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CHECKERED KEELBACKS (*XENOCHROPHIS* - REPTILIA: SERPENTES: NATRICIDAE) AT THE MOYINGYI WETLAND BIRD SANCTUARY, MYANMAR

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(with six text-figures)

ABSTRACT.– Two colour morphotypes of *Xenochrophis* occur syntopically at the Moyingyi reserve in south-central Burma (Myanmar). A mensural and meristic analysis indicates that these two colour morphs represent distinct species: *X. flavipunctatus* and *X. piscator*. In Myanmar, the former is the smaller (adult females 440-694 mm SVL) of the two (*piscator* females 540-800 mm). The two species share scalation traits but are readily distinguished by a plain venter in *X. piscator* and black-lined ventral scales in *X. flavipunctatus*. Preliminary distributional data suggest that south-central Myanmar is the western limits of *X. flavipunctatus*, a predominantly south-east Asian species; the eastern limits of *X. piscator*, a predominantly South Asian species, appears to occur in western Laos.

KEYWORDS.– Squamata, Natricidae, *Xenochrophis*, morphological analysis, species differentiation, taxonomy, nomenclature, distribution, Myanmar (Burma).

INTRODUCTION

The Moyingyi Wetland Bird Sanctuary lies about 80 km northwest of Yangon in the deltaic area of the Waw River. This small oasis of semi-natural wild rice marsh hosts several kinds of aquatic snakes: *Enhydris enhydris*, *Homalopsis buccata*, *Amphiesma* sp., and seemingly two species of *Xenochrophis*. The latter two are the most frequently seen snakes owing to their superficial, terrestrial foraging.

Because one of the *Xenochrophis* morphs appears more slender and brighter coloured and possesses black-lined ventral scales, we identified this morph as *X. flavipunctatus*, and the heavier-bodied and duller snake as *X. piscator*. Our search of the herpetological literature to confirm our species assignments did not yield confirmation owing to the lack of a consensus on the status of *X. flavipunctatus* as either a distinct species or a colour variant of *X. piscator*.

Xenochrophis flavipunctatus was described from the Pearl River, presumably in the vicinity of Hong Kong (Hallowell, 1861). This name has been variously used since then. Boulenger (1893) placed it in the synonymy of *X. piscator*. Malcolm Smith (1943) recognized it as a subspecies of *X. piscator*, and in 1965, Taylor declared it a distinct species with both species occurring in the same streams and ponds of northern Thailand. Subsequently and more recently, it has been variously recognized as a distinct species (e.g., Manthey and Grossmann, 1997; Gruber, 2002) or as colour variant, hence a synonym (e.g., Zhao and Adler, 1973; Cox et al., 1998).

The presence of both morphologies at the Moyingyi reserve and their syntopic occurrence suggested that we had two species; nonetheless, we were not totally convinced or satisfied with this ad hoc conclusion. We decided to examine the question further and present here our observations and interpretations.

MATERIALS AND METHODS

Our examination of variation in the morphology of these two colour types focuses on our Moyingyi sample with a few additional specimens from other parts of Myanmar (n = 11) and a few from elsewhere in Asia (n = 12; see Appendix I: Specimens examined). We selected a set of mensural and meristic characters of external morphology that encompassed most of the traits used in previous studies and descriptions of *Xenochrophis*. These traits consist of 9 head and body measurements (millimeters, usually to 0.1 mm), 16 features of scalation (present & absence characters as binary and quantitative ones as integers), and 8 aspects of colour pattern (present and absent as binary, multistate as unordered numeric values); these are detailed in Appendix I: Characters examined. The condition of each bilaterally symmetrical character was recorded from the right side unless damaged. All individuals were sexed and maturity determined by dissection and examination of the gonads. Mature females possess vitellogenic follicles >2.0 mm, oviducal eggs/embryos, or stretched but empty oviducts; mature males have enlarged testes and strongly convoluted epididymides. Determination of maturity for female is more reliable for individuals in transition owing to the discreteness of virginal versus nonvirginal oviducts in females compared to the recognition of "enlarged" testes in males. Nevertheless, we are confident on the accuracy of the minimum adult size of our samples. All analyses were performed with SYSTAT 10.2

Table 1. Summary of select characters in adults of the two morphotypes of *Xenochrophis "piscator"*. Values are means ± standard deviation and range; measurements are in millimeters.

	n	SVL	TailL	HeadL	Ventral	Subcaud
flavipunctatus						
Moyingyi						
females	3	536.3 ± 137.6	193.0 ± 45.3	21.8 ± 4.4	139.0 ± 2.8	75.0 ± 1.0
		440-694	162-245	19.2-26.9	137-143	74-76
males	1	434	191	24.4	129	80
Hong Kong						
females	1	577		30.2	136	
males	3	428.7 ± 38.4	191.5 ± 41.7	24.4 ± 2.5	127.0 ± 1.0	70.0 ± 14.1
		394-470	162-221	22.7-27.3	126-128	60-80
piscator						
Moyingyi						
females	5	646.8 ± 61.2	220.3 ± 17.1	33.7 ± 2.8	140.6 ± 2.7	76.5 ± 2.4
		565-714	201-237	29.6-37.5	137-147	74-79
males	1	555	239	30.1	134	86
Myanmar						
females	9	647.4 ± 85.7	212.4 ± 20.3	34.0 ± 4.1	142.8 ± 3.3	76.4 ± 2.4
		540-800	186-237	29.4-41.0	137-147	73-79
males	5	464.4 ± 87.3	210.2 ± 39.5	26.1 ± 3.9	136.4 ± 1.8	88.4 ± 2.3
		320-555	142-239	19.8-30.1	134-139	86-92

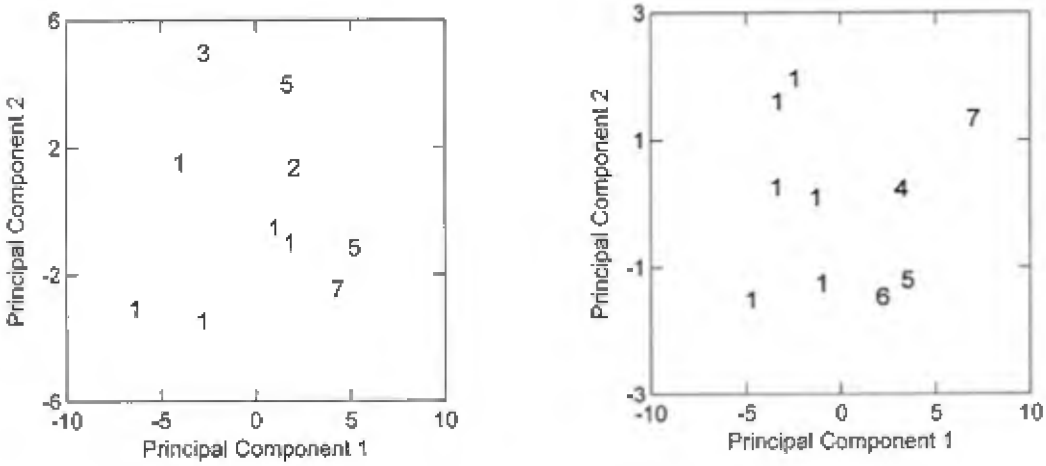

Figure 1. Principal components comparison (scalation) of Moyingye *Xenochrophis piscator* females (left) and males (right) with conspecifics from other Myanmar localities. Symbols: 1, Moyingyi; 2, Bago Yoma; 3, Mwe Hauk; 4, Shwe-Settaw; 5, Shwe-U-Daung; 6, Le Kiang; 7, Pyin-Oo-Lwin.

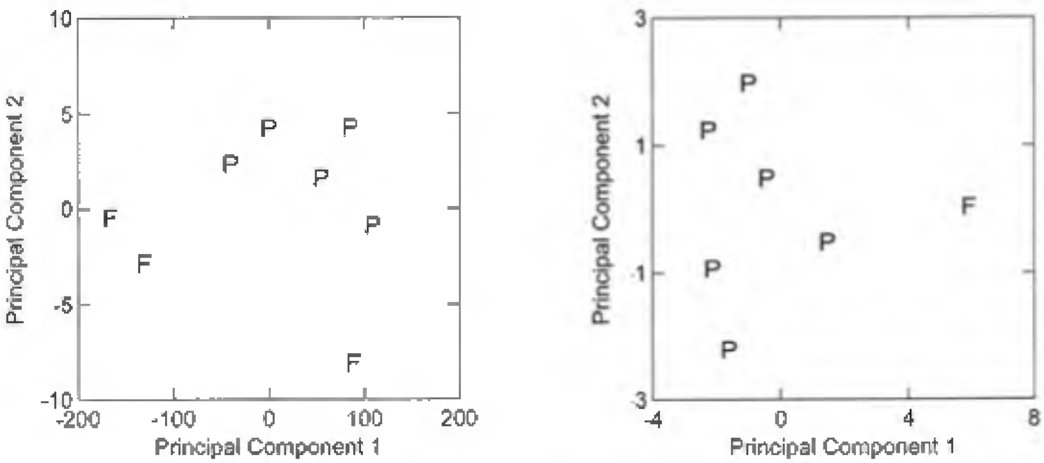

Figure 2. Principal components comparison of female (left; measurements) and male (right; scalation) *Xenochrophis flavipunctatus* and *X. piscator* from the Moyingyi Wetland Bird Sanctuary. Symbols: F, *flavipunctatus*; P, *piscator*.

statistical software; all principal components analyses (PCA) used covariance matrices and no rotation of axes.

RESULTS

Within sample variation.– Our sample sizes are small and do not permit statistically valid tests of character dimorphism between adult females and males. Sexual dimorphism, nevertheless, is indicated for some characteristics (Table 1) in both colour morphs: SVL and other measurements; Ventral; Subcaud. This dimorphism is the same for the *flavipunctatus* and the *piscator* morphs and in all samples. Females average larger, have more Ventral and fewer Subcaud. Increasing sample size by combining all adult and juveniles of Myanmar *piscator* (n = 15, 10; female, male, respectively) confirms the scalation dimorphism: Ventral 142.8, 137-147 & 133.8, 130-139 (t = 7.13 df 23 p<0.01); Subcaud 78.1, 73-83 & 87.4, 84-92 (t = 7.27 df 18 p < 0.01), respectively.

Owing to small sample sizes for adults, variance of the mensural characters is generally high within the Moyingyi *flavipunctatus* and the *piscator* samples. Coefficient of variation

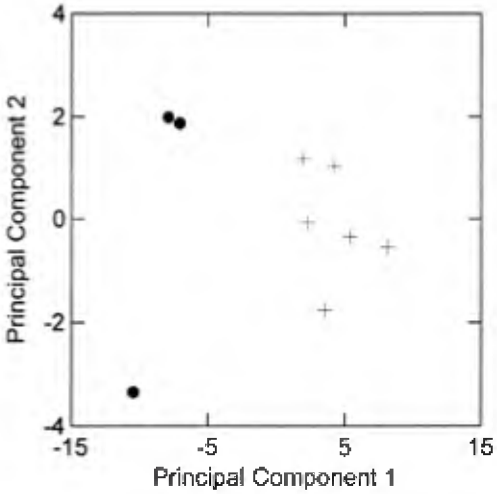

Figure 3. Principal components comparison (scalation) of Hong Kong and Moyingyi *Xenochrophis flavipunctatus*. Symbols: plus, female; circle, male.

(*V*) for SVL of female *flavipunctatus* is 24%; the other mensural parameters are slightly lower and about the same for SVL, OrbD, Intorb, and Intnar of the two adult males and 10-15% for the males' TailL, HeadL HeadW, SnEye, and NarEye. For Moyingyi *piscator* females, *V* falls within the usual range of populational variation, that is, *V* = 9.5% for SVL and 7.8-11.9% for the other mensural characters.

For scalation, *V* for adult female *flavipunctatus* from Moyingyi ranges from 0 to 40%. Many of the scalation traits are invariant (*V* = 0%, e.g., Suplab) or rarely variable (40%, LorS; a single deviation in an otherwise uniform trait generates a high *V*). Ventral and Subcaud have low variation, *V* = 2.0 & 2.9%, respectively. Adult female *piscator* show the same levels and patterns of variation as the female *flavipunctatus*. The combined Myanmar *piscator* sample (juveniles and adults from all Myanmar localities) has the same level of variance (e.g., female Ventral *V* = 2.2%) as for the Moyingyi sample.

Variance, as expressed by *V*, for colouration traits is either 0% or extreme (e.g., 62.5% PaSpot for all Myanmar *piscator* females). Both the artificial coding and the infrequent occurrence of one state result in high *V*.

The Hong Kong adult males (*n* = 3) show a low variance: *V* = 9% SVL, 10% HeadL, 15% HeadW, SnEye 7%. The pattern of variation matches that of the Moyingyi and all-Myanmar *piscator* samples.

Among sample variation.– The all-Myanmar sample of *piscator* derives from several distant localities and possibly may represent different species. Although this study cannot address the possibility of geographic differentiation, we used principal components analyses (PCA) to examine how members of the sample were distributed in multi-character space. PCA results of adult males and females separately each for mensural and scalation suggest homogeneity within this sample. The analyses identifies SVL with the highest component loading (85.7, 66.4; female, male) in both sexes, HeadL and HeadW as distant seconds in loading (range 2.0-4.0), and the other measurements < 0.9. The first component accounts for 99.9% of variance in both sexes, hence placement in PC space is largely by size/length of the individual snakes. For scalation of juveniles and adults of the all-Myanmar sample, females and males have Ventral, Subcaud, and Preven as the traits loading highest on the first component. Subcaud and Ventral loadings (-2.9, -2.2, respectively) are nearly equal in females, and Ventral (3.0) and Subcaud (1.8) loadings are less similar in males. Preven (0.5, -1.4) loading is less strong in females. For the second component loading, Ventral and Subcaud are the major loading traits for females and all three for males. The first component accounts for 60% of the scalation character-set variance in females and 84 % in males, 35% and 10%, respectively, for the second component. We note that component scores (Fig. 1) show some segregation of the Moyingyi snakes from those of other localities.

PCA comparison of the two Moyingyi morphotypes by measurements reveals SVL, HeadL, and HeadW as the traits with the major loading on the first component, and the first component accounts for 99.9% of the variance. Size provides a strong segregation of the *flavipunctatus* and *piscator* samples (Fig. 2). PCA of scalation does not demonstrate a segregation of the two morphotypes (Fig. 2). As in the all-Myanmar *piscator* sample, Ventral and Subcaud have the highest loading in both the first and second components. The first component accounts for 65% of sample variance, the second for 30%.

Figure 4. Morphology of Moyingyi *Xenochrophis flavipunctatus* (left; USNM 562757) and *X. piscator* (right; USNM 562766). Top, dorsal views; bottom, ventral views.

Comparison of Moyingyi and Hong Kong *flavipunctatus* rests mainly on scalation, because SVL weighs so heavily on the first and second components. Although the average SVLs differ somewhat (Table 1), the differences are not great, and the ranges of SVL for the adults of each sex from the two localities strongly overlap. PCA of scalation for a combined female-male sample identifies Ventral with the highest loading (5.8) on the first component (91% of

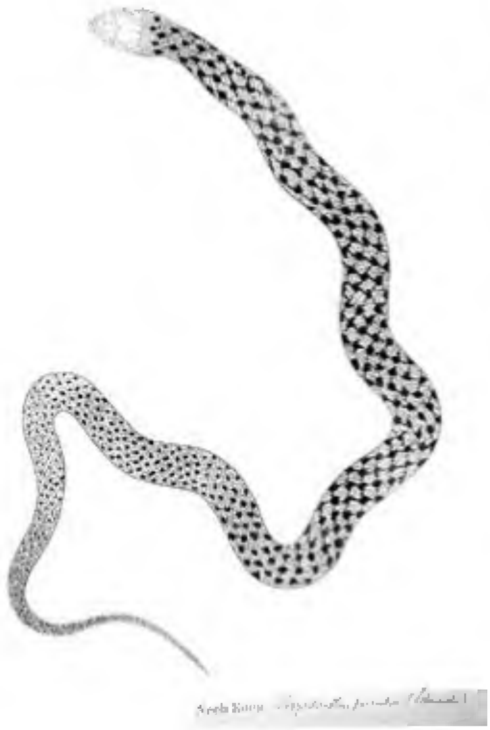

Figure 5. Reproduction of plate 20 from Russell's "Account of Indian serpents…" (1796). This illustration is the holotype of *Hydrus piscator* Schneider, 1799.

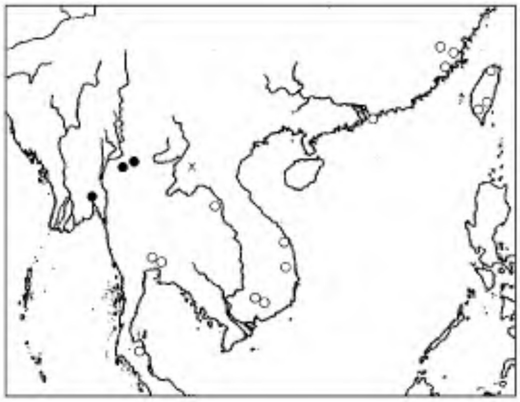

Figure 6. General occurrence of *Xenochrophis flavipunctatus* (open circles) and *X. piscator* (X) in south-east Asia; a solid circle denotes the sympatric occurrence of the two taxa. Localities based on an examination of *Xenochrophis* specimens in the USNM herpetological collection.

variance), Subcaud (3.2) as second, and Inflab (0.2) as a distant third factor in loading. Loading on the second component (6% of variance) reverses the loading weights of Subcaud (-1.05) and Ventral (-.6), and elevates the influence of Inflab (1.11). The distribution of females in PC space (Fig. 3) clusters the Moyingyi and Hong Kong females. Similarly, a Hong Kong and a Moyingyi male are close (upper middle of Fig. 3); the male syntype (USNM 7387, Hong Kong) is strongly segregated from all females and the other two males, although it shares a similar valued negative PC 1 as the other males. The outlier status of the syntype probably derives from possession of 85 Subcaud, 5 more than any other *X. flavipunctatus* specimens; its other characters are within the range of the other *flavipunctatus* specimens.

Our sample of two male *X. piscator* from Orissa suggest that this population is similar in size and proportions to the Myanmar *X. piscator*. Scalation is also similar, although the Orissa males have 135, 130 Ventral and 76, 83 Subcaud (CMNH 96315-316); these values are at the lower end of the range for these traits in the Myanmar males.

Our quantification of colouration shows no differences between the two morphotypes other than black-lined ventral and subcaudal scales of *flavipunctatus* contrasting to the plain venters of *piscator*. Similarly in none of the samples can we detect any sexual differences in colouration. Within the Moyingyi samples, more (71%) of the *flavipunctatus* have PaSpot and NucStrp than *piscator* (36%). The proportion decreases slightly for PaSpot (30%) for the all-Myanmar sample and increases slightly for NucStrp (40%). In Moyingyi *flavipunctatus*, BodyLatN ranges from 20 to 73 (median = 56), whereas the range for *piscator* is 48-57 (52); however, BodyLatN variation increases (10-65) in the all-Myanmar sample even though the median remains unchanged. The Hong Kong and Moyingyi *flavipunctatus* share similar colouration values, including the median and range of BodyLatN.

A visual comparison of Moyingyi *flavipunctatus* to Moyingyi and all-Myanmar *piscator* demonstrates a few colouration differences that are not evident from our quantification. Both morphotypes possess distinct subocular and postocular dark stripes (Fig. 4), but in *flavipunctatus*, the NucStrp is truly nuchal in position, arising on the last Inflab, just posteriorad to the

PosttmpStr and immediately curving dorsally on the first dorsal scale row. In contrast, the NucStrp of *piscator* arises on the fourth or fifth dorsal scale row and curves upward. Dorsally, the NucStrp of *flavipunctatus* forms a parallel-sided loop (Fig. 4) extending anteriorly onto the posterior surface of the parietal scales. This anterior loop is uncommon in *piscator*, and if present, the loop is not a continuous dark line. Another difference is the shape of the BodyLatS: narrow (one scale row in width or less) vertical bars in *flavipunctatus*; blotches or spots (about 2 scale row in width) in *piscator*. Most *flavipunctatus* have many dorsal scales narrowly edged in cream; this edging is absent in *piscator*.

DISCUSSION

The goal of our study focused on the question of intraspecific polymorphism or speciation of the *flavipunctatus* and *piscator* morphotypes. The study confirmed our visual impression of a modest level of morphological differentiation of these morphotypes at the Moyingyi reserve and the persistence of the difference when the *piscator* sample is enlarged to include representatives of *piscator* from elsewhere in Myanmar. We interpret these differences to support the recognition of the black-lined ventral morphotype as a distinct species, *Xenochrophis flavipunctatus*. Subsequent comments proceed from this hypothesis.

Variation at Moyingyi and within Myanmar.– We used PCA as an exploratory tool because we wished its assistance in examining the relationship of individuals in multi-character space. Without PCA of mensural traits, Moyingyi adult *Xenochrophis flavipunctatus* are on the average smaller than co-occurring *X. piscator* in all traits (Table 1). Our samples are too small to test, via covariance analysis, whether proportional differences exist between the two taxa. Both taxa display sexual dimorphism with females larger than males. The preceding size difference are strengthened by enlarging the *X. piscator* sample with individuals from other Myanmar localities.

The PCA of mensural data emphasizes size, SVL with highest loading and greatest contributor to overall variance, and this size component readily segregates Moyingyi *X. flavipunctatus* and *X. piscator*. Scalation shows no striking difference between the two species at Moyingyi and Moyingyi *flavipunctatus* from "all" Myanmar *piscator*. Ventral and Subcaud have nearly matching ranges and means (Table 1) for females and more Ventral and fewer Subcaud in male *X. flavipunctatus*. A concordance occurs in all other scalation traits. A PCA of scalation results in a segregation of males of the two taxa (Fig. 2, right) with highest loading on Ventral and Subcaud.

We did not perform PCA on colouration owing to our arbitrary coding of character states. Colouration does differentiate the two taxa, at first glance by the brighter appearance of *X. flavipunctatus* with its lighter coloured head and neck with hints of red and yellow. In hand, the plain venter of *X. piscator* contrasts sharply with the black-lined ventral scales of *X. flavipunctatus*. Less apparent, but no less distinct, are the position of the nuchal collar, middorsal shape of collar, and ventrolateral body marks between the two taxa in Myanmar and elsewhere in Asia. These colouration differences re-enforce our interpretation of the two taxa being distinct phylogenetic lineages.

Although less apparent from our analysis, the *X. piscator* from multiple and distant localities in Myanmar hint at geographic differentiation among this lineage. Both the PCAs (scalation) of females and males place the non-Moyingyi specimens in different quadrates of the graph (Fig. 1). Individuals from more northern Myanmar localities have a less large-spotted pattern. This geographic variation requires a more detailed investigation.

Variation elsewhere in southern Asia.– The type locality of *Hydrus piscator* Schneider is eastern India, likely the Coromandel Coast (roughly 10° 30'N to 16° 20'N) where Russell worked. Specimens from this latter area were not available to us to compare directly with Moyingyi *piscator*. Two males *X. piscator* (CNMH 69315-316; Orissa - Puri) from further north have size and scalation characteristic that lie within the range of the Moyingyi sample. As noted in the comparison of Myanmar *X. piscator*, there is a possibility of colouration differences among populations, but comments beyond this observation are unwarranted from our samples.

Although our study does not address *X. piscator* as a single or several species, we offer a few observations derived from our review of the literature and superficial survey of specimens in the USNM herpetological collection. The taxon *piscator* is based on an illustration in Russell's account of Indian serpents (1796: plate 33, text pp. 38-39). The illustration bears the name "Neeli Koea," which represents a local vernacular name. This diagrammatic illustration (Fig. 5) shows a dorsal pattern of five rows of equal-sized spots on the trunk. This pattern is similar to the dorsal patterns of M. Smith's *Natrix piscator* (1943: fig. 96 C & D), Whitaker and Captain's photographs (2004: 223), and other illustrations of Indian *X. piscator*. This regular spotted pattern is matched by the Moyingyi and many other Myanmar specimens, and as in the Russell illustration, the spotted pattern becomes reduce or amorphous on the posterior two-thirds of body and tail. The venter is not displayed in the Russell illustration, although his remarks in the text (1796: 39) indicate a plain "yellowish white" venter. These observations confirm our use of *piscator* for the Myanmar immaculate-bellied Myanmar morphotype. Associating the name *piscator* with this morphotype yields a distribution (Fig. 6) for the *X. piscator* taxon extending from the Indus valley (Minton, 1962) through the Indian subpeninsula and Myanmar into northern Thailand and western Laos (USNM 68133 [Laung Prabang]).

At present, we have seen voucher specimens of Myanmar *X flavipunctatus* only from Moyingyi. We expect this taxon to occur more broadly in Lower Burma (i.e., lowlands and coastal areas S of 19°N) and through the Thaninthary Division. *X. flavipunctatus* is the common *Xenochrophis* across south-east Asia and southern China to Taiwan (Fig. 6). Our cursory survey of all USNM "*piscator-flavipunctatus*" specimens suggests that the Javanese population requires close examination to determine its relationship to the mainland populations. Others (e.g., David and Vogel, 1996) have noted the differentiation of Sumatran and Javanese populations from the mainland ones. There is a similar need to confirm the distribution of these snakes in other Sundaic islands.

Taxonomic comments.– Although the preceding results are preliminary in the evaluation of geographic variation of *Xenochrophis flavipunctatus* and *X. piscator*, and are hampered by small samples, we are confident that the trends reveal the basic patterns that will emerge from a broader and larger sampling of both taxa across the breadth of southern Asia.

We draw two conclusions from our analysis: 1) *flavipunctatus* and *piscator* morphotypes represent distinct evolutionary lineages; and 2) *piscator* "group" populations display geographic differentiation, thus suggesting multiple separate genetic "entities." These conclusions have broader implications for the taxonomy of *Xenochrophis piscator* group snakes throughout southern Asia. We address only one taxonomic item associated with the recognition of *Xenochrophis flavipunctatus* as a broadly distributed south-east Asian species.

Recognition of *Xenochrophis flavipunctatus* as a distinct species requires the resolution of a nomenclatural matter: fixation of the type specimen for this taxon. Hallowell (1861: 503) based his description of *Amphiesma flavipunctatum* on a single specimen from the Canton River. His second specimen derived from the "Island of Hong Kong," but owing to the Hong Kong specimen being "somewhat injured" and smaller than the Canton R. one, he chose to base his description exclusively on the Canton R. specimen. Having noted both in the description and referring to the Hong Kong as a type denote that the two specimens are syntypes. The Hong Kong specimen still exists as USNM 7387. The Canton River specimen, presumably ANSP 6616, was not located when Malnate prepared the Academy's herpetological typelist (1971). This specimen's absence was confirmed by N. Gilmore (in litt., 15 June 2004). The catalog entry for ANSP 6616 gives the locality as "Canton River" and denotes "Dr. Ruschenberger" as collector or donor. The original catalog entry for USNM 7387 is solely the locality "Hong Kong." Sex, taxonomic identity, collector/donor, and its identification as a type were entered in the catalog register subsequently in pencil (not dated) by Doris Cochran (identified by handwriting). She (Cochran, 1961) listed this specimen erroneously as a holotype and without reference to the ANSP specimen. Because USNM 7387 appears to be the sole survivor of the two syntypes noted by Hallowell, we designate this specimen as the lectotype of *Amphiesma flavipunctatum* Hallowell, 1861.

USNM 7387 is a juvenile male; viscera are somewhat macerated, so determination of sex is uncertain although a small testis and a straight segment of a sperm duct were tentatively recognized. Its measurements are: 273 mm SVL; 125 mm TailL; 16.7 mm HeadL; 6.6 mm HeadW; 4.1 mm SnEye; 2.9 mm NarEye; 3.3 mm OrbD; 4.2 mm Intorb; 1.9 mm Intnar; 9 Suplab; 7 Inflab; 1 LorS; 1 Preoc; 4 Postoc; 2 Tempor1; 2 Tempor2; 19 DorsalAnt; 19 DorsalMidb; 17 DorsalPost; 128 Ventral; 85 Subcaud; 1 Preven; 1 Anal; 1 KeelD; 0 KeelVnl. Colouration: distinct postocular black-lined eye stripe; dark nuchal collar dorsally from angle of mouth upward along rear of temporals to midline, anterior loop indistinct although white spot with dark edge on nuchal scales; dorsal spots small and indistinct except for ventrolateral ones on anterior quarter of trunk; numerous clusters of bright beige scales (2-4); ventrals from neck onto tail transversely black-lined at scale attachment.

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Appendix I

A. Definition of characters.

Mensural. [mm; all bilateral measurements recorded from the right side.] Snout-vent length (SVL): distance from tip of snout to vent. Measurement taken with side of the snake pressed against meter rule. Head length (HeadL): straight-line, horizontal distance from tip of snout to posterior corner of jaws. Head width (HeadW): straight-line, transverse distance from left to right edges of head at posterior edges of last supralabials. Internarial distance (Intnar): transverse distance between left and right nares. Interorbital distance (Intorb): transverse distance between left and right anterodorsal (anteromedial) edges of orbits. Naris-eye distance (NarEye): distance between naris and anterior corner of orbit. Orbit diameter (OrbD): distance from anterior medial to posterior medial edge of orbit (maximum horizontal diameter). Snout-eye distance (SnEye): distance between middle/tip of snout to anterior corner of orbit. Tail length (TailL). distance from vent to tip of tail.

Scalation. [All bilateral characters recorded from right side.] Anal (Anal): anal scale entire (0) or divided (1). Rows of dorsal scales anteriorly (DorsalAnt): number of rows dorsal scales at one head length behind head. Rows of dorsal scales at midbody (DorsalMidb): number of dorsal scale rows at midbody. Rows of dorsal scales posteriorly (DorsalPost): number of dorsal scale rows at one head length in front of vent. Infralabials (Inflab): number of scales edging mouth (lower mandible) from first touching mental to last enlarged scale below last supralabial. Keeling middorsally (KeelD): relative amount of keeling of first parasagittal dorsal scale at middle of body: none (0); distinct but moderate height (1); strongly elevated (2). Keeling ventrolaterally (KeelVnl): keeling of second dorsal scale from ventrals; coding as for KeelD. Loreal shape (LorS): height > length (0), H = L (1), H < L (2). Postoculars (Postoc): number of postocular scales. Preoculars (Preoc): number of preocular scales. Preventral scales (Preven): number of enlarged scales anterior to first ventral scale. Subcaudals (Subcaud): number of subcaudal scales, excluding tip scale. Supralabials (Suplab): number of scales edging upper mandible from first touching rostral to last enlarged scale at posterior edge of mouth. Primary temporals (Tempor1): number of primary temporal scales. Secondary temporals (Tempor2): number of secondary temporal scales. Ventrals (Ventral): number of ventral scales (Dowling, 1951, definition).

Colour pattern. [All observations on colour pattern derive from preserved specimens and recorded from right side if pattern is bilateral.] Number of ventral lateral spots or stripes (BodyLatN): number of lateral spots or stripes posterior to head and anterior to vent. Shape of ventral lateral body markings (BodyLatS): shape of lateral body markings: spots (0); transverse stripes (1). Nuchal stripe (NucStrp): black or dark-coloured transverse stripe on rear of head and sides of neck, absent [0] or present [1]. Parietal spot (PaSpot): white or light-coloured spot or pair in mid-parietal area, absent [0] or present [1]. Postocular stripe (PostocStr): black stripe extending from bottom posterior edge of eye to bottom of 6th-7th supralabial, absent [0] or present [1]. Post-temporal stripe (PosttmpStr): black stripe extending diagonally from posterior medial edge of eye to last supralabials, absent [0] or present [1]. Colour of subcaudal scales (SubcaudC): ventral scales same colour throughout [0] or with dark transverse border at scale insert [1]. Colour of ventral scales (VentralC): ventral scales same colour throughout [0] or transverse black border at insertion of ventral, i.e., "black-lined" [1].

B. Specimens examined

Xenochrophis flavipunctatus: China – Hong Kong MCZ R-176026, 176030, 176035, 176037-041, USNM 7387. Myanmar – Moyingyi Wetland Bird Sanctuary CAS 210529, USNM 562756-759.

Xenochrophis piscator: India – Puri CMNH 69315-316; Calcutta USNM 129715. Myanmar – Moyingyi Wetland Bird Sanctuary CAS 210747, USNM 562760-570, 562772, 562781-782; Bago Yoma, USNM 562771; Le Kaing USNM 562779; Mwe Hauk USNM 562778; Pyin-Oo-Lwin USNM 562773-775; Shwe-Settaw USNM 562780, 562784; Shwe-U-Daung USNM 562776-777, 562783.

CAS, California Academy of Sciences; CMNH, Carnegie Museum of Natural History; MCZ, Museum of Comparative Zoology, Harvard University; USNM, National Museum of Natural History, Smithsonian Institution.