes in O. nikhili) and the immaculate belly (ventrals with black spots in O. nikhili); from O. notospilus Günther (the Philippines), by the absence of a loreal and the dorsal coloration (large rhombic yellow spots in O. notospilus); from O. octolineatus (Schneider) (Malaysia and Indonesia), by the dorsal coloration (longitudinal stripes in O. octolineatus), the absence of a loreal and a lesser number of ventrals (131-144 vs. 155–197); from O. ornatus Van Denburgh (China and Taiwan), by the dorsal coloration (crossbars in O. ornatus), DSR 17 vs. 15 and a lesser number of ventrals (131-144 vs. 156-182); from O. perkinsi (Taylor) (the Philippines), by the absence of a loreal and a lesser number of ventrals (131–144 vs. 183–188); from O. petronellae Roux (Indonesia), by the dorsal coloration (dark spots in O. petronellae), DSR 17 vs. 15 and the absence of a loreal; from O. praefrontalis Werner (Indonesia), by the presence of internasals, an entire anal plate vs. divided and a lesser number of ventrals (131–144 vs. 183–193); from O. propinguus Jan (Indonesia), by the absence of a loreal and DSR 17 vs. 15; from O. pulcherrimus Werner (Indonesia), by the dorsal coloration (elongate spots on dorsum in O. pulcherrimus), the absence of a loreal and a lesser number of ventrals (131–144 vs. 152–176); from O. purpurascens (Schlegel) (Thailand, Malaysia and Indonesia), by the absence of a loreal, DSR 17 vs. 19-21 and a lesser number of ventrals (131-144 vs. 150-210); from O. signatus (Günther) (Indonesia and Malaysia), by the dorsal coloration (yellow spots on dorsum in O. signatus) and the absence of a loreal; from O. trilineatus (Duméril, Bibron & Duméril) (Indonesia), by the dorsal coloration (longitudinal stripes in O. trilineatus) and the absence of a loreal; from O. unicolor (Kopstein) (Indonesia), by the absence of a loreal and a lesser number of ventrals (131– 144 vs. 162); from O. vertebralis Günther (Indonesia and Malaysia), by the dorsal coloration (white or yellow dorsal spots in O. vertebralis), DSR 17 vs. 15 and the absence of a loreal; from O. waandersi (Bleeker) (Indonesia), by DSR 17 vs. 15 and a greater number of subcaudals (36-60 vs. 18-29); from O. wagneri David & Vogel (Indonesia), by DSR 17 vs. 15 and the dorsal coloration (white crossbars in O. wagneri).

Discussion

Among the 19 species of kukri snakes currently known from Vietnam, there are members of four informal species groups, mostly determined after the features of their hemipenial morphology (Smith 1943, David et al. 2008ab, Green et al. 2010, David et al. 2012): O. cyclurus group, O. taeniatus group, O. dorsalis group and O. cinereus group. The first and the second groups possess deeply forked hemipenes, sometimes with papillae but always devoid of spines. In contrast, in the members of the O. dorsalis group and the O. cinereus group with known hemipenial morphology, the hemipenes are unforked (except in O. dorsalis: 1/3 forked - Smith 1943); the copulative organs are spinose or/and flounced in the O. dorsalis group and always devoid of spines but having large papillae in the O. cinereus group. Thus, based on the morphology of the hemipenis in Oligodon arenarius sp. **nov.**, which is unforked but lacks both spines and obvious papillae, the attribution of the new species to any of these groups is unclear. Presumably, Oligodon arenarius sp. nov. is not a likely candidate for the O. dorsalis group, because all members of this group display some characters that are absent in the new species, such as a distinct dorsal pattern (longitudinal stripes or crossbars) or a divided anal plate; also, the members of the O. dorsalis group tend to have a rather thin body and a very low dorsal scale row count for the genus (mostly 13–15 DSR, except for 17 DSR in O. erythrogaster from Nepal and Sikkim, India). At the same time, the external characters of Oligodon arenarius sp. nov. show a rather good fit to the features of the species of the O. cinereus group (sensu Smith 1943; Green et al. 2010, David et al. 2011, 2012), which are characterized by a rather robust body, 17–21 dorsal scale rows, an entire anal plate, and no more than 12 maxillary teeth (8-12), and which sometimes display an incomplete head scalation lacking the loreal. The distribution of this group is rather wide and embraces Indochina, China, Myanmar and India. Three species of this group occur in Vietnam: O. nagao, recently described from the Lang Son

Province in the northern part of the country (David *et al.* 2012); *O. albocinctus*, reported once from the Tam Dao Mountains in the north (Orlov *et al.* 2010); and *O. cinereus*. The last species has an extremely extended distribution from India and Bangladesh through Indochina to Thailand and China and includes several subspecies, based on the variety of the dorsal patterns and some differences in the scalation; three subspecies occur in Vietnam, namely, *O. c. tamdaoensis* in the north, *O. c. cinereus* in the north and center, and *O. c. pallidocinctus* in the south of the country. Some authors do not accept the subspecies and consider the presently constituted *O. cinereus* to be a group of several species (Wagner 1975, David *et al.* 2011).

However, the absence of obvious papilla on the hemipenes of *Oligodon arenarius* **sp. nov.** does not allow this species to be definitively assigned to the *O. cinereus* group. Thus, to date, the new species cannot be unambiguously attributed to any of the informal *Oligodon* species groups distributed in Vietnam.

The remarkable sexual dimorphism in the relative tail length and the number of subcaudal scales, which was observed in *Oligodon arenarius* **sp. nov.**, was not previously recorded in the species of the *O. dorsalis* or *O. cinereus* group. However, a certain dimorphism in body proportions is characteristic of some *Oligodon* species, e.g., for example for those belonging to the *O. cyclurus* or *O. taeniatus* groups: males usually possess relatively longer tails, a greater number of subcaudals and a lesser number of ventrals in comparison with conspecific females (David *et al.* 2008ab). For example, in the rather long-tailed species *O. saintgironsi* the relative tail length in males (TaL/TL= 0.19–0.20) is approximately 22% greater than in female (TaL/TL= 0.16) (calculated from the data of David *et al.* 2008a). However, in *Oligodon arenarius* **sp. nov.**, variability between sexes is much more evident: in males, the average relative tail length is almost twice (1.8) as long as that of females.

Most species of the genus *Oligodon*, including the members of the informal *O. cinereus* group, display a specific dorsal coloration that includes well defined crossbars, vertebral spots or transverse reticulations. However, the uniform coloration (or with indistinct dark crossbars or reticulations) of the dorsum in *O. c. cinereus* and *O. inornatus* is more similar to the dorsal coloration in *Oligodon arenarius* **sp. nov.**, which is uniform or with more or less pronounced dark speckling. Presumably, the absence of any bright pattern and the orange, yellowish or grayish coloration of *Oligodon arenarius* **sp. nov.** may be considered to function as camouflage in its coastal sandy habitats. Interestingly, *O. macrurus*, which inhabits the coastal dune areas of Vietnam to the north of the area of distribution of *Oligodon arenarius* **sp. nov.**, namely, in Binh Thuan, Ninh Thuan and Khanh Hoa provinces (Campden-Main 1970, Nguyen *et al.* 2009, Geissler *et al.* 2011), also has an uniform brownish-gray, grayishbrown or tan coloration with indistinct reticulations or dark spots (Smith 1943, Geissler *et al.* 2011, own observations). Additionally, a short head and narrowed snout with a protruding rostral scale in *Oligodon arenarius* **sp. nov.** may be advantageous for locomotion beneath the sand.

Oligodon arenarius **sp. nov.** is the second endemic reptile discovered in the Binh Chau–Phuoc Buu Nature Reserve, along with the legless blind lizard *Dibamus deharvengi* Ineich, 1999 (Dibamidae). Another species recently described from the area, the butterfly lizard *Leiolepis ngovantrii* Grismer & Grismer, 2010 (Agamidae, Leiolepidinae), was also recorded near Can Gio, Ho Chi Minh City (author's unpublished data).

Currently, *Oligodon arenarius* **sp. nov.** is the fourth *Oligodon* species endemic to Vietnam, along with *O. cattienensis*, *O. macrurus* and *O. moricei*. The species *O. annamensis* was recently withdrawn from the list of endemics because it was also found in Cambodia (Neang & Hun 2013).

The actual distribution area of the new species is unknown but appear to be narrowly restricted. This fact is rather alarming because of the highly disturbed state of the natural coastal habitats in Binh Chau–Phuoc Buu Nature Reserve and their continuing disappearance due to the construction of resorts and hotels. Although *Oligodon arenarius* **sp. nov.** appear to be well adapted to living in the vicinity of roads and human dwellings, the well-being of this snake may be soon threatened by the accelerating destruction of natural habitats in the region.

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APPENDIX. Material examined.

- *Oligodon arenarius* **sp. nov.**: 5 specimens, ZMMU R-14002, R-14503, R-14504, VNMN 04724 (southern Vietnam, Ba Ria– Vung Tau Province, Binh Chau–Phuoc Buu Nature Reserve).
- *Oligodon cattienensis*: 5 specimens, ZMMU R-11473, R-13815, R-13865, R-13866 (southern Vietnam, Dong Nai Province, Cat Tien National Park).
- Oligodon cinereus pallidocinctus: 1 specimen, ZMMU R-13574 (southern Vietnam, Dong Nai Province, Cat Tien National Park).
- *Oligodon deuvei*: 5 specimens, ZMMU R-03271, R-03283, R-13574, R-13867 (southern Vietnam, Dong Nai Province, Cat Tien National Park), R-14106 (southern Vietnam, Ba Ria–Vung Tau Province, Binh Chau–Phuoc Buu Nature Reserve).

Oligodon chinensis: 3 specimens, ZMMU R-14284 (northern Vietnam, Phu Tho Province, Xuan Son National Park).

- *Oligodon fasciolatus*: 3 specimens, ZMMU R-13421, R-14306 (southern Vietnam, Ba Ria–Vung Tau Province, Con Dao Islands, Con Son).
- Oligodon lacroixi: 1 specimen, ZMMU R-13364 (northern Vietnam, Phu Tho Province, Xuan Son National Park).

Oligodon macrurus: ZMMU R-13857 (southern Vietnam, Khanh Hoa Province, Hon Tre Island).

- *Oligodon ocellatus*: 3 specimens, ZMMU R-14000, R-14001, R-14059 (southern Vietnam, Dong Nai Province, Cat Tien National Park).
- Oligodon saintgironsi: 2 specimens, ZMMU R-13580, R-13594 (southern Vietnam, Dong Nai Province, Cat Tien National Park).