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http://dx.doi.org/10.11646/zootaxa.3926.4.4

http://zoobank.org/urn:lsid:zoobank.org:pub:6CCC3C5B-0DF1-4677-B9E9-BD49941921D4

A new genus and species of xenodermatid snake (Squamata: Caenophidia: Xenodermatidae) from northern Lao People's Democratic Republic

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Abstract

A male snake collected in Louangphabang Province and a second specimen observed in Houaphan Province, North Laos, share morphological characters with the Asian genus Fimbrios Smith, 1921, including erected edges on the first supraand infralabial scales, but differ in the following morphological characters: fewer dorsal scale rows (25-27 vs. 30-33), fewer maxillary teeth (27 vs. 30-35), posterior teeth progressively slightly enlarged, and especially the correspondence of two dorsal scale rows per ventral plate throughout the body (i.e. the first dorsal scale row made of a small scale above the fore part of a ventral, followed by a much larger scale above its hind part), a condition known only in Xenodermus Reinhardt, 1836. As the Laotian specimens differ in morphological characters from other genera and species in the family Xenodermatidae, and on the basis of molecular analyses showing a large genetic divergence from the genus Fimbrios (pdistance ≥ 14.7 %, mitochondrial COI gene), we place these specimens in a new genus, *Parafimbrios* gen. nov., and describe them as a new species, Parafimbrios lao sp. nov. Besides the characters mentioned above, the new species is diagnosed by a combination of the following ones: small, strongly keeled dorsal scales; rostral and first four supra- and infralabials with raised, erected edges; horizontal tissue ridges above the rostral; loreal single, large, elongate; ventral scales 177–189; subcaudals 55–56, undivided; dorsal colour purplish-grey, neck with a broad, very pale grey collar reaching downwards the pale grey colour of the venter. The morphological characters of the new genus are compared with those of the genera Fimbrios Smith, 1921, Xenodermus Reinhardt, 1836, Stoliczkaia Jerdon, 1870, Achalinus Peters, 1869, and Xylophis Beddome, 1878. A key to the genera Achalinus, Fimbrios and Parafimbrios gen. nov. is provided. Parafimbrios *laos* spec. nov. is the 111th snake species currently recorded from Laos.

Key words: Fimbrios, Parafimbrios gen. nov., Parafimbrios lao spec. nov., morphology, phylogeny, Laos

Introduction

According to Vidal (2002) and the Reptile Database (Uetz & Hošek 2014), the Asian family Xenodermatidae currently includes five genera: *Xenodermus* Reinhardt, 1836 (1 species), *Achalinus* Peters, 1869 (9 species), *Fimbrios* Smith, 1921 (2 species), *Stoliczkaia* Jerdon, 1870 (2 species), and *Xylophis* Beddome, 1878 (3 species), for a total of 17 species. The Philippine genus *Oxyrhabdium* Boulenger, 1893 (2 species) has been removed from the family based on molecular data, nevertheless, its phylogenetic position should be further investigated as it is now classified as Elapoidea *incertae sedis* (Vidal *et al.* 2008).This family has long been considered to be a

subfamily of the Colubridae (see Dowling 1988; Dowling and Pinou 2003). Recent phylogenetic studies have shown that this well-defined assemblage deserved a distinct familial status (Vidal *et al.* 2007; Zaher *et al.* 2009). These genera include species with more or less highly modified cephalic (labials with raised and everted edges, presence of ridges of skin between rostral and internasals, and a large loreal) and dorsal scalation (usually small scales, subequal or intermixed with large scales). The Neotropical genus *Nothopsis* Cope, 1871, previously also referred to the family Xenodermatidae, was transferred to the family Dipsadidae (Vidal *et al.* 2010) and the members of Xenodermatidae are currently recorded only from Asia, ranging from India eastwards to Japan and Taiwan, and southwards to Borneo and Java, possibly also the Philippines, with a disjunct distribution (Uetz & Hosek 2014).

Smith (1921) erected the monotypic snake genus *Fimbrios* for a new species, *Fimbrios klossi* Smith,1921, described from Da Lat, Langbian Plateau in southern Vietnam. This species was subsequently recorded from Elephant Mountains, in southwestern Cambodia, and from various provinces of central and southern Vietnam (Orlov *et al.* 2003; Orlov 2005; Ziegler *et al.* 2008; Nguyen *et al.* 2009). Although this species had been recorded close to the Laotian border, it had not been recorded from the Lao People's Democratic Republic (hereafter cited as Laos) until Stuart & Heatwole (2008) collected a specimen in Paksong District, Champasak Province, in Boloven Highlands. Teynié & David (2010) cited two additional specimens, found in 2007 and 2008 in the same locality of the Boloven Highlands between 1,320 and 1,340 m a.s.l., respectively. Lastly, Ziegler *et al.* (2008) described *Fimbrios smithi* Ziegler, David, Mirallès, Doan & Nguyen, 2008, the second known species of the genus, on the basis of a specimen obtained in the karst forest of Phong Nha—Ke Bang National Park, Quang Binh Province, in central Vietnam.

During a trip in the northern part of Louangphabang Province, we collected a small snake specimen presenting several diagnostic characters of the genus *Fimbrios* as defined by Smith (1943) (see below). A second specimen, obviously of the same species, was subsequently found in Houaphan Province. Up to now, no member of the family Xenodermatidae has ever been recorded from this part of Laos. However, a detailed comparison of the specimens from Louangphabang and Houaphan provinces with members of the genus *Fimbrios* revealed that some characters were definitely distinct from those recorded in the genus *Fimbrios*, especially in maxillary teeth and in the dorsal scalation. They also showed other noteworthy differences in measurements, scalation and color pattern from the two known species of the genus. On the basis of the morphological characters and molecular analyses, we here address the taxonomic status of these specimens. Their morphological characters are compared with those of species of all other genera of Xenodermatidae. An updated key to Xenodermatidae is provided.

Materials and methods

Molecular data and phylogenetic analyses. We used Le et al.'s (2006) protocols for DNA extraction, amplification, and sequencing. A fragment of a mitochondrial gene, the cytochrome c oxidase subunit 1 (COI), was amplified using the primer pair RepCOI-F and RepCOI-R (Nagy et al. 2012). Sequences were aligned with Clustal X v2 (Thompson et al. 1997), and phylogenetic analyses were performed using maximum parsimony (MP) and maximum likelihood (ML) as implemented in PAUP*4.0b10 (Swofford 2001), and Bayesian analysis (BA), as implemented in MrBayes v3.2 (Ronquist et al. 2012). Settings for these analyses followed Le et al. (2006), except that the number of generations in the Bayesian analysis was increased to 1×10^7 . The optimal model for nucleotide evolution was set to GTR+G+I for ML and BA as selected by Modeltest v3.7 (Posada & Crandall 1998). Nodal support was evaluated using Bootstrap replication (BP) as calculated in PAUP*4.0b10 (1000 replicates with 100 taxon addition in MP and 1000 replicates with simple taxon addition in ML) and posterior probability (PP) in MrBayes v3.2. In the Bayesian analysis, -lnL scores reached stationarity after 7,000 generations in both runs. Based on the Alethinophidia's phylogenetic relationships supported by recent studies (e.g., Vidal et al., 2009), we selected two outgroups, Xenopeltis unicolor and Acrochordus granulatus, for our analyses. We also included three species, Achalinus meiguensis, Fimbrios klossi, and Xenodermus javanicus, of the family Xenodermatidae, in addition to the newly collected species in the ingroup (Fig.1, Tables 1, 2). Uncorrected pairwise divergences were calculated using PAUP*4.0b10.

Morphology. We retained only external characters and the dentition. These characters were compared from those obtained from voucher specimens and data available from the literature (Smith 1921, 1943; Orlov *et al.* 2003; Ziegler *et al.* 2008). The list of examined voucher specimens is given in the Appendix.

TABLE 1 Samples used in molecular analyses.

Species	Genbank No.	Locality	Voucher information
Acrochordus granulatus	AB177879	-	-
Xenopeltis unicolor	AB179620	_	_
Fimbrios klossi	KP410744 KP410745	Vietnam, Quang Ngai Province Vietnam, Gia Lai Province	IEBR 3275 IEBR A.2013.56
Parafimbrios lao gen. nov., spec. nov.	KP410746	Laos,Louangphabang Province	MNHN 2013.1002
Achalinus meiguensis	FJ424614	China, Sichuan Province	-
Xenodermus javanicus	KP410747	Maninjau Lake, Sumatera Barat Province, Sumatra	_

Measurements, except body and tail lengths, were taken with a slide-calliper. The number of ventral scales was counted according to Dowling (1951). The numbers of dorsal scale rows are given at one head length behind head, at midbody, and at one head length before vent respectively. The terminal scute is not included in the number of subcaudals. Because the right head side was partly destroyed (including the rostral), infralabials and supralabials were only counted at the left head side. Maxillary teeth were counted by dissecting out the right maxilla of the holotype.

Abbreviations of measures and other characters used in the text. Measurements and ratios: HL: head length (from tip of snout to posterior edge of parietals), SnL: snout length (from tip of snout to anterior margin of eye), SVL: snout-vent length (from tip of snout to anterior margin of cloaca), TaL: tail length (from posterior margin of cloaca to tip of the tail), TL: total length, TaL/TL: ratio of tail length to total length. Meristic and other characters: DSR: dorsal scale rows, IL: infralabial scales, InN: internasal scale, Lor: loreal scale, SC: subcaudal scales (excluding the last one), SL: supralabial scales, VEN: ventral scales.

Museum abbreviations. BMNH: The Natural History Museum, London, UK; IEBR: Institute of Ecology and Biological Resources, Vietnamese Academy of Science and Technology, Hanoi, Vietnam; MNHN: Muséum National d'Histoire Naturelle, Paris, France.

The spelling of Laotian provincial names follows McCoy (2003) and The World Factbook (Anonymous 2012).

Results

Phylogenetic analyses

The alignment was straightforward, and the final matrix contains 685 aligned characters. All nodes received strong support (Bootstrap value \geq 70%, Hillis and Bull 1993, and PP \geq 0.95) from at least two analyses (Fig. 1). The new species is significantly divergent from other taxa within the family, including the sister genus *Fimbrios*, with the minimum pairwise divergence (p-distance) of 14.7% from *F. klossi* (Table 2). Furthermore, it is more distantly related to *Xenodermus* (p-distance: 19.4%), even though they share some morphological similarities.

Species name	1	2	3	4	5	6	7
1. Acrochordus granulatus	-						
2. Xenopeltis unicolor	21.2	-					
3. Fimbrios klossi (IEBR 3275)	21.0	19.4	-				
4. Fimbrios klossi (IEBR A.2013.56)	21.0	19.1	1.9	-			
5. Parafimbrios lao gen. nov., spec. nov.							
(MNHN 2013.1002)	24.2	20.7	14.7	14.9	-		
6. Achalinus meiguensis	24.5	18.8	19.6	18.7	20.7	-	
7. Xenodermus jāvanicus	23.1	18.7	16.4	16.5	19.4	18.7	-

TABLE 2. Uncorrected ("p") distance matrix showing percentage pairwise genetic divergence (COI) between species used in the analysis.



FIGURE 1. Phylogenetic hypothesis based on the maximum likelihood. Numbers above and under branches are MP / ML bootstrap values and Bayesian posterior probabilities, respectively. Asterisk represents 100% BP value or 1 PP value.

Morphological characters

Both specimens from Laos share the following characters considered to be diagnostic of the genus *Fimbrios*, as defined by Smith (1921) and modified by Smith (1943), Campden-Main (1970), and Ziegler *et al.* (2008): (1) rostral separated from the internasals by a horizontal ridge of tissue; (2) rostral, mental, and both supralabials and infralabials with raised and everted edges; (3) head not distinct from neck, covered by large shields; (4) eye with vertically elliptic pupil; (5) loreal very large, extending from nasal to eye; (6) chin shields in a single pair, enlarged; (8) scales of the first dorsal scale row enlarged, (9) ventrals large and rounded; and (10) subcaudals undivided. However, the Laotian specimens differ from the genus *Fimbrios* by a series of diagnostic characters: (1) a lower number of dorsal scale rows (25–27 vs. 30–33); (2) a lower number of maxillary teeth (27 vs. 30–35); (3) maxillary teeth slightly but progressively enlarged posteriorly (vs. equal); (4) dorsal scales small, cycloid or subrectangular (vs. elliptic), as typical of Caenophidia; and, especially (5) the correspondence of two dorsal scale rows per ventral plate throughout the body (vs. a single scale row).

On the basis of their morphological characters, these specimens cannot be referred to any recognized genus of Xenodermatidae. According to characters provided by De Rooij (1917), Smith (1943), and Manthey & Grossmann (1997), they differ from the genus *Xenodermus* by (1) its homogeneous scalation on the sides of the body (vs. heterogeneous with a mixture of elliptical scales, minute scales and enlarged dorsal scales in *Xenodermus*); (2) enlarged cephalic scales (vs. minute with the exception of the presence of only internasals and prefrontals); (3) everted supra- and infralabials (vs. none); (4) fewer subcaudal scales (55–56 vs. 133–165); (5) more maxillary teeth (27 vs. about 15); (6) head barely separated from neck (vs. clearly distinct); and (7) a body rather stout (vs. slender).

The Laotian specimens do not agree with the diagnosis of the genus *Achalinus* by (1) dorsal scales small, cycloid or subrectangular (vs. elliptic); (2) the presence of two scale rows above each ventral plate (vs. a single scale row, typical of Caenophidia); (3) everted supra- and infralabials (vs. none); (4) maxillary teeth subequal (vs. equal); (5) postoculars not fused with anterior temporals (vs. fused) (after Smith 1943 and examined specimens).

The specimens from Luangphrabang can be distinguished from *Stoliczkaia* by (1) dorsal scales small, cycloid or subrectangular (vs. elliptic); (2) the presence of two scale rows above each ventral plate (vs. a single scale row, typical of Caenophidia); (3) everted supra- and infralabials (vs. none); (4) head barely distinct from head (vs. clearly distinct); and (5) more maxillary teeth (27 vs. 14–20) (after De Rooij 1917 and Smith 1943).

Lastly, the Laotian specimens differ from the genus *Xylophis* by (1) maxillary teeth progressively slightly enlarged (vs. teeth in the middle of the maxilla enlarged); (2) nostril in a distinctly enlarged concave nasal scale (vs.

piercing between two small nasals); (3) dorsal scales small, cycloid or rectangular, in 25–27 rows (vs. elliptic, in 13–15 rows); (4) the presence of two scale rows above each ventral plate (vs. a single scale row, typical of Caenophidia); and (5) everted supra- and infralabials (vs. none). Other characters of *Xylophis* were given by Smith (1943).

As the Laotian specimens differ from all other genera and species of the family Xenodermatidae by a unique suite of morphological characters, and on the basis of the significantly divergent genetic distance between them and the genus *Fimbrios*, we here consider them to represent a new species deserving to be placed in a new genus, which we describe as:

Parafimbrios gen. nov.

Type species. Parafimbrios lao spec. nov., herein described.

Diagnosis. A genus of Caenophidia, family Xenodermatidae, characterized by (1) maxillary teeth 27, progressively slightly enlarged posteriorly; (2) head not distinct from neck; (3) dorsal scales small, cycloid or subrectangular, with the correspondence of two dorsal scale rows per ventral plate throughout the body; (4) two consecutive scales of the first dorsal scale row enlarged; (5) rostral separated from internasals by a fold of skin, larger on the sides than above the middle of the rostral; (6) nostril piercing the anterior part of a large, concave nasal; (7) mental and both anterior supralabials and infralabials with strong, raised, everted edges; (8) eye with vertically elliptic pupil; (9) loreal single, large, extending from nasal to eye; (10) chin shields in a single pair, enlarged; (11) body moderately elongate; (12) ventrals large, rounded; (13) subcaudals undivided; (14) cloacal plate entire; and (15) hemipenis short, forked, distal half strongly spinose.

Although *Parafimbrios* gen. nov. shares morphological similarities with other members of the family Xenodermatidae, it is morphologically most similar to *Fimbrios*. *Parafimbrios* gen. nov. differs from *Fimbrios* by a combination of the five characters listed above, the most important being (1) the correspondence of two consecutive dorsal scale rows per ventral plate throughout the body, (2) fewer dorsal scale rows, and (3) posterior teeth progressively and slightly enlarged (vs. equal). Additional comparisons between the new genus and species and members of the genus *Fimbrios* are given below in the species description.

Distribution. Laos. Currently recorded from karst formations in Louangphabang and Houaphan provinces.

Etymology. The generic nomen *Parafimbrios* is composed of the modern Latin generic nomen *Fimbrios* and the Latin adjective *par (paris)*, meaning, among other possibilities, "similar to". The nomen *Fimbrios* itself stems from the Latin noun *fimbria (-ae)*, meaning "a fringe", by allusion to the edges of labial scales producing a kind of fringe around the snout. So, the generic nomen *Parafimbrios* refers to one of the diagnostic characters of *Fimbrios*, to which *Parafimbrios* **gen. nov.** is morphologically quite similar but taxonomically distinct.

Contents. The new genus currently contains a single species, *Parafimbrios lao* **spec. nov.**, which we describe as:

Parafimbrios lao spec. nov.

(Figs. 2-4; 5A, B; 6B)

Holotype. MNHN 2013.1002, a young adult male, from the vicinity of Muang Ngoi (20°42.005'N, 102°41.730'E; datum WGS84), Ngoi District, Louangphabang Province, Laos, at an elevation of ca. 360 m a.s.l.; collected by Alexandre Teynié and Anne Lottier on 25 September 2012.

Additional material. A second specimen was found, examined and photographed (Fig. 4) but not collected, in the vicinity of Vieng Xai, or Viengxay (20°24.417'N, 104°13.433'E), Vieng Xai District, Houaphan Province, Laos, at an elevation of ca. 890 m a.s.l., by Alexandre Teynié and Anne Lottier on 11 May 2013.

This specimen was released after obtaining morphological characters and photographing.

Diagnosis. A species of the genus *Parafimbrios* **gen. nov.**, defined by a combination of generic characters listed above plus (1) dorsal scale rows 27-29 - 25-27 - 23-25, distinctly keeled, small, cycloid, progressively larger on the top of the body than on the sides; (2) scales of the first DSR distinctly enlarged, also two per ventral, first smallest, last largest; (3) ventrals 177–189, large, laterally rounded; (4) subcaudals 55–56, undivided; (5) $1^{st}-4^{th}$ or $1^{st}-5^{th}$ supralabials, mental, and $2^{nd}-4^{th}$ infralabials with raised and everted edges; (6) suture between the

internasals 0.7 times as long as suture between the prefrontals; (7) 1 / 1 (upper) preocular, 1 / 1 supraocular, 2 / 2 postoculars, and 1 / 1 subocular; (8) 1 / 1 loreal, large; (9) nuchal scales 3, one in central and one enlarged on each side; (10) dorsum dark purplish-grey, slightly paler on the sides; and (11) neck with a pale creamish-grey collar, more or less pronounced with age, reaching downwards the pale grey colour of the venter.

Etymology. The specific epithet, *lao*, refers both to the official name of Laos, the Lao People's Democratic Republic in which the species was discovered, and to the Lao, the main people group inhabiting Laos.

Description of holotype. Body elongate, slightly laterally compressed; head short (4.1% of SVL), ovoid, not distinct from the thick neck, dorsally covered with large shields; snout average, approximately 3.1 times as long as eye diameter, distinctly extending beyond lower jaw, rounded in profile and from above; a large, oval nostril, piercing in the anterior part of a large, concave nasal; eye small, its diameter 0.7 times of the distance between eye and lip, with a vertically elliptic pupil; tail average, relatively thick, tapering progressively.



FIGURE 2. *Parafimbrios lao* **spec. nov.**, holotype (MNHN 2013.1002): A) Close-up view of the head and of the dorsal scalation at midbody and B) Ventral view. Photographs: A. Teynié.



FIGURE 3. *Parafimbrios lao* **spec. nov.**, holotype (MNHN 2013.1002), alive in its natural biotope, Ngoi District, Louangphabang Province, Laos: A) General view and B) Close-up view of head. Photographs: A. Teynié.

Measurements. SVL 236 mm; TaL 49 mm; TL 285 mm; ratio TaL/TL 0.172; HL 9.75 mm; SnL 2.75 mm.

Dentition. Maxillary teeth: right maxilla with 27 small, curved, subequal teeth, progressively slightly enlarged posteriorly.

Body scalation. DSR 27-25-23, small, cycloid or subrectangular, not elongate, barely imbricate and distinctly keeled with a narrow keel, outermost rows formed by small and enlarged scales alternately; each ventral topped by two dorsal scales above, anterior small, posterior enlarged and surrounding the posterior lateral portion of the corresponding ventral.

The dorsal scalation of this species is quite peculiar. On the 1st DSR, the anterior small scale is in contact with its corresponding ventral on the anterior part of the body, narrowly separated by an area of skin posteriorly; the posterior enlarged scale is always in contact with the posterior lateral portion of the corresponding ventral. Scales on $2^{nd}-7^{th}$ DSR small, slightly enlarged on $8^{th}-9^{th}$ DSR, moderately enlarged on $10^{th}-11^{th}$ DSR, and distinctly enlarged on 12^{th} DSR; scales of vertebral row hexagonal.



FIGURE 4. *Parafimbrios lao* **spec. nov.**, the second specimen in life in natural biotope, Vieng Xai District District, Houaphan Province, Laos: A) View of head and B) Close-up view of the body showing dorsal ranks of scales. Note the two dorsal rows above each ventral scale, an almost unique condition in snakes that is also present in the monotypic genus *Xenodermus* of the same family. Photographs: A. Teynié.

The dorsal scale row reductions are as follows:

27
$$\frac{5+6 \to 5 \text{ (VEN 18) (left)}}{5+6 \to 5 \text{ (VEN 25) (right)}} 25 \qquad \frac{6+7 \to 6 \text{ (VEN 114) (left)}}{6+7 \to 6 \text{ (VEN 115) (right)}} 23$$

VEN 177 (+ 2 preventrals), laterally rounded; SC 56, undivided; cloacal plate entire, large; terminal caudal scale pointing.



FIGURE 5. Views of head of *Parafimbrios lao* spec. nov compared with those of the two known species of the genus *Fimbrios: Parafimbrios lao* spec. nov., holotype (MNHN 2013.1002): A) dorsal view and B) lateral view; C) *Fimbrios klossi*, Paksong, Champasak Province, Laos; and D) *Fimbrios smithi*, holotype (IEBR 3157), Phong Nha–Ke Bang National Park, Quang Binh Province, Vietnam. Photographs: A. Teynié (A–C) and T. Ziegler (D).

Head scalation. Upper head scalation complement complete, comprising 2 internasals, 2 prefrontals, 2 supraoculars, 1 frontal, and 2 parietals. Rostral large, wider than high, not visible from above due to the presence of a ridge of skin between rostral and internasals; nasal 1 / 1, large, elongate, pentagonal, 1.3 times as long as high, entire, most of forward part of scale area being occupied by the nostril; internasals subrectangular, narrow, much wider than long, separated from each other by a short suture, 0.7 times as long as the suture between prefrontals, internasals 0.6 times as long as prefrontal; prefrontals large, pentagonal, much wider than long, 0.75 times as long as frontal, separated from each other by a suture 0.65 times as long as frontal; supraoculars small, slightly beanshaped, approximately 1.3 times as long as broad, 0.25 times as wide as frontal and 0.5 times as wide as internasals; frontal hexagonal, abruptly truncated anteriorly with its apex pointing backwards, large and especially wide, rather squat, 1.5 times as wide as long; parietals strongly enlarged, roughly heptagonal with a jagged posterior edge, longer than wide, extending on about 47% of head length, about 1.6 times longer than frontal, altogether forming a "bat-like" shape; nuchal scales 3, one in central, coarsely rounded, inserted between the posterior inner limits of parietals, and much larger one on each side, larger than upper temporal, edging the whole of the posterior outer margin of each parietal; loreal 1 / 1, large, subrectangular, covering nearly the whole of the side of the snout between nasal and eye, entering the lower half of orbit, much longer and higher than anterior supralabials, 1.2 times longer than high; SL 8 / 8, anterior and posterior edges of 1st-4th strongly everted and raised, much less so on the anterior edge of 5th, 8th largest, narrow and distinctly elongate; 1st-3rd SL in contact with nasal, $3^{rd}-5^{th}$ in contact with loreal, $5^{th}-6^{th}$ and a part of 7^{th} in contact with subocular, 7^{th} bordering the "postsubocular" (the scale inserted between subocular), lower anterior temporal and posterior supralabials, 8th in contact with "postsubocular" and lower temporal; preocular 1 / 1, small, higher than long, entering the upper anterior part of orbit, in contact with loreal below and prefrontal above, not reaching the frontal; subocular 1 / 1, large, long and tall, just below the eye; postoculars 2/2, relatively large, higher one slightly enlarged; postsubocular 1/1, relatively large, inserted behind subocular and lower postocular; temporals 2 + 2 on each side, upper anterior one large and elongate, lower anterior one smaller, posterior ones larger, upper posterior one in broad contact with the lateral nuchal scale (which cannot be qualified of temporal as it is high on the side of the head and barely on the temporal regions); IL 8 / 8, 1st very narrow, in contact with each other behind mental, $1^{st}-4^{th}$ in contact with the sole

pair of chin shields, 1st-4th with strongly raised and everted anterior edges; mental small, with a strong transversal ridge; chin shields in contact with each other in anterior half, diverging and separated by a scale posteriorly.

Hemipenis. In situ, the hemipenis is long, reaching the level of 12th SC, forked at level of 9th SC; half proximal part of the organ and area on the side of the sulcus close to the bifurcation smooth; distal half of the organ strongly spinose, covering broad spines; sulcus spermaticus very prominent.

Colour and pattern. Body uniformly dark purplish-grey or purplish / brownish-grey, slightly iridescent and somewhat paler on the lower sides, more dark grey than brown; scales of the first DSR edged in cream posteriorly; a broad, white (in life) or pale creamish-grey (in preservative) nuchal collar, extending from the occiput and temporal region to the anterior part of the body up to the level of the 10th VEN, in length of 11 vertebral scales on the top of the body, narrowing progressively, downwards with an irregular, wavy posterior limit, narrower at midheight of the side, in width of 9 dorsal scales, widening progressively downwards and connect with the pale colour of the venter; tail in shades of dark purplish-grey as the body.

Head dark purplish-brown, slightly darker than the body, more purplish brown anteriorly; side of snout slightly paler; supralabials paler greyish-brown anteriorly, progressively heavily speckled with whitish-brown; 8th supralabial and lower posterior temporal, turning to pale creamish-grey as the nuchal collar; chin dark purplish-brown, turning quickly to dark then medium grey; throat uniformly pale grey, darker on posterior infralabials.

Venter uniformly pale grey, with, on the anterior part of the body, the outer quarter of each ventral dark grey as the lower part of body, progressively reduced to a dark grey blotch on the posterior margin of the tip of each ventral; ventral surface of the tail dark grey, distinctly darker than the venter.

Variation. The second specimen (male; Vieng Xai, Houaphan Province; Fig. 4) has the following main characters:

Measurements (approximate). SVL 298 mm; TaL 55 mm; TL 353 mm; ratio TaL/TL 0.156.

Body scalation. DSR 27-25-23, similar to that of the holotype, especially the two consecutive rows of dorsal scales above each ventral.

VEN 189 (+ 1 preventral), laterally rounded; SC 55, all undivided; cloacal plate entire.

Head scalation. Upper head scalation complement complete, comprising 2 internasals, 2 prefrontals, 2 supraoculars, 1 frontal, and 2 parietals; SL 7 / 7, anterior and posterior edges of $1^{st}-3^{rd}$ strongly everted and raised, much less developed on the anterior edge of 4^{th} , 7^{th} largest, narrow and distinctly elongate; $1^{st}-3^{rd}$ SL in contact with nasal, $4^{th}-5^{th}$ in contact with loreal, 6^{th} in contact with subocular, $6^{th}-7^{th}$ bordering the "postsubocular", 7^{th} in contact with lower temporal; preocular 1 / 1, small; subocular 1 / 1, large; postoculars 2 / 2, relatively large; temporals 2 + 2/2 + 1; IL 7 / 7, $1^{st}-4^{th}$ in contact with the sole pair of chin shields, $1^{st}-3^{rd}$ with strongly raised and everted anterior edges; other characters of head scalation agree with those of the holotype.

Colour and pattern. Body uniformly dark purplish-grey or dark purplish-brown, depending on the angle of the light source, barely paler on the lower sides, distinctly iridescent; scales of first dorsal scale rows narrowly edged with pinkish-cream on their hinder margins; only the lower half of the neck pinkish-white as a broad triangle, the apex of which about at mid-height of the side of the neck, the base extending from the corner of the mouth to the level of the 10th VEN; upper part of the neck coloured as the body; tail in shades of dark purplish-grey or dark purplish-brown as the body.

Head dark purplish-brown, behind slightly darker than the body, paler and more purplish brown anteriorly; side of snout slightly paler; supralabials brown, paler than upper head surface anteriorly, progressively creamish-brown; 7th supralabial and lower posterior temporal creamish-brown, darker than the nuchal collar; chin dark purplish-brown, turning quickly to medium grey; throat uniformly pale pinkish-grey, darker on hinder infralabials.

Venter uniformly pinkish-cream or very pale pinkish- grey, with, on the anterior part of the body, the outer quarter of each ventral dark greyish-brown, progressively reduced to a dark greyish-brown blotch on the posterior margin of the tip of each ventral; ventral surface of the tail dark grey, distinctly darker than the venter.

Comparisons. The genus *Parafimbrios* can be distinguished from all genera of Xenodermatidae, at the partial exception of *Fimbrios*, by a series of diagnostic characters at the generic level given above in the introduction to its description. The combination of (1) 2 dorsal scale rows above each ventral; (2) dorsal scale rows very small, uniform in shape; (3) supralabials and infralabials with strongly everted edges; (4) 27 maxillary teeth; and (5) 25–27 dorsal scale rows at midbody, is sufficient to distinguish this species from members of the genera *Xenodermus*, *Stoliczkia, Achalinus*, and *Xylophis*. Furthermore, the relatively slender body of *Parafimbrios lao*

spec. nov. is closer to the habitus of members of the genus *Achalinus* than of *Fimbrios* but much less slender than the habitus of *Xenodermus* and *Stoliczkia*. However, *Parafimbrios lao* **spec. nov.** readily differs from all the species currently included in the genus *Achalinus* by its much more strongly erected ridges on labial scales, which are barely or not erected in *Achalinus*.

Parafimbrios lao **spec. nov.** shares several similarities with the two species of the genus *Fimbrios* currently recognized, *F. klossi* (Figs. 5C & 6A) and *F. smithi* (Fig. 5D).



FIGURE 6. Comparative general views in life: A) *Fimbrios klossi*, Paksong, Champasak Province, Laos and B) *Parafimbrios lao* **spec. nov.** (MNHN 2013.1002), Muang Ngoi, Ngoi District, Louangphabang Province, Laos. Photographs: A. Teynié.

According to Smith (1921, 1943), Campden-Main (1970), Orlov *et al.* (2003), Ziegler *et al.* (2008) and our own data, *Parafimbrios lao* **spec. nov.** differs from both species of the genus *Fimbrios* by (1) a more slender body, (2) fewer maxillary teeth (27 vs. at least 30), (3) only 25 or 27 DSR at midbody vs. at least 30, (4) 2 dorsal scale rows per ventral plate vs. one, (5) a shorter tail with a ratio of Tal/TL of 0.156–0.172 vs. 0.185–0.197 in males of *F. klossi* and 0.214 in the single known male of *F. smithi*, (6) and by the pale creamish-grey nuchal collar, vs. no pattern in *F. klossi* and only pale blotches and stripes in the neck region in *F. smithi*. Furthermore, *Parafimbrios lao*

spec. nov. has more ventrals than in *F. klossi*, (177–189 vs. 161–176 in *F. klossi*) but fewer than in *F. smithi* (193 VEN). Bourret (1937) mentioned a specimen of *F. klossi* (M. 558) with 190 ventral scales, a value reported by Campden-Main (1970). This specimen was not examined but we suspect that it might belong either to *F. smithi* or to another undescribed species. Bourret (1937) emphasized the unusually high ventral scale count of that specimen but did not mention any other difference compared with *F. klossi*. He counted 53 subcaudals in this specimen that, furthermore, had a bluish-grey dorsum, 315 mm total length, and a tail length / total length ratio of 0.16. All other known specimens of *F. klossi* have less than 180 ventrals.



FIGURE 7. Comparative distributions of *Parafimbrios lao* with species of the genus *Fimbrios: Parafimbrios lao*: (1) Ngoi District, Luangphrabang Province, Laos (type locality); (2) Vieng Xai district, Houaphan Province. - *Fimbrios smithi*: (3) Phong Nha—Ke Bang National Park, Quang Binh Province, Vietnam (type locality). - *Fimbrios klossi*: Vietnam: (4) Quang Tri Province, (5) Thua Thien—Hue Province, (6) Kon Tum Province, (7) Quang Ngai Province, (8) Gia Lai Province, (9) Dak Lak Province; (10) Langbian Plateau, Lam Dong Province (type locality); Laos: (11) Paksong, Boloven Highlands, Champasak Province; and Cambodia: (12) Bokor, Kampot Province (Notes: Orlov *et al.* [2003] mentioned only provincial records of *Fimbrios klossi* in southern Vietnam without precise localities. As a consequence, corresponding numbers (localities Nr 4 to 6) are placed approximately in the centre of the corresponding provinces.



FIGURE 8. General view of the biotope of *Parafimbrios lao* at the type locality in Louangphabang Province, Laos. Photograph: A. Teynié.

Parafimbrios lao **spec. nov.** also differs from *F. klossi* in having only the first 3 or 4 infralabials with raised edges vs. first 7 infralabials in *F. klossi*. Lastly, *Parafimbrios lao* **spec. nov.** differs from *F. smithi* by having (1) fewer subcaudals (55–56 vs. 72 in *F. smithi*), (2) suture between internasals shorter than that between prefrontals (character shared with *F. klossi*) vs. distinctly longer in *F. smithi*, (3) 1 subocular vs. 2, and (4) 3 posterior temporals vs. 5.

Distribution (Fig. 7). Laos. Louangphabang Province: Vicinity of Muang Ngoi Village, Muang Ngoi District and Houaphan Province: Vicinity of Vieng Xai, Vieng Xai District.

This species is currently known from its type and near the historical city of Vieng Xai or Viengxay, separated by 162 airline kilometers.

Natural history. The holotype of *Parafimbrios lao* was discovered in a steep, rocky evergreen forest, with some remaining trees of primary forest, surrounding a rugged karst formation (Fig. 8). The holotype was lying motionless at night (19.45) during the rainy season on a rocky outcrop among a large pile of rocks at the foot of a limestone cliff of the karst formation at an elevation of 360 m. A few dozens of meters down below, a water course, about 1 m wide and 40 cm deep, used to run in this period of the year. The collection site is located on a steep slope which is converted into cultures (bananas, chilli beans) when the slope becomes more moderate. The adjacent lowland is mainly covered with rice fields, patches of secondary forests and a few scrub and grasslands.

The second specimen was observed around the historical city of Vieng Xai, "Birth place of Lao PDR". It was found near one of the "Former Pathet Lao Leaders Caves", a place heavily bombed by the U.S. Air Force from 1964 to 1973 and where no large primary forest remain. This specimen was observed in the same general karstic environment as the holotype. It was lying motionless at the beginning of the rainy season on a rocky outcrop emerging near a cave entrance and an anti-rocket wall at the foot of a limestone cliff of the karst formation at an elevation of 890 m. No water course, except an artificial pool, was seen in its vicinity. The adjacent area is mainly covered with some small parcels comprising, among others, bananas, chilly beans and peanuts.

Both specimens did not display any reaction and remained perfectly motionless when they were photographed. When they were handled, they did not try to form a "ball", a defensive posture frequent in *Fimbrios klossi* (our data), nor did they display any other defensive action. Nothing else is known on the biology of *Parafimbrios lao*. Stomachs of both specimens were seemingly empty.

In the same biotope and within 50 meters from the collection site of the holotype we found the following amphibians: *Microhyla fissipes* (Boulenger), *Micryletta inornata* (Boulenger), *Leptobrachium smithi* (Matsui, Nabhitabhata & Panha), *Xenophrys major* (Boulenger), *Hoplobatrachus chinensis* (Osbeck), *Ferjervarja limnocharis* (Gravenhorst), and *Theloderma asperum* (Boulenger). We also found several reptile species, some of them new for the province (Teynié *et al.* 2014b). In the vicinity of the locality of the second specimen, we found *Microhyla fissipes*, *Micryletta inornata*, and *Rhacophorus kio* (Ohler & Delorme), as well as at least seven reptile species. All species were photographed. Lastly, quite interestingly, each locality of *Parafimbrios lao* included in its fauna a different species of the genus *Cyrtodactylus*, new to the fauna of Laos (Schneider 2014).

Discussion

Our molecular phylogenetic results show that the new genus is strongly supported as a sister group to *Fimbrios*, although this set of relationships needs to be verified with the inclusion of *Stoliczkaia* and *Xylophis*, the two remaining genera in the family Xenodermatidae. *Parafimbrios lao* shares with *Xenodermus javanicus* the correspondence of two dorsal scale rows per ventral plate throughout the body but differs by its homogeneous dorsal scalation. *Parafimbrios lao* is morphologically somewhat intermediate between the genera *Fimbrios* and *Achalinus*. Diagnostic characters of these three genera were given above.

The definition of the genus *Fimbrios*, as given by Smith (1921) in the description of *Fimbrios klossi*, was not subsequently modified even after the description of the second known species of the genus, *F. smithi* by Ziegler *et al.* (2008). Besides the peculiar scheme of the dorsal scalation, *Parafimbrios lao* differs from both species of *Fimbrios* by its lower number of dorsal scale rows, 25 or 27 at midbody vs. 30–33. Campden-Main (1970) mentioned a range from 24 to 33 dorsal scale rows in *F. klossi*. However, such a variation was questioned by Ziegler *et al.* (2008), because no specimen with less than 30 dorsal scale rows at midbody has ever been recorded after Campden-Main (1970). As stated by Ziegler *et al.* (2008), pending the examination of genuine specimens of *Fimbrios* with less than 30 dorsal scale rows at midbody, it is better to consider this genus characterized by 30–33 dorsal scale rows at midbody. In contrast, the genus *Achalinus* is characterized by a range of dorsal scale rows varying from 21 to 27 rows at midbody. With 25 and 27 dorsal scale rows at midbody, *Parafimbrios lao* shares this character with members of the genus *Achalinus*. Currently nine species are included in this genus, of which two, *Achalinus ater* Bourret, 1937 and *A. rufescens* Boulenger, 1888, inhabit the northern part of the Indochinese Peninsula (Orlov *et al.* 2000; Nguyen *et al.* 2009). However, there cannot be any possible confusion between *Parafimbrios lao* and any species of the genus *Achalinus*. If both genera shares a body more slender than *Fimbrios*, no species of *Achalinus* has the strongly everted supra- and infralabials.

Morphological characters revealed close similarity between the three genera. Although these genera are easily distinguishable from each other, a phylogeny of Xenodermatidae is needed. Pope (1935: 181) already stated that *Fimbrios* and *Achalinus* bear striking resemblances which argues for their close relationship.

The genus *Achalinus*, the two known species of *Fimbrios* and *Parafimbrios lao* can be distinguished from each other by the following key (based on Smith 1921, 1943; Ziegler *et al.* 2008; examined specimens):

1.	Supralabials and infralabials with edges not raised or everted, or barely so on anterior most scales; no more than 27 DSR at
	midbody Genus Achalinus
-	Supralabials and infralabials with edges distinctly raised and everted, at least on first four scales; at least 25 DSR at midbody
2.	At least 30 maxillary teeth; 30–33 DSR at midbody; 1 dorsal scale row per ventral plate; no nuchal collar
-	27 maxillary teeth; 25 or 27 DSR at midbody; 2 dorsal scale rows per ventral plate; a broad, pale nuchal collar, complete or
	restricted to sides of the neck Parafimbrios lao
3.	First 4 supralabials, mental and first seven infralabials bear raised and everted edges; 161-176 VEN, 43-60 SC; suture
	between the internasals shorter than that between the prefrontals; ratio of tail length / total length 0.126–0.197 (both sexes);
	dorsum uniformly dark grey, olivaceous or purple brown Fimbrios klossi
-	First 4 supralabials, mental and first three infralabials bear raised and everted edges; 193 VEN, 72 SC; suture between the
	internasals longer than that between the prefrontals; ratio of tail length / total length 0.214; dorsum dark greyish-brown with a
	distinctly paler flank area and pale blotches and stripes in the nuchal region

Conclusion

Parafimbrios lao is the first species of Xenodermatidae recorded from the North Laos. *Fimbrios klossi*, the sole other species of this family to have been recorded from Laos to date, was found, however, from the extreme south of the country, in Boloven Highlands, near Paksong in Champasak Province by Stuart & Heatwole (2008) and Teynié & David (2010) (see Fig. 7). This locality is about 700 km far from the type locality of *Parafimbrios lao*. Furthermore, although specimens of the latter species have been collected at elevations from 360 to 890 m; in Laos, *F. klossi* has been found at elevations between 1,350 and 1,420 m.

In addition, the type locality of *Parafimbrios lao* is located in the northern part of Louangphabang Province, about 47 km away from the closest point of the Laotian-Vietnamese border. The second locality is approximately 16.5 km away from this border. This species is expected to be present in Vietnam. On the other hand, *Fimbrios smithi* has been recorded in Quang Binh Province in central Vietnam, about 520 kilometers from the type locality of *Parafimbrios lao*, the closest locality known for a member of the genus *Fimbrios* (Fig. 7). In Vietnam, the genus *Fimbrios* has been collected near the Laotian border, with localities in provinces of Quang Binh (*F. smithi*) and Quang Tri, Thua Thien—Hue, Quang Ngai, KonTum, Gia Lai, Dak Lak, and Lam Dong (*F. klossi*) (Nguyen *et al.* 2009; Nemes *et al.* 2013). These provinces are at the levels of the Laotian provinces of Khammouane, Savannakhet, Salavan, Sekong, and Attapeu as well as Kampot Province in Cambodia, far more south than the locality of *Parafimbrios lao*.

Deuve (1970: 116) suggested the occurrence of four species of *Achalinus* in Laos but no voucher specimen has been reported to confirm his records up to now. This poor representation of members of Xenodermatidae in Laos reinforces the interest of the discovery of *Parafimbrios lao* in an area previously devoid of these snakes. However, farther north, *Achalinus spinalis* Peters, 1869 is known from the Chinese provinces of Yunnan (Yang & Rao 2008) and Guangxi Autonomous Region, whereas *A. ater* and *A. rufescens* also occur in the latter province (Zhang 2009) and in other Chinese provinces (see also Zhao & Adler 1993; Zhao 2006). In northern Vietnam, *A. ater*, *A. rufescens*, and *A. spinalis* have been recorded and are more or less widespread (Nguyen *et al.* 2009). Members of the genus *Achalinus* should indeed be present in northern Laos.

At present, 111 snake species are definitely known from Laos, on the basis of Teynié and David (2010), modified by David *et al.* (2012), Vogel *et al.* (2012), Luu *et al.* (2013), Teynié and David (2014), including a new snake of the genus *Opisthotropis* (see Teynié *et al.* 2014a). Other recently described species are *Oligodon nagao* David, Nguyen, Nguyen, Jiang, Chen, Teynié & Ziegler, 2012 and *Lycodon davidi* Vogel, Nguyen, Kingsada & Ziegler, 2012, both from karst formations of central and northern Laos. Furthermore, three new species have been recently recorded for the first time from Laos: *Lycodon ruhstrati abditus* Vogel, David, Pauwels, Sumontha, Norval, Hendrix, Vu & Ziegler, 2009 and *Lycodon futsingensis* (Pope, 1928) were found in Hin Nam No National Protected Area, Khammouane Province (Luu *et al.* 2013), and, in addition, *Trimeresurus truongsonensis* Orlov, Ryabov, Bui & Ho, 2004 was seen in karst formation of Phou Hin Boun National Park, Khammouane Province (Teynié & David 2014).

Both the discovery of *Parafimbrios lao* and the lack of definite records of *Achalinus* species stress how much limited, if not fragmentary, is our knowledge of the herpetofauna in North Laos.

The herpetological richness of the Indochinese Peninsula as a whole and, particularly of Laos, is characterized both by a high level of endemism and by species widespread in Indochina (see Stuart 1999; Stuart & Heatwole 2008; Teynié *et al.* 2004; Teynié & David 2007, 2010).

According to Ziegler *et al.* (2008) citing Brandon-Jones (1996), the distribution of many Indochinese species with a current restricted range might be the consequence of the last glaciations, in which species took refuge in cool but humid mountain forests emerging as "islands" between warmer but dry lowlands. These species may also have a wider geographic range than currently known but be naturally very rare (Ziegler & Herrmann 2002; Herrmann *et al.* 2004). Sterling *et al.* (2006) concluded that the "current elevated endemism may reflect past barriers of climate, habitat and geology that are no longer visible". According to these authors, the Truong Son Range, which extends along Vietnam and Laos, can be divided into three regions that often serve as species boundaries. This barrier has been discussed at length by Ziegler *et al.* (2008) with relevance to both several Vietnamese species and to the distributions of *Fimbrios klossi* and *F. smithi.*

The mountain refuges may well explain the presence of Indo-Malayan species in the Boloven Highlands (see Teynié *et al.* 2004) and the current ranges of *Fimbrios klossi* in Laos and Vietnam and *F. smithi* in Vietnam (Fig.

5D) but not clearly the range of *Parafimbrios lao* which is not located in montane refuges. Additional surveys of the herpetofauna of Laos should show whether these geographic distributions are the consequence of zoogeographic barriers or, merely of our very limited knowledge of the reptile diversity in Laos.

Acknowledgements

We are grateful to Assoc. Prof. Sengdeuane Wayakone, Assoc. Prof. Somchanh Bounphanmy, Dr. Bounthob Praxaysombath, Mr. Liphone Nophaseud (National University of Laos, Vientiane, Lao PDR) and Mr. Vilaphong Kanyasone (Provincial Natural Resources and Environment Office of Luang Prabang, Lao PDR) for supporting our field research in Laos. Export of collected specimens was done due to the export permit Nr 143/13 signed by the CITES Management Authority of Lao PDR. Thanks to Khoi Vu Nguyen (Ho Chi Minh City) and Chung Van Hoang (Hanoi) for providing comparative material. Truong Quang Nguyen thanks Assoc. Prof. Canh Xuan Le (Hanoi), Prof. Michael Bonkowski, Assoc. Prof. Thomas Ziegler, and Mr. Theo Pagel (Cologne, Germany) for support of his research.

The three first authors thank the Société d'Histoire Naturelle 'Alcide d'Orbigny' which financed and made possible our several field trips to Laos. They are especially grateful to Khamphieng Manichit, head of Luang Prabang Travel & Tour and Adrien Doré, head of Luang Prabang Travel Exclusive for diplomatic facilities and working plan. They also thank Mr. Steeve Collard, entomologist, for his help in the preparation of our stay in Louangphabang and Houaphan Provinces, and Mr. Bounmi Saymoua, official guide to the "Former Pathet Lao Leaders Caves" pour having facilitated our visit of these caves.

We are grateful to Gernot Vogel (Heidelberg, Germany), Olivier S.G. Pauwels (Brussels, Belgium), Alain Dubois (MNHN) and Ivan Ineich (MNHN) for their critical review of the manuscript. We also thank Thomas Ziegler (Cologne, Germany) for the photograph of the holotype of *Fimbrios smithi*, and Eleanor Sterling (New York) and Kevin Koy (Berkeley) for providing the map, and Sara Ruane (New York) and Ha T. Duong and Hanh T. Ngo (Hanoi) for advice and assistance. Furthermore we want to thank the following people, who gave us access to specimens in their care and helped us while visiting their respective institutions: Colin J. McCarthy and Patrick Campbell (BMNH), and Alain Dubois, Ivan Ineich and Annemarie Ohler (MNHN). Research of T. Q. Nguyen is funded by the Alexander von Humboldt Stiftung / Foundation (VIE 1143441).

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APPENDIX. Examined specimens.

Fimbrios klossi (n = 6). Vietnam. Lam Dong Province. BMNH 1946.1.15.87, "Da Lat", now Da Lat, Langbian Plateau;
BMNH 1946.1.15.88, BMNH 1965.1, Cam Ly. <u>Quang Tri Province</u>. MNHN 1938.0152, "Dong Tam-ve", now Dong Tam Ve. <u>Quang Ngai Province</u>. IEBR 3275, Ba To. <u>Gia Lai Province</u>. IEBR A.2013.56, Kon Ka Kinh. – Laos. <u>Champasak Province</u>. MNHN K 3517, near Paksong, Boloven Highlands. – Cambodia. <u>Kampot Province</u>. BMNH 1965.2, BMNH 1965.639, "Bockor, Elephant Mts.", now Bokor.

Fimbrios smithi (*n* = 1). **Vietnam**. <u>Quang Binh Province</u>. IEBR 3157, Phong Nha-Ke Bang National Park.

Achalinus ater (*n* = 5). **Vietnam**. <u>Vinh Phuc Province</u>. MNHN 1935.0049, MNHN 1938.0128, MNHN 1948.0076, MNHN 1958.471, "Tam Dao", Tram Tam Dao (Tam Dao Hill Station). <u>Bac Kan Province</u>. MNHN 1948.77, "Ngan Son", now Ngan Son District.

Achalinus niger (n = 1). Taiwan. MNHN 1993.0858, no locality information.

Achalinus rufescens (*n* = 6). **Vietnam**. <u>Vinh Phuc Province</u>. MNHN 1935.0439–0041, MNHN 1935.0051, MNHN 1958.0472, MNHN 1958.0475, "Tam Dao", now Tam Dao.

- *Achalinus spinalis* (*n* = 7). **Vietnam**. <u>Lao Cai Province</u>. MNHN 1948.0078, MNHN 1958.0469–0470, "Chapa", now Sa Pa. <u>Vinh Phuc Province</u>. MNHN 1935.0050, MNHN 1935.0442, "Tam Dao", now Tam Dao. **China**. MNHN 5225–5226, no locality information.
- *Xenodermus javanicus* (n = 1). Indonesia. *Sumatra*. Province of Sumatera Barat. Specimen photographed and examined but not collected, vicinity of Lubuksao.