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Authors: Lee, Justin L., Vogel, Gernot, Miller, Aryeh H., and Zug, George R.

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Rediscovery of *Xenochrophis bellulus* (Stoliczka, 1871) from Myanmar (Serpentes: Natricinae) with comments on its taxonomic status

Justin L. Lee,* Gernot Vogel, Aryeh H. Miller, and George R. Zug

(JLL) College of Computer, Mathematical and Natural Sciences, University of Maryland, College Park, MD, 20742, U.S.A., e-mail: justinllee@verizon.net;
(GV) Society for Southeast Asian Herpetology, Im Sand 3, D-69115 Heidelberg, Germany, e-mail: Gernot.Vogel@t-online.de;
(AHM) Department of Biology, University of North Carolina Asheville, Asheville, NC 28804, U.S.A.: e-mail: millerari8@gmail.com;
(GRZ) Department of Vertebrate Zoology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, Washington, District of Columbia, 20013-7012, U.S.A., e-mail: ZUGG@si.edu

Abstract.—*Xenochrophis bellulus* (Stolickza, 1871) was described as *Tropidonotus bellulus* based on a single specimen collected from Myanmar in the late 19th century. Since then the holotype has been lost, and the species has been transferred to several genera in the subfamily Natricinae including *Natrix*, *Sinonatrix* and finally *Xenochrophis* based on one museum specimen matching the original description. Herpetofaunal surveys of the Moyingyi Wildlife Sanctuary and vicinity, Bago Region, Myanmar revealed three individuals obtained in 2001 and 2003 that match the type description of *X. bellulus*. This small series of newly collected specimens allows us to redescribe this species based on all known material, provide a description of the hemipenis, designate a neotype and comment on its taxonomic status.

Keywords: biodiversity, morphology, natural history, rare species, redescription, snakes, Southeast Asia, taxonomy

Myanmar has experienced an increase in herpetological research with the addition of new surveys that have helped fill in sampling gaps and led to the discovery of several endemic snake species (Slowinski & Wüster 2000, Slowinski et al. 2001, Murphy 2007, Zug et al. 2011, Vogel & Van Rooijen 2011, Vogel et al. 2012, Vogel 2015; Quah et al. 2017). Still, Myanmar remains poorly known herpetologically, and many species from the country are poorly represented in museum collections.

The genus *Xenochrophis* Günther, 1864 currently consists of twelve species of semi-aquatic snake found in Southeast Asia (Uetz 2017). Of these, only the *Xenochrophis piscator* group has received recent taxonomic treatment (Zug et al. 2006, David & Vogel 2012). Perhaps the most poorly known of all species within the genus is *Xenochrophis bellulus*. This species was described as *Tropidonotus bellulus* in 1871 by herpetologist Ferdinand Stoliczka, who illustrated the taxon on the basis of a single specimen (Zoological Society of India [ZSI number unknown] = holotype now considered to be lost according to Das et al. [1998]) collected from "Prome, near Pegu, Burma" (= Pyay, Bago Region, Myanmar). The specimen, unsexed, was "16 ½ inches, of which the tail is 5 inches" (=

* Corresponding author.
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419 mm Total Length, 127 mm Tail Length) and was described by its unique suite of morphological characteristics and color pattern, especially the "sides of the neck with transverse yellowish bars, the skin next to the bars being intensely black". Stoliczka (1871) acknowledged the distinctiveness of this species, but noted some similarities with other species in the genus *Tropidonotus* (currently in *Xenochrophis*). Theobald (1876) and Boulenger (1890) continued to recognize the species as *T. bellulus*. However, Boulenger (1893) synonymized this species with *Tropidonotus trianguligerus* F. Boie, 1827 (= now *Xenochrophis trianguligerus*) with some reservations (a question mark is present before the synonym). He had no specimen at hand at the time and likely judged the identity from the illustration provided by Stoliczka. This synonymy was repeated by Wall (1926) who reported a specimen (BMNH 1930.5.8.182) as *Natrix trianguligerus* from "Minhla, Thayetmyo District, Burma" (= Minhla, Magway Region, Myanmar). In his review of Burmese snake fauna, Smith (1943) removed *T. bellulus* from synonymy and placed it in the genus *Natrix* Laurenti, 1768. Smith also reported another specimen (BMNH 1938.2.2.1) collected "near Rangoon" (= Yangon) and tentatively recognized the specimen reported by Wall (1926) as *Natrix bellula*. Later, *Natrix bellula* was moved to the newly created *Sinonatrix* by Rossman & Eberle (1977). The latter authors did not examine a preserved specimen for this species and likely moved it to this genus based on descriptions in the literature. Malnate & Underwood (1988), while investigating species of *Tropidonophis* Jan, 1863, identified differences between the only other available specimen of *Sinonatrix bellula* (presumably BMNH 1938.2.2.1) and other members of the genus and described some aspects of the taxon's viscera and hemipenial morphology. They moved *Sinonatrix bellula* "with some insecurity" to the genus *Xenochrophis* Günther, 1864, which they believed shared similar traits. However, Dowling & Jenner (1988) as well as Rao & Yang (1998) continued recognizing this species as member of the genus *Sinonatrix*. These latter authors likely missed Malnate & Underwood's taxonomic decision for this species, as it was only included in the appendix of their publication and was published the same year as Dowling and Jenner's.

Between 2001 and 2003, the Myanmar Herpetological Survey (MHS) collected three specimens of an unidentified natricine snake. These snakes were deposited in the National Museum of Natural History (USNM) and the California Academy of Sciences (CAS) herpetology collections. Further investigation shows that these specimens match the type description of *Xenochrophis bellulus*, giving us the opportunity to report important new data on this poorly known species.

Materials and Methods

Morphological data taken from the three specimens collected in Bago Region, Myanmar by the MHS in 2003 and from the only other known specimen BMNH 1938.2.2.1 were compared with the original description of the species. The specimen BMNH 1930.5.8.182 reported by Wall (1926) is known only from its skull and was not examined by us. Specimens deposited by MHS were collected in the field by hand and preserved in a 10% formalin mixture before being transferred to 70% ethanol. Tissue was collected from the liver and heart before fixation and stored in 95% ethanol for future molecular phylogenetic analysis.

Sex was determined based on a small ventral incision directly posterior to the cloaca. Body measurements including Snout-Vent-Length (SVL), Tail Length (TailL) and Total Length (TotalL) were

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measured using a flexible ruler to the nearest millimeter. Head Length (HeadL), Head Width (HeadW) and length/width of the chin shields, were measured using a slide-caliper to the nearest 0.1 of a millimeter. Ventral scale counts were made according to Dowling (1951), but data from Stoliczka (1871) and Smith (1943) include preventral scales and thus should be 1 or 2 ventrals lower. The tail tip was not counted for the total number of subcaudals. Dorsal scale row counts were made at one head length behind the head, midbody and one head length before the vent. Values for head scutellation are given in left/right order. Maxillary teeth were carefully counted *in-situ* on the right side of the mouth by removing the exterior gum surface. The hemipenial description is based on specimen USNM 587199. The partially everted left organ was dissected, then prepared, following the procedures recommended by Pesantes (1994), Myers & Cadle (2003) and Zaher & Prudente (2003). Alizarin red staining was used to reveal calcified structures as recommended by Harvey & Embert (2008). Terminology for hemipenial morphology follows Dowling & Savage (1960). Comparisons with other species of the genus *Xenochrophis* and *Sinonatrix* were based on pertinent literature, including Guo et al. (2014), Malnate (1960), Malnate & Minton (1965), Malnate & Underwood (1988), Pauwels et al. (2001), Smith (1943), Stoliczka (1871), Vogel & David (2012) and Zug et al. (2006) as well as from examined specimens (see: Appendix).

Museum abbreviations: The Natural History Museum, London, England (BMNH); California Academy of Sciences, San Francisco, California, U.S.A. (CAS); Naturhistorisches Museum Wien, Austria (NHMW); Nationaal Natuurhistorisch Museum (Naturalis), Leiden, The Netherlands (RMNH); Natur-Museum und Forschungs-Institut Senckenberg, Frankfurt-am-Main, Germany (SMF); National Museum of Natural History – Smithsonian Institution, Washington, D.C., U.S.A. (USNM); Zoologisches Museum für Naturkunde der Humboldt-Universität zu Berlin, Berlin, Germany (ZMB); Zoological Survey of India, Kolkata, West Bengal, India (ZSI); and Zoologische Staatssammlung, München, Germany (ZSM).

Results

Morphological analyses of these three new specimens match those in the description of the holotype made by Stoliczka (1871) and the only other known specimen of *X. bellulus* (BMNH 1938.2.2.1). The discovery of new material prompts us to redescribe the taxon. While the written description of *Tropidonotus bellulus* by Stoliczka (1871) is detailed enough to identify it with certainty, we believe that the designation of a neotype is necessary in order to clarify its nomenclatural status. We offer the following reasons that justify our decision: (1) the name *Tropidonotus bellulus* has been synonymized with *Tropidonotus* (= *Xenochrophis*) *trianguligerus*, causing some taxonomic confusion, (2) the name *Tropidonotus bellulus* and *Xenochrophis bellulus* must be re-associated with specimens present in Myanmar that have transverse yellowish bars anteriorly, with the skin next to the bars being intensely black; and (3) the holotype of *Tropidonotus bellulus* is lost and several detailed efforts have failed to locate it (Smith 1943, Das et al. 1998). We therefore designate specimen USNM 587200 from Moyingyi Wetland Wildlife Sanctuary, Bago Region, Myanmar as the neotype of *Xenochrophis bellulus*. The specimen is from the same geographic division as the original type locality (Pyay, Bago Region, Myanmar) and matches the description of the holotype made by Stoliczka (1871) (for details, see Table 1). All these conditions agree with the stipulations for neotype designation based on Article 75.3 of the

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Table 1.—Meristic and morphological comparisons between all four specimens of *Xenochrophis bellulus*. The "?" marks stand for missing data not available in the literature accounts for each specimen. Asterisk stands for data collected by Stoliczka (1870).

	Holotype (Lost)*	BMNH 1938.2.2.1	CAS 222087	USNM 587119	USNM 587200
Sex	Unknown	Male	Female	Female	Male
SVL	419 mm	349 mm	316 mm	321 mm	429 mm
TailL	127 mm	141 mm	117 mm	120 mm	163 mm
TailL/TotalL	0.30	0.29	0.27	0.27	0.28
Dorsal scales	19/?–?–?	19–19–17	19–19-17	19–19–17	19–19–17
Ventral scales	140	137	143	135	139
Subcaudal scales	63	79	70	72	71
Supralabials	9/?	9/9	9/9	9/9	9/10
Supralabials in contact with eye	4–6	4–6/4–6	4–6/4–6	4–6/4–6	4–6/4–6
Preoculars	1	1/1	1/1	1/1	1/1
Postoculars	3	3/3	3/3	3/3	3/3
Temporals	1+2/?	1+2/1+2	1+1/1+1	1+1/1+2	1+1/1+1
Maxillary teeth	20–22	32 + 3	–	18	21

International Code of Zoological Nomenclature (ICZN, 1999).

Xenochrophis bellulus (Stoliczka, 1871)
Figs. 1–7; Table 1

Tropidonotus bellulus: Stoliczka 1871: 432 *Holotype*: "Prome, near Pegu" (= now Pyay, Bago Region, Myanmar). ZSI, lost; Theobald (1876: 159), Boulenger (1890: 350), Das et al. (1998: 157)

Tropidonotus trianguligerus: Boulenger (1893: 224) (in part).

Natrix trianguligerus: Wall (1926: 560) (in part).

Natrix bellula: Smith (1943: 298).

Sinonatrix bellula: Rossman & Eberle (1977: 42), Dowling & Jenner (1988: 9), Rao & Yang (1998).

Xenochrophis bellula: Malnate & Underwood (1988: 195), Das et al. (1998: 157) (in part), Vogel & David (2012), Wallach et al. (2014: 797), Uetz. (2017).

Xenochrophis bellulus: Pauwels et al. (2001).

Neotype.—Adult female (USNM 587200) collected on Jul 2003 by Sai Wunna Kyi and Thet Win from Moyingyi Wetland Wildlife Sanctuary, Bago Region, Myanmar (17°35′27.4" N, 96°34′24.5" N; 3 m. in elevation).

Specimens examined.—Adult male (BMNH 1938.2.2.1) donated by F. J Meggitt from "Kemmendine, suburbs of Rangoon" (present day = near Yangon, Myanmar). Adult female (CAS 222087) collected on 19 Jul 2001 by H. Tun, K.S. Lwin and A.K. Shein of the Myanmar Herpetological Survey from Kyauk Taga Township, Forest Office, Bago Region, Myanmar (18°09′56.7" N, 96°36′18.4" E; 29 m. in elevation). Adult male (USNM 587119) collected on 5 May 2003 by Sai Wunna Kyi and Thet Win of the Myanmar Herpetological Survey from Moyingyi Wetland Wildlife Sanctuary, Bago Region, Myanmar (17°35′17.88'' N, 96°34′44.04'' E; 3 m. in elevation).

Diagnosis.—Including data from Stoliczka (1871) and Smith (1943). *Xenochrophis bellulus* is separated from all other Southeast Asian natricine snakes by the following set of characteristics: (1) dark olive-brown to jet black dorsal coloration with anterior transverse bars dissipating around midbody; (2) supralabials and infralabials light cream with black sutures; (3) a single light dot on each parietal scale and one occipital scale bordering the parietals; (4) nine (rarely 10) supralabials, with the 4^{th}–6^{th} in contact with the eye; (5) dorsal scales keeled, 19–19–17 rows; (6) 135–144 unkeeled ventrals; (7) 63–83

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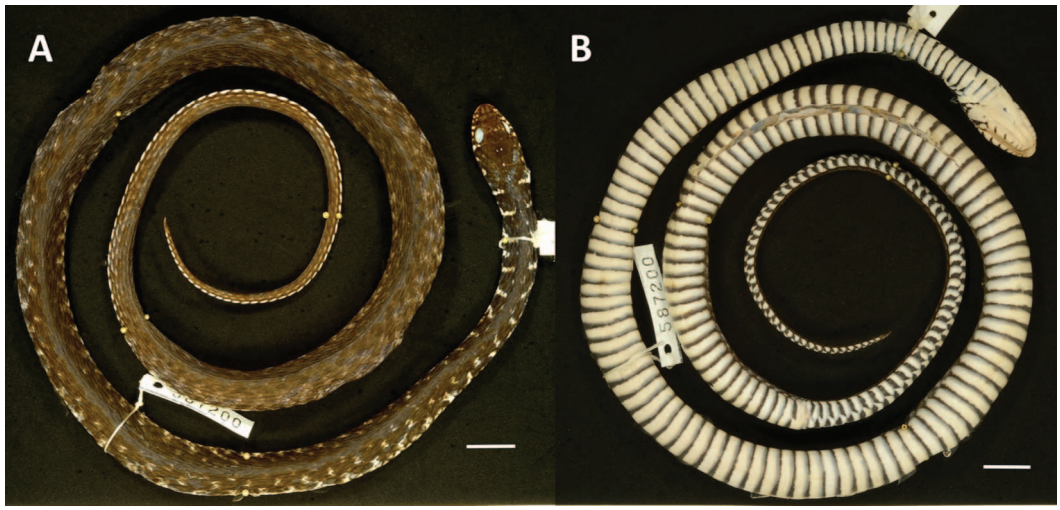


Figure 1. *Xenochrophis bellulus,* Neotype (USNM 587200): Dorsal (A) and ventral (B) views. Photographs by James Poindexter III. Scale bar = 10 mm.

unkeeled paired subcaudals; (8) single anterior temporal scale; (9) tail length 27.0%–30.0% of the total length; (10) bilobed hemipenis with large basal hooks, elongate spines on the tip of each lobe and a shallowly forked sulcus spermaticus; and (11) short, slender asymmetrical hemipenial lobes slightly separated from the rest of the hemipenial body, with the left lobe shorter and smaller in size compared to the right lobe.

Comparisons.—Xenochrophis bellulus is immediately distinguished from most Southeast Asian natricine snakes by its dorsal color pattern, which is black to dark olive–brown with slight checkering and anterior transverse crossbars. *X. punctulatus* (Günther, 1858) is superficially similar to *X. bellulus* by its black and white color scheme but can be distinguished by its larger body size (SVL range of 398–642 mm in both sexes); 17–17–13 dorsal scale rows; lack of anterior transverse bars; a continuous white lateral line extending from the anterior part of the neck terminating at the tail 1–2 dorsal scales rows wide; two anterior temporal scales; 134–154 ventral scales; and a bilobate hemipenis with a nude area on the lobes (data from Pauwels et al. 2003 and Cadle 2011). In addition, the genus *Sinonatrix* differs from *X. bellulus* by having two anterior temporal scales; 0–2 supralabials (rarely 3) in contact with the eye; a weakly forked hemipenis with a simple sulcus spermaticus terminating on the left lobe and lack of basal hooks and elongate spines (Rossman & Eberle 1977, Malnate & Underwood 1988).

Description of the Neotype (Fig. A–B).—A female specimen preserved in a circular arrangement and in good condition with no injuries or errors in preservation. The mouth is permanently open. SVL 429 mm, TailL 163 mm, TotalL 592 mm; TailL consists of 27.5% of TotalL. HeadL 18.5 mm, HeadW 10.1 mm; HeadL is of 3.1% of the TotalL. Eyes round, horizontal length 3.3 mm, vertical length 2.9 mm; horizontal eye length approximately 18.0% of the HeadL. Internasals rectangular, length 1.6 mm, width 1.3 mm, 1.2x longer than wide, wider posteriorly than anteriorly; prefrontals rectangular, length 1.8 mm, width 2.4 mm, 1.3x wider than long, 1.1x longer than internasals. The frontal scale appears pentagonal (shield-shaped) and is partially fused with part of the

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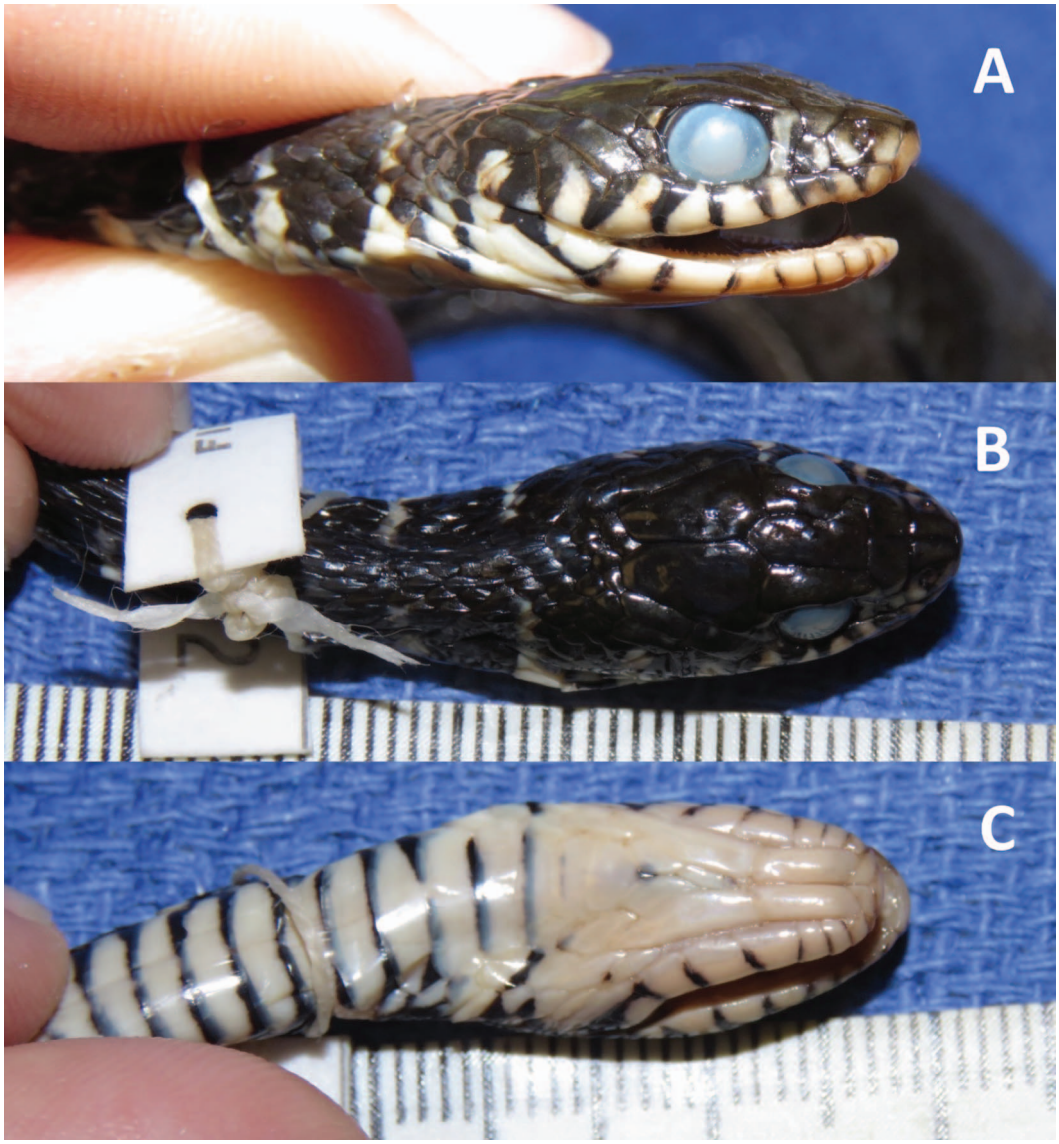


Figure 2. *Xenochrophis bellulus*, Neotype (USNM 587200): Lateral (A), dorsal (B) and ventral (C) views of the head. Photographs by Justin L. Lee.

supraocular on the left side. This appears to represent an abnormality. Frontal length is 5.4 mm, width 2.7 mm, 2.0x longer than wide, 3.0x longer than prefrontals. Parietal length 6.6 mm, width 4.2 mm, 1.6x longer than wide; 1.2x longer than frontal scale. Mental scale length 0.8 mm, width 3.2 mm, 4.0x wider than long; upper chin shield length 6.2 mm, width 2.0 mm; lower chin shields longer than upper chin shields, length 9.2 mm, width 2.9 mm; rostral barely visible from above, length 0.7 mm, width 3.2 mm, 4.6x wider than long. Dorsal scales in 19–19–17 rows, all keeled except for the first dorsal scale row which has some scales that are smooth or weakly keeled; 2 preventrals, 139 ventrals, all unkeeled; 71 paired subcaudals, all

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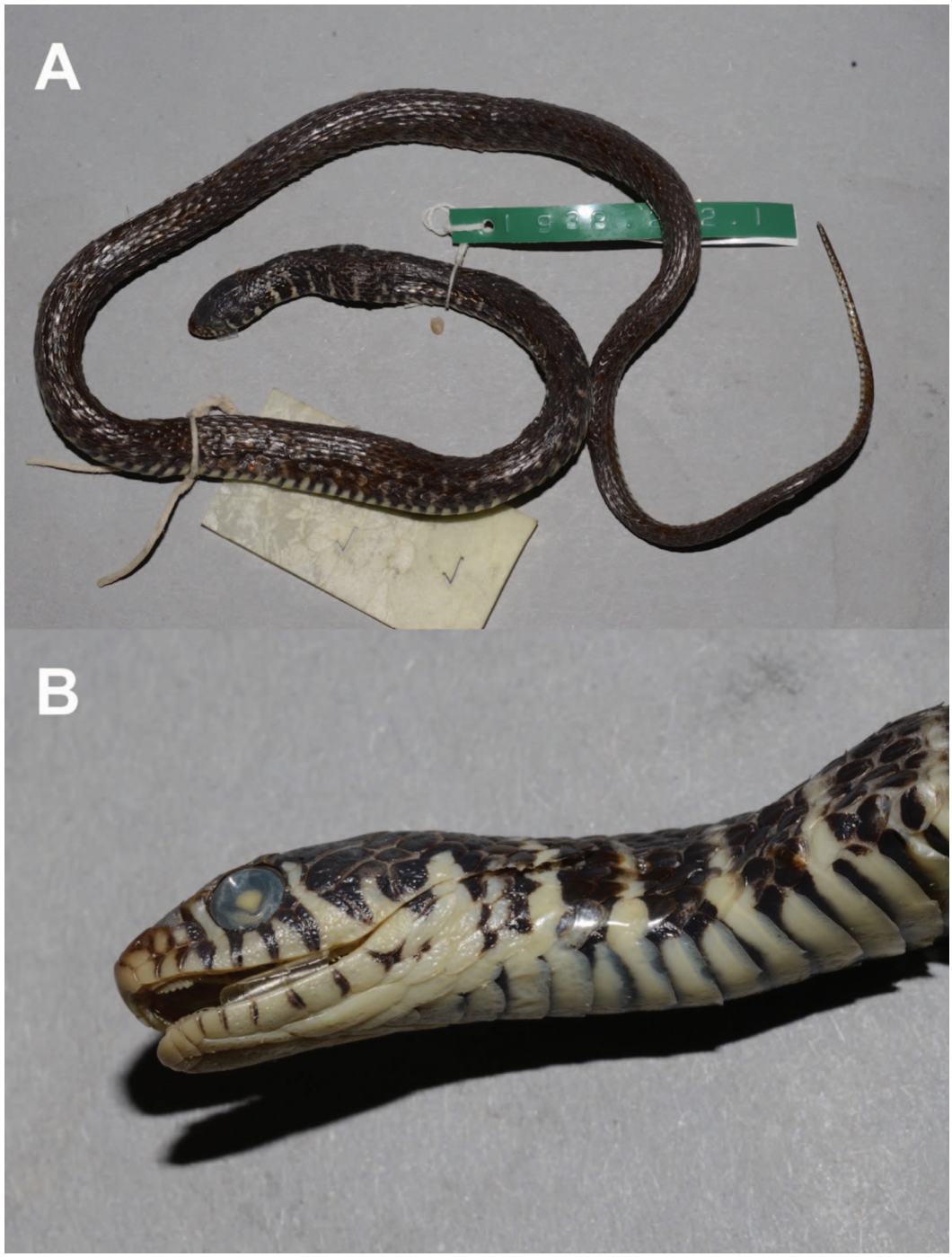


Figure 3. *Xenochrophis bellulus*, (BMNH 1938.2.2.1): General aspect (A) and dorsolateral view showing light anterior traverse bars, and the heavy dark margins on the ventral scales (B). Photographs by Gernot Vogel

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Figure 4. *Xenochrophis bellulus*, (CAS 222087) general aspect of preserved specimen. Photograph by Aryeh H. Miller.

unkeeled; divided anal plate; supralabials 9/9, on both sides supralabials 2–3 contacting loreal and supralabials 4–6 contacting eye; 8th labial is largest; infralabials 10/10, on both sides labials 1–5 contacting anterior chin shields, 5–7 contacting posterior chin shields; nasal scale divided; nostrils dorsolateral; single supraocular; preoculars 1/1; postoculars 3/3; temporals 1+1/1+1. 21 maxillary teeth on right side of the mouth, increasing in size posteriorly; diastema absent.

Coloration in preservative.—The dorsal portion of the head is jet black; a small white dot is present on anterior tip of both parietals; another spot is present on one of the occipital scales bordering the parietals; all supralabials, postoculars and preocular cream in color with black sutures on each scale; anterior supralabials and lower rostral slightly darker; chin and lower throat cream, most of the infralabials with black edges; loreal and nasal hued with white; all ventral and subcaudal scales white with conspicuous dark margins along the edges; ground color black anteriorly becoming olive brown towards the tail; the first row of dorsal scales have clear white fringes, also present along the tail; dorsum contains a faint checkerboard-like pattern made up of rectangular blotches along their flanks, larger anteriorly, nonexistent on the tail; anterior portion of the dorsum with series of white transverse bars outlined with black, the peak of each bar generally hued with olive-brown; the bars eventually dissipate forming small white spots midbody.

Variation (based on all four specimens; 2 males, 2 females).—All morphological

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Figure 5. The fully everted hemipenis of *Xenochrophis bellulus* (USNM 587199) showing (left–right) asulcate, sulcate and lateral views. Scale bar = 5 mm. Photographs courtesy of Alexandre Ascenso.

counts are similar between among specimens. Morphological variation is compared to the type description given by Stoliczka in Table 1. SVL 349–429 mm in males, 316–321 mm in females; TailL 141 mm–163 mm in males, 117–120 mm in females (male TotalL 490–592 mm, female TotalL 433–441 mm); tail consists of 27.5–28.8% of TotalL in males, 27.0–27.2% in females. HeadL 14.5–18.5 mm, HeadW 7.2–10.1 mm; HeadL consists of 3.1–3.8% of TotalL. Eyes round, horizontal length 2.5–3.3 mm, vertical length 2.1–3.1 mm; horizontal length of the eye 17.0–19.0% of headL. Internasals rectangular, 1.4–1.6 mm long, 1.0–1.6 mm wide, 0.9–1.4x longer than wide, always wider posteriorly. Prefrontals rectangular, 1.5–1.8 mm long, 2.0–2.5 mm wide, 1.3–1.7x wider than long, 1.0–1.1x longer than internasals. Frontal almost always pentagonal (partially fused with supraocular on the left side in USNM 587200), 4.4–5.4 mm long, 2.0–3.3 mm wide, 1.5–2.2x longer than wide, 2.8–3.3x longer than prefrontals. Parietals 5.1–6.6 mm long, 3.2–4.2 mm wide, 1.5–1.6x longer than wide, 1.1–1.3x longer than frontal. Mental scale length 0.7–0.8 mm, 2.2–3.2 mm wide, 3.1–4.7x wider than long. Anterior chin shields 4.0–6.2 mm long, 1.5–2.0 mm wide; posterior chin shields longer, 5.2 mm–9.2 mm long, 1.5–2.9 mm wide. Rostral barely visible from above, 0.7–1.2 mm long, 2.7–3.2 mm wide, 2.3–4.6x wider than long. Dorsal scales 19–19–17, keeled on all rows except for the first anterior row which can be smooth or slightly keeled; 2–4 preventrals; ventrals 137–139 in males, 135–143 in females, all unkeeled; 71–79 paired sub-

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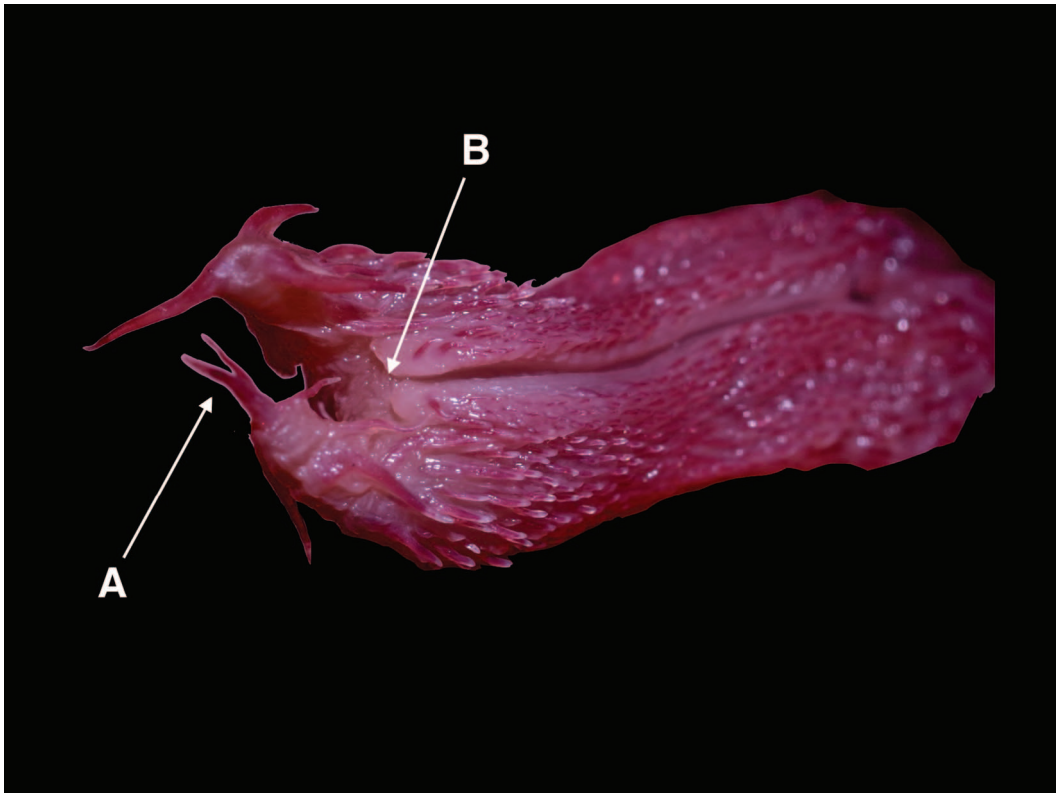


Figure 6. Apical view of the hemipenis of *Xenochrophis bellulus* (USNM 587199), showing (A) unique elongate spines protruding from the tip of each lobe and (B) the bifurcation point of the sulcus spermaticus, showing its shallowly forked condition. Photograph courtesy of Alexandre Ascenso.

caudals in males, 70–72 in females, all unkeeled; anal plate divided; supralabials 9/9 (n = 3) or 9/10 (n = 1), 2^{nd}–3^{rd} contacting loreal, 4^{th}–6^{th} contacting eye; infralabials 9/9 (n = 1) or 10/9 (n = 1) or 10/10 (n = 2), , 1^{st}–5^{th} in contact with anterior chin shields, 5^{th}–7^{th} in contact with posterior chin shields; nasal scale always divided, with dorsolateral nostrils; single supraocular; preoculars 1/1; postoculars 3/3; temporals 1+1/1+1 (n = 2) or 1+1/1+2 (n = 1) or 1+2/1+2 (n= 1). Maxillary teeth were not available to count in CAS 222087, but range from 18–21 in both USNM specimens, increasing in size posteriorly, lacking a diastema. The dentition of BMNH 1938.2.2.1 contains 31 maxillary teeth, plus three posterior teeth, which are notably enlarged and blade-like. The disjunct range in maxillary teeth may be due to the low number of specimens, which does not allow us to account geographic variation. The specimen could also be anomalous.

Minor differences in color pattern are present between specimens. USNM 587119 does not have black margins along the anterior infralabial scales. In CAS 222087, the posterior half of the dorsum is gray-brown with dark checkering, lighter than the anterior section. The dorsum of BMNH 1938.2.2.1 is black posteriorly. The skin on BMNH 1938.2.2.1 also contains pores across the entirety of the body, perhaps due to the preservation state or the age of the specimen. Our sample size is too small to determine if sexual dimorphism exists in this species. The two female

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specimens do not have any substantial differences in scalation or body measurements compared to the males, but the TailL/TotalL ratio in females is slightly lower than that of the males (27.0% vs. 28.0–29.0% in males).

Description of the Hemipenis.—Based on the left organ of specimen USNM 587199, which was half-everted before preparation, extending to the 9th subcaudal *in situ* and the *musculus retractor penis magnus* ending at the 23rd subcaudal. The fully everted organ is bliobed and semicapitate, the left lobe shorter and thinner than the right (asymmetrical). The *sulcus spermaticus* is shallowly forked and centrifugal, beginning laterally, dividing at the apex with branches reverting below the point of bifurcation forming a small nude area. Intersulcal region smooth, moderately depressed. Lobes contain elongate protruding spines at the terminal end, with three large spines on the left lobe and one large plus three slightly smaller spines on the right lobe. Capitulum contains several spinulous calyces, larger near the apex. Midsection of the asulcate side slightly raised, otherwise identical to the sulcate and lateral sides. Lower portion of the hemipenial body with large hook-shaped spines, increasing in size towards the base. Base bears smaller spinules similar to those on the capitulum.

Distribution.—*Xenochrophis bellulus* is considered endemic to south-central Myanmar, perhaps owing to its elusiveness in preceding and current collections. So far it is only known from Yangon, Bago Region and possibly the Magway Region (see Fig. 4). All four of these localities lie in the Ayeyarwady and Sittang River drainages, which pass through the Myanmar coastal rain forest and Irrawaddy moist deciduous forest ecoregions.

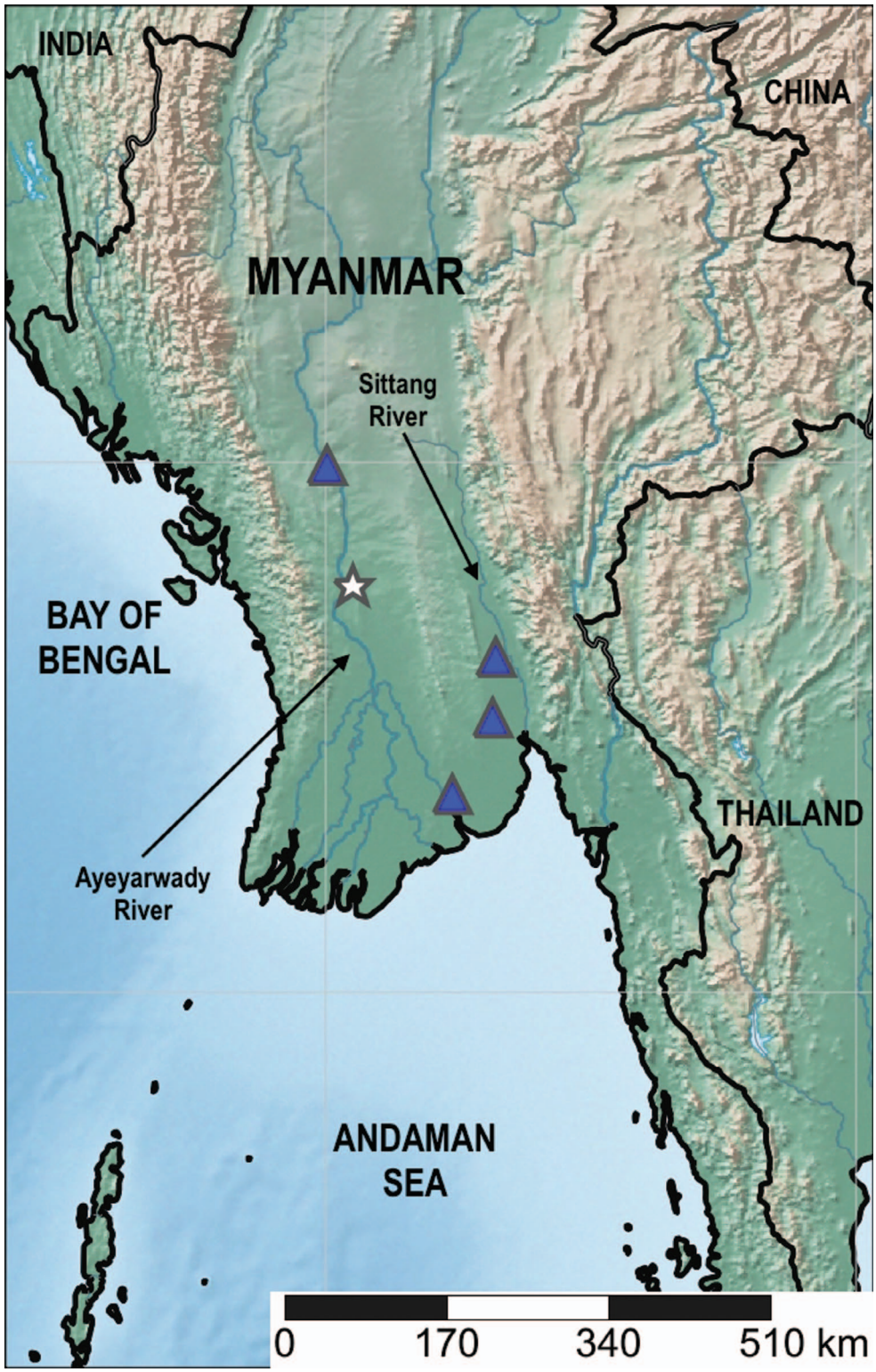
Habitat and Natural History.—CAS 222087 was collected close to a major paved highway surrounded by rice fields and patches of tropical dry forest. The USNM specimens were collected in fish traps during the morning hours. Other aquatic snakes sympatric with this species include *Enhydris enhydris* (Schneider, 1799), *Homalopsis semizonata* Blyth, 1855, *Xenochrophis flavipunctatus* (Hallowell, 1860), and *Xenochrophis piscator* (Schneider, 1799). One male (USNM 587200) contained fragments of an unidentified frog (Family: Dicroglossidae). The Ayeyarwady and Sittang River drainages lie along areas with a heavy agricultural presence, with patches of moist tropical deciduous forests. Similar to other Southeast Asian *Xenochrophis*, *X. bellulus* is likely semiaquatic and may be tolerant of agricultural expansion and anthropogenic landscapes. Its diet likely consists of amphibians and fish.

Etymology.—"*bellulus*" is a diminutive of the word "bellus" which roughly means "pretty little one" or "beauty" in Latin. Several authors, including Malnate & Underwood (1988), Wallach et al. (2014) and Uetz (2017) incorrectly spell this species as *Xenochrophis bellula*, perhaps in confusion with the taxon's previous affiliation(s) with the genera *Natrix* and *Sinonatrix*, which have a feminine gender in Latin. Since the genus *Xenochrophis* is considered masculine, the specific name should concordantly be "*bellulus*". Pauwels et al. (2001) spelled the name of this species correctly. No common name has been designated for this species. Therefore, we suggest the English name "Burmese White-barred Keelback", referencing its unique color pattern on the anterior portion of its dorsum, as well as its geographic distribution.

Conclusions

The identification of these four specimens as *Xenochrophis bellulus* agrees with the description of the holotype by Stoliczka (1871) and Smith (1943). Beside scale counts (see Table 1), all specimens share an anterior transverse black and white bar-

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ring on the dorsum, light infralabials and supralabials with a dark edge along the suture between adjacent labials, and a pale dot on each parietal.

Smith (1943) presumably examined BMNH 1938.2.2.1 in writing his account for *Natrix bellula*, but published ranges for several morphological counts in his treatment. He may have examined a second specimen (BMNH 1930.5.8.182) reported as *Natrix trianguligerus* by Wall (1926) for his analysis. Several discrepancies exist in Smith's description compared to our re-examination of BMNH 1938.2.2.1. Smith (1943) did not count ventral scales according to Dowling's method, so his count of "139–144" ventrals should actually be 137–142. Smith (1943) notes that the 3rd, 4th and 5th supralabials contact the eye, however in our re-examination of the same specimen we find that the 4th, 5th and 6th supralabials are the ones to contact the eye. Lastly, Smith (1943) describes the hemipenis as "to the 8th caudal plate, not forked". It is important to note that Smith's work came well before the publication of Dowling & Savage (1960), which established the terminology used by us in this paper. In their publication, Dowling & Savage (1960) use the term "forked" to describe the condition of the *sulcus spermaticus*, while the term "bilobed" is used to describe hemipenes with divided lobes. We assume that Smith (1943) is referring to the hemipenial body in *X. bellulus*, as he does not explicitly mention the *sulcus spermaticus* in this description. An examination of the hemipenis of USNM 587199 shows the organ is bilobed, similar to the finding of Malnate & Underwood (1988). Smith (1943) likely examined the hemipenis *in-situ*, where the bilobed condition is difficult to see until the organ is everted. The identification of BMNH 1930.5.8.182 from "Minhla" (= Minhla, Magway Region, Myanmar) reported in Wall (1926) as *X. bellulus* is problematic. The specimen is now known only from its skull and could not be examined during this study. Wall (1926) reports that the color of the specimen is "dark olive green with ill-defined and obscure quincunciate dark spots, less indistinct anteriorly. The belly is dirty white, the bases of all ventrals and subcaudals conspicuously black. There is periocular buff zone, and the upper labials have black posterior borders". Wall neglects to include whether or not the specimen has white anterior bars on its dorsum, but we can infer based on his other color notes that the specimen matches *X. bellulus*. Specimens of *X. trianguligerus* examined by us do not have black on the base of all ventral and subcaudal scales, and the black coloration is notably less conspicuous. Based on this description, we agree with Smith (1943) in the re-identification of this specimen.

A definitive phylogenetic position of *X. bellulus* is challenging. Many aspects of its hemipenial morphology are unique among natricines. In particular, the presence of long hook-like spines on the basal portion of the organ, a shallowly forked *sulcus spermaticus*, and asymmetrical lobes with elongated spinous tips. Contemporary reviews of natricine hemipenis have noted spines at the end of lobes (Rossman & Eberle 1977, McDowell 1987, Malnate & Underwood 1988, Cadle, 2011), but these ornamentations are not as long or protrusive as those in *X. bellulus*. Cadle (2011) noted the presence of nude areas on the lobes for several species of *Xenochrophis*. Such a condition is seemingly present on *X. bellulus* though the nude area does not seem to extend onto the lobes in a way similar to that of other *Xenochrophis*. *X.*

←

Figure 7. Distribution of *Xenochrophis bellulus* in Myanmar based on literature records and examined specimens (blue triangles). The white star represents the type locality. Map created using http://www.simplemappr.net/

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bellulus also shares a bilobed hemipenis, forked *sulcus spermaticus* with *Xenochrophis* in addition to similarities in scutellation and behavior. Therefore, we agree with Malnate & Underwood's interpretations that *X. bellulus* shares more apomorphies with taxa assigned to *Xenochrophis* than *Sinonatrix*, but note that the phylogenetic relationships of the two genera in relation to other Southeast Asian natricines is far from resolved. Molecular analyses conducted by Dubey et al. (2012) and Guo et al. (2012) suggest that *Xenochrophis sensu stricto* is not monophyletic. Members of the *X. piscator* group nested with members of the genus *Atretium,* and *X. vittatus* (Linnaeus, 1758) was placed sister to *Rhabdophis*. Several species of *Xenochrophis* and many other southeast Asian natricines were not included in these molecular analysis. An equal number of natricines are poorly known taxonomy-wise and lack a detailed description of their hemipenial morphology. Until future phylogenetic studies sample more species and additional hemipenial descriptions become available, we recommend keeping this species in *Xenochrophis*.

In conclusion, *Xenochrophis bellulus* remains one of the most poorly known of all natricine snakes in Southeast Asia. Its presence in the Moyingyi Wetland Wildlife Sanctuary adds to the high levels of aquatic snake diversity known in the region (see: Habitat and Natural History), and enforces the characterization of this region as exceptionally diverse for amphibians and reptiles in Myanmar (Zug et al. *in prep*). For now, the conservation status of this species appears stable, given its presence in a preserved wildlife sanctuary with substantial wetland habitat and minimal human disturbance. However, herpetological surveys are needed to confirm its distribution and abundance further east along the Ayeyarwady River in Yangon and Magway. It is our hope that the data provided in this paper will help clarify the relationships of this taxon and lead to a better understanding of the evolutionary history of natricine snakes throughout Southeast Asia.

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Appendix.1. Specimens Examined

Sinonatrix aequifasciata (n = 4).

China: Guangdong: ZMB 38660 & ZMB 67317 "Wutzung, South Kuantung". Hainan: ZMB 29234.

Myanmar: Sagaing Region: CAS 245264–5, Lahe Township, Khandi District (26°19′32.7" N, 95°26′57.6" E).

Vietnam: Tam Dao: NHMW 39555.

Sinonatrix annularis (n = 7).

China: Fujian: ZSM 8.1947 "Kuantung, Fukien"; ZSM 159.1947, "Kwangtsets, Fukiewn". Jiangxi: NHMW 22447.2 & NHMW 22576 "Pingskiang" (= Pingxiang). Taiwan (Taipei): ZSM 159.1947 "Tamsui, Nord Formosa" now Tamsui District, New Taipei. Zhejiang: ZSM 31.0 "Ning-Po Gebirge".

Sinonatrix percarinata (n = 13).

China: Jiangxi: NHMW 14184.1–.2 "Pingshiang" (= Pingxiang); RMNH 4590 "Pingshiang, Kiangsi" (= Pingxiang, Jiangxi); SMF 17407 "Pingshiang, Kiang-Shi" (= Pingxiang); ZSM (no number) "Shin-Chow-Fu". Shandong: SMF 17404 "Tsingtau, Deutsch China" (= Qingdao, Shandong). Taiwan (Taipei): NHMW 22411.3 & NHMW 22411.10 "Taihorin". Zhejiang: ZSM 1452.0 "Ning–Po Gebirge" (= Ningbo).

Myanmar: Kachin State: BMNH 1936.7.4.90 "Gole Tutap, Upper Burma"; BMNH 1940.6.4.19 "Sumprabum Triangle, Upper Burma".

Xenochrophis trianguligerus (n = 18).

Myanmar: Tanintharyi Region: USNM 587045, Yeybu village, 6.5 km (air) NE of, Yeybu-chaung-ngal (stream) (12°26′2.76" N, 99°8′42.36" E; 156 m. in elevation). BMNH 1940.3.4.11, Mergui.

Indonesia: Java: RMNH 1102, no exact locality, lectotype; Sulawesi: BMNH 96.4.29.26, Indrulaman, South Sulawesi, 2000ft; BMNH 1980.912–913, Torro, Kulawi, Kabupaten Donggala, Central Sulawesi, 600 m. Sumatra: BMNH 1915.12.2.32, Sandaran Agong, Korinchi, 2450ft; BMNH 1920.1.16.15, Lebong Tandai; NMHW 22404:1–4, NHMW 14093 Deli (=Medan); RMNH no number, Padang. Ternate: BMNH 781.31.12 no exact locality. Nias. BMNH 85.5.4.9–12

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