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A review of the Xenodermidae and the Dragon Snake *Xenodermus javanicus* Reinhardt, 1836 species group, including the formal description of three new species, a division of *Achalinus* Peters, 1869 into two genera and *Stoliczkia* Jerdon, 1870 into subgenera (Squamata; Serpentes, Alethinophidia, Xenodermidae).

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ABSTRACT

Snakes in the genera *Xenodermis* Reinhardt, 1836 and *Achalinus* Peters, 1836 were reviewed.

Regional variants of the putative species X. *javanicus* Reinhardt, 1836 were found to be sufficiently divergent to warrant being treated as full species.

Other genera within the Xenodermidae were also reviewed.

The species currently known as *Achalinus meiguensis* Hu and Zhao, 1966 was found to be sufficiently divergent both morphologically and by molecular analysis from other *Achalinus* Peters, 1869 species to warrant being placed in a separate genus.

Stoliczkia Jerdon, 1870 currently contains two species that are divergent geographically and to a lesser extent morphologically and well separated by habitat. Therefore one is transferred to a new subgenus.

As a result this paper formally names three new species of *Xenodermus*, namely *X. oxyi sp. nov.*, *X. crottyi sp. nov.* and *X. sloppi sp. nov.*, a new monotypic genus *Fereachalinus gen. nov.* and a new subgenus within *Stoliczkia*, namely *Parastoliczkia subgen. nov.*.

Keywords: Taxonomy; snakes; nomenclature; Asia; *Xenodermus*; *Achalinus*; species; *javanicus*; *meiguensis*; new species; *oxyi*; *crottyi*; *sloppi*; new genus; *Fereachalinus*; new subgenus; *Parastoliczkia.*

INTRODUCTION

In recent years, significant numbers of the distinctive Asian Dragon Snake *Xenodermus javanicus* Reinhardt, 1836, have made their way into the private pet trade in Europe and the United States. The nominate form is allegedly common in parts of Java. The putative species is also known from elsewhere in south-east Asia, including Peninsula Malaysia, Thailand, Sumatra and Borneo.

While this appears to be a widespread distribution, a close inspection of known specimens found that the taxon as currently recognized is largely confined to small areas of hilly forested habitat at higher elevations or immediately adjacent sites. By way of example, no specimens are known from flatter areas in Borneo, including the far south, or anywhere in Sumatra except for the far north-west which is relatively hilly.

Specimens from Thailand, possibly Burma and Peninsula Malaysia are only known from the border areas of the Isthmus of Kra in the regions where the three countries (more-or-less) abut.

Specimens from all known collection locations were inspected and found to be morphologically divergent in characteristics that indicated long-term divergence of populations, notwithstanding the evolutionarily conservative nature of the snakes.

In spite of land bridges between the relevant parts of South-east Asia during ice-age minima, it is unlikely any gene flow would have occurred between populations in the recent past on the basis of generally unsuitable habitat in the intervening spaces.

Even now, the putative species *Xenodermus javanicus* remains absent on low-lying islands between the higher land masses that these snakes are found, indicating recent gene flow between the populations is not likely to have happened.

Based on both the genetic isolation of the known populations and the morphological divergences of each, it is appropriate that they be recognized as distinct species.

As there are no names available for the Peninsula Malaysia/ Thailand population, that from northern Borneo or that from north-west Sumatra, each are named according to the rules of the *International Code of Zoological Nomenclature* (Ride *et al.* 1999).

I note herein that the names *Gonionotus plumbeus* Gray, 1846 and *Xenoderma gonyonotus* Lichtenstein and Martens, 1856 are unavailable for the two unnamed populations as both apply to snakes from Java (Boulenger, 1893).

At the same time this review took place, other taxa within the Xenodermidae were inspected and reviewed in order to check that all were appropriately placed at the genus level and/or if there were any obviously unrecognized taxa within any genus.

At the first level, it became clear that one species within the genus *Achalinus* Peters, 1869 was significantly divergent from the others in the genus in terms of morphology and genetically.

This was the taxon formally described as *Achalinus meiguensis* Hu and Zhao, 1966 which has noticeably larger body scales (evidenced by a lower mid body scale rows count), as well as significantly different head scalation to all the other species.

Set apart morphologically, this taxon was also shown to be significantly divergent in the molecular results of Pyron *et al.*

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(2013) and so I have no hesitation in erecting a new genus for this taxon. It is called *Fereachalinus gen. nov.*.
The genus *Stoliczkia* Jerdon, 1870 currently contains two species that are divergent geographically and to a lesser extent morphologically and well separated by habitat. Therefore one is transferred to a new subgenus named *Parastoliczkia subgen. nov.*.

I note further that the two relevant species are confined to highland areas and so have no obvious bridge between populations.

Publications relevant to the snakes currently referred to as *Xenodermus javanicus* Reinhardt, 1836 *sensu lato*, including the taxonomic judgements made herein include the following: Boulenger (1893), Brongersma (1929), Chan-ard *et al.* (2015), Das (2012), David and Vogel (1996), de Rooij (1917), Flower (1896), Gower *et al.* (2012), Grandison (1978), Gray (1849), Haas (1950), Jan (1863), Kopstein (1938a, 1938b), Kudryavtsev and Latyshev (2015), Lampe (1902), Lönnberg and Rendahl (1925), Manthey and Grossmann (1997), Müller (1887, 1890), Reinhardt (1836), Robinson and Kloss (1920), Rovatsos *et al.* (2015), Savage (2015), Smith (1930, 1943), Stuebing and Inger (1999), Taylor (1965), Teynié *et al.* (2010), Tweedie (1983), Volz (1904), Welch (1988), Werner (1900, 1922) and sources cited therein.

Key publications relevant to the snakes in the genus *Achalinus* Peters, 1869 as defined to date include the following: Barbour (1917), Boulenger (1893, 1888, 1908), Bourret (1937), Chen (2009), Fang and Wang (1983), Gao (1991), Goris and Maeda (2004), Günther (1889), Guo *et al.* (1999), Hecht *et al.* (2013), Hu and Zhao (1966), Hu *et al.* (1975), Inger *et al.* (1990), Kou and Wang (2003), Maki (1931), Mell (1931), Moriguchi and Naito (1979), Orlov, *et al.* (2000), Ota (2000), Ota and Toyama (1989a, 1989b), Ota *et al.* (1991), Peters (1869), Pyron *et al.* (2013), Sang *et al.* (2009), Shie (2005), Smith (1943), Steindachner (1913), Stejneger (1907, 1910), Toriba (1993), Van Denburgh (1912), Ziegler (2002), Zong and Ma (1983) and sources cited therein.

Key publications relevant to the snakes in the genus *Stoliczkia* Jerdon, 1870 as defined to date include the following: Boulenger (1893, 1899), Das (1997, 2006, 2012), de Rooij (1917), Jerdon (1870), Malkmus *et al.* (2002), Manthey (1983), Manthey and Grossmann (1997), Sharma (2004), Smith (1943) and sources cited therein.

The materials and methods used as the basis for the following taxonomic results included a review of all available literature (as cited above) and specimens of all relevant taxa from all or most of where they are known to occur, when good locality information was available for specimens.

I also note that, notwithstanding the theft of relevant materials from this author in an illegal armed raid on 17 August 2011, which were not returned in breach of undertakings to the court (Court of Appeal Victoria 2014 and VCAT 2015), I have made a decision to publish this paper in view of the conservation significance attached to the formal recognition of unnamed taxa and on the basis that further delays may in fact put these unnamed taxa at greater risk of extinction, noting the extensive increase in human population in the area and associated habitat destruction occurring.

XENODERMUS OXYI SP. NOV.

Holotype: A preserved specimen at the Field Museum of Natural History, Chicago, Illinois, USA, specimen number: FMNH 246192, collected from the Lahad Datu District in Sabah, Borneo, Malaysia.

This facility allows access of its holdings to scientists.

Paratypes: 1/ A preserved specimen at the Field Museum of Natural History, Chicago, Illinois, USA, specimen number: FMNH158613, collected from the Bintulu District, Sarawak, Borneo, Malaysia.

2/ A preserved specimen at the Field Museum of Natural History, Chicago, Illinois, USA, specimen number: FMNH248958, collected from the Tawau District, Sabah, Borneo, Malaysia.

Diagnosis: *Xenodermus oxyi sp. nov.* is readily separated from the other three species of *Xenodermus* by the presence of light tubercles on the labial line. It is further distinguished from the other species by the presence of a large number of red specks on the upper surface of the head and forebody. When specimens of *Xenodermus* from Java, Sumatra or the Isthmus of Kra have red or orange specks, they are very few.

Xenodermus crottyi sp. nov. is readily separated from the other three species of *Xenodermus* by the presence of a distinct reddish tinge dorsally.

It is further separated from the other species by the ventral colouration. In life, the individual scales are mainly black (in the centre), with thick white edges. In the other species, except for *X. sloppi sp. nov.* this edging is bluish-black tinged.

X. sloppi sp. nov. is separated from the other three species in the genus by colouration. In this species the dorsal surface has a dark brownish tinge (as opposed to being overwhelmingly bluish-grey in the others, excluding *X. crottyi sp. nov.* which is bluish-grey above, but with a noticeable reddish tinge that separates it from the rest).

Ventrally, *X. sloppi sp. nov.* differs from the other species with each subcaudal being dark brown in colouration, with thick off-white edges forming a well-defined boundary for each scale.

X. sloppi sp. nov. has 174 ventrals (similar to the other species), 128 subcaudals (versus 147 in *X. javanicus*) and 48 midbody rows, (versus 40 in *X. javanicus*, 48 in *X. crottyi sp. nov.* and 44 in *X. sloppi sp. nov.*).

X. javanicus is readily separated from the other species of *Xenodermus* by having (in life) a pinkish-white tongue, versus a bluish-white tongue in the other three species. *X. javanicus* is further separated by the very prominent blunt edged spines that form the longitunal rows running down the length of the body, which are noticeably darker (as in black) than the bluish-grey background colour of the upper body. While these raised spines are also present in the other species, the individual spines are proportionately smaller and slightly more angular in appearance and only slightly darker in colour than the nearby greyish scales.

X. javanicus is also characterised by an average of 40 dorsal mid body rows, versus 44 or more in the other three species.

The four species in the genus *Xenodermus*, namely *X. oxyi sp. nov.*, *X. crottyi sp. nov.*, *X. sloppi sp. nov.* and *X. javanicus* Reinhardt, 1836, and the genus itself are all defined and separated from all other snakes by the following unique suite of characters:

Teeth subequal, about 15 in each maxillary. Head distinct from neck, covered with granular juxtaposed scales; nostrils directed forwards, in an undivided nasal; eye moderate, with a round pupil. Body slender, compressed, with small juxtaposed keeled scales and longitudinal rows of large tubercles; ventrals well developed. Tail long, with single subcaudals. Rostral small, triangular, not visible from above; nasals meeting behind the point of the rostral, followed by two pairs of small shields; labials scarcely enlarged, about 20 on each side; no chinshields. About 40-48 scales across the body (mid body rows); the tubercles disposed in pairs alternating with single ones on the vertebral line, and forming a single series along each side of the back. 173-185 ventrals; anal entire; 128-147 subcaudals. Colour is a dark greyish brown above and without markings, blotches or stripes. The venter is light in colour, with or without darker markings in the center of each scale (adapted from Boulenger, 1893).

Distribution: *Xenodermus oxyi sp. nov.* is confined to the northern two-thirds of Borneo, either in, or directly adjacent to the northern and central mountain ranges.

Etymology: Named in honour of my now deceased family pet Great Dane named *Oxyuranus* (or “Oxy” for short), who spent

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some 8 years protecting the Hoser family children from thieves and thugs and also played a valuable role in teaching people to be nice to animals via the Snakebusters educational wildlife shows.

I have no hesitation in naming a species in honour of a non-human inhabitant of this planet who has made a worthwhile contribution to humanity and the welfare of other animals.

By the way *Oxyuranus* Kinghorn, 1923 is the scientific name for a genus of Australasian elapid snake.

XENODERMUS CROTTYI SP. NOV.

Holotype: A preserved specimen at the Field Museum of Natural History, Chicago, Illinois, USA, specimen number: FMNH178442, collected from Yala, southern Thailand.

This facility allows access of its holdings to scientists.

Paratype: A specimen at the Museum of Natural History, UK, specimen number: 1939.1.4.5 (also stored as: NHMUK:catalogue:1890625) from Victoria Point (now known as Kawthaung), Thailand.

Diagnosis: *Xenodermus crottyi sp. nov.* is readily separated from the other three species of *Xenodermus* by the presence of a distinct reddish tinge dorsally.

It is further separated from the other species by the ventral colouration. In life, the individual scales are mainly black (in the centre), with thick white edges. In the other species, except for *X. sloppi sp. nov.* this edging is bluish-black tinged.

Xenodermus oxyi sp. nov. is readily separated from the other three species of *Xenodermus* by the presence of light tubercles on labial line. It is further distinguished from the other species by the presence of a large number of red specks on the upper surface head and forebody. When specimens of *Xenodermus* from Java, Sumatra or the Isthmus of Kra have red or orange specks, they are very few.

X. sloppi sp. nov. is separated from the other three species in the genus by colouration. In this species the dorsal surface has a dark brownish tinge (as opposed to being overwhelmingly bluish-grey in the others, excluding *X. crottyi sp. nov.* which is bluish-grey above, but with a noticeable reddish tinge that separates it from the rest).

Ventrally, *X. sloppi sp. nov.* differs from the other species with each subcaudal being dark brown in colouration, with thick off-white edges forming a well-defined boundary for each scale.

X. sloppi sp. nov. has 174 ventrals (similar to the other species), 128 subcaudals (versus 147 in *X. javanicus*) and 48 midbody rows, (versus 40 in *X. javanicus*, 48 in *X. crottyi sp. nov.* and 44 in *X. sloppi sp. nov.*).

X. javanicus is readily separated from the other species of *Xenodermus* by having (in life) a pinkish-white tongue, versus a bluish-white tongue in the other three species. *X. javanicus* is further separated by the very prominent blunt edged spines that form the longitunal rows running down the length of the body, which are noticeably darker (as in black) than the bluish-grey background colour of the upper body. While these raised spines are also present in the other species, the individual spines are proportionately smaller and slightly more angular in appearance and only slightly darker in colour than the nearby greyish scales.

X. javanicus is also characterised by an average of 40 dorsal mid body rows, versus 44 or more in the other three species.

The four species in the genus *Xenodermus*, namely *X. oxyi sp. nov.*, *X. crottyi sp. nov.*, *X. sloppi sp. nov.* and *X. javanicus* Reinhardt, 1836, and the genus itself are all defined and separated from all other snakes by the following unique suite of characters:

Teeth subequal, about 15 in each maxillary. Head distinct from neck, covered with granular juxtaposed scales; nostrils directed forwards, in an undivided nasal; eye moderate, with round pupil. Body slender, compressed, with small juxtaposed keeled scales and longitudinal rows of large tubercles; ventrals well developed. Tail long, with single subcaudals. Rostral small, triangular, not visible from above; nasals meeting behind the point of the rostral, followed by two pairs of small shields; labials scarcely enlarged, about 20 on each side; no chinshields. About 40-48 scales across the body (mid body rows); the tubercles disposed in pairs alternating with single ones on the vertebral line, and forming a single series along each side of the back. 173-185 ventrals; anal entire; 128-147 subcaudals. Colour is a dark greyish brown above and without markings, blotches or stripes. The venter is light in colour, with or without darker markings in the center of each scale, or as described for each species above (adapted from Boulenger, 1893).

Distribution: *Xenodermus oxyi sp. nov.* is confined to the northern two-thirds of Borneo, either in, or directly adjacent to the northern and central mountain ranges.

Etymology: Named in honour of my now deceased family pet Great Dane/Rottweiler Cross named *Crotalus* (or "Crotty" for short), who spent some 13 years protecting the Hoser family and research facility from thieves and thugs and also played a valuable role in teaching people to be nice to animals via the the educational displays we did at the time.

I have no hesitation in naming a species in honour of a non-human inhabitant of this planet who has made a worthwhile contribution to humanity and the welfare of other animals.

By the way *Crotalus* Linnaeus, 1758 is the scientific name for a genus of mainly North American Pitvipers.

XENODERMUS SLOPPI SP. NOV.

Holotype: A preserved specimen at the Museum Wiesbaden, Wiesbaden, Germany, specimen number: 1119 collected at Peiiak, Süd-Atjeh, Sumatra, Indonesia, in 1902 by. Dr. A. Fuchs of Bornich, Germany.

A detailed description of this specimen is in Lampe (1902). The Museum Wiesbaden allows access to its holdings.

Diagnosis: *Xenodermus sloppi sp. nov.* is separated from the other three species in the genus by colouration. In this species the dorsal surface has a dark brownish tinge (as opposed to being overwhelmingly bluish-grey in the others, excluding *X. crottyi sp. nov.* which is bluish-grey above, but with a noticeable reddish tinge that separates it from the rest).

Ventrally, *X. sloppi sp. nov.* differs from the other species with each subcaudal being dark brown in colouration, with thick off-white edges forming a well-defined boundary for each scale.

X. sloppi sp. nov. has 174 ventrals (similar to the other species), 128 subcaudals (versus 147 in *X. javanicus*) and 48 midbody rows, (versus 40 in *X. javanicus*, 48 in *X. crottyi sp. nov.* and 44 in *X. sloppi sp. nov.*).

Xenodermus oxyi sp. nov. is readily separated from the other three species of *Xenodermus* by the presence of light tubercles on the labial line. It is further distinguished from the other species by the presence of a large number of red specks on the upper surface head and forebody. When specimens of *Xenodermus* from Java, Sumatra or the Isthmus of Kra have red or orange specks, they are very few.

Xenodermus crottyi sp. nov. is readily separated from the other three species of *Xenodermus* by the presence of a distinct reddish tinge dorsally.

It is further separated from the other species by the ventral colouration. In life, the individual scales are mainly black (in the centre), with thick white edges. In the other species, except for *X. sloppi sp. nov.* this edging is bluish-black tinged.

X. javanicus is readily separated from the other species of *Xenodermus* by having (in life) a pinkish-white tongue, versus a bluish-white tongue in the other three species. *X. javanicus* is further separated by the very prominent blunt edged spines that form the longitunal rows running down the length of the body, which are noticeably darker (as in black) than the bluish-grey background colour of the upper body. While these raised spines are also present in the other species, the individual spines are proportionately smaller and slightly more angular in appearance

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and only slightly darker in colour than the nearby greyish scales.

X. javanicus is also characterised by an average of 40 dorsal mid body rows, versus 44 or more in the other three species.

The four species in the genus *Xenodermus*, namely *X. oxyi sp. nov.*, *X. crottyi sp. nov.*, *X. sloppi sp. nov*. and *X. javanicus* Reinhardt, 1836, and the genus itself are all defined and separated from all other snakes by the following unique suite of characters:

Teeth subequal, about 15 in each maxillary. Head distinct from the neck, covered with granular juxtaposed scales; nostrils directed forwards, in an undivided nasal; eye moderate, with round pupil. Body slender, compressed, with small juxtaposed keeled scales and longitudinal rows of large tubercles; ventrals well developed. Tail is long, with single subcaudals. Rostral small, triangular, not visible from above; nasals meeting behind the point of the rostral, followed by two pairs of small shields; labials scarcely enlarged, about 20 on each side; no chinshields. About 40-48 scales across the body (mid body rows); the tubercles disposed in pairs alternating with single ones on the vertebral line, and forming a single series along each side of the back. 173-185 ventrals; anal entire; 128-147 subcaudals. Colour is a dark greyish brown above and without markings, blotches or stripes. The venter is light in colour, with or without darker markings in the center of each scale or as described for each species above (adapted from Boulenger, 1893).

Distribution: Known only from north-west Sumatra, in the vicinity of the locations of Perlak (AKA Peureulak) and Sibolangit, north-west Sumatra, Indonesia.

Etymology: Named in honour of the family pet Great Dane named *Slopp*, who has spent some years protecting the Hoser family and research facility from thieves and thugs and also played a valuable role in teaching people to be nice to animals via the the educational displays we do via Snakebusters: Australia's best reptiles, being the only hands on reptile shows in Australia.

I have no hesitation in naming a species in honour of a non-human inhabitant of this planet who has made a worthwhile contribution to humanity and the welfare of other animals.

FEREACHALINUS GEN. NOV.

Type species: *Achalinus meiguensis* Hu and Zhao, 1966.

Diagnosis: *Fereachalinus gen. nov.* is readily separated from *Achalinus* Peters, 1869 by the following unique suite of characters: The internasal is fused to the prefrontal (as opposed to being separated from the prefrontal by a suture in all species of *Achalinus*), the mental is in contact with the anterior postmental (versus being separated from the anterior postmental by the second infralabial in all species of *Achalinus*), 19 midbody scale rows (versus 21 or more in all species of *Achalinus*).

The divergent species *Achalinus formosanus* Boulenger, 1908 with 25 or 27 midbody rows has been placed in the genus *Achalinopsis* Steindachner, 1913, which has been accepted by some authors (e.g. Zong and Ma, 1983), but not others (e.g. Shie, 2005).

In any event, this taxon is not as divergent from the nominate species for *Achalinus*, namely *Achalinus spinalis* Peters, 1869 (23 midbody rows) as "*Achalinus meiguensis* Hu and Zhao, 1966".

Both the genera *Fereachalinus gen. nov*. and *Achalinus* are separated from all other snakes by the following unique suite of characters: Maxillary teeth 22 to 25, small equal; mandibular teeth equal. Head not distinct from the neck; eye small, with round or vertically sub-elliptic pupil; nostril rather large, pierced or not pierced in the anterior of two nasals; posterior nasal concave; no praeocular, loreal extending from the nasals to the eye; postoculars not distinct from anterior temporals. Body cylindrical, slender; scales lanceolate, feebly imbricate, keeled, without apical pits, in 19-27 midbody rows; ventrals rounded. Tail long, subcaudals single. Hypapophyses developed throughout the vertebral column.

Distribution: Restricted to West Sichuan and Yunnan, China at an elevation of 1200-1400 m.

Etymology: Named in reflection of the fact that the relevant taxon is nearly, but not quite "*Achalinus*".

Content: *Fereachalinus meiguensis* (Hu and Zhao, 1966) (monotypic).

PARASTOLICZKIA SUBGEN. NOV.

Type species: *Stoliczkia borneensis* Boulenger, 1899.

Diagnosis: *Parastoliczkia subgen. nov.* from the island of Borneo is physically similar to *Stoliczkia* Jerdon, 1870 from the Khazi Hills in north-east India.

However, *Parastoliczkia subgen. nov.* differs from *Stoliczkia* by having a large triangular rostral (versus tiny in *Stoliczkia*), ten supralabials (as opposed to eight in *Stoliczkia*), a large loreal that is much longer than deeo (versus a tiny loreal in *Stoliczkia*), roughly 124 subcaudals in females (versus 115 in *Stoliczkia*); colouration that is generally rufous, with large blackish spots, at least as large as the space between them, disposed more or less regularly in three longitudinal series, with a brownish venter, with each scale etched with yellowish (versus purplish brown above; three or four outer rows of scales and the ventrals are white with brown edges, in *Stoliczkia*).

Both *Parastoliczkia subgen. nov.* and *Stoliczkia* are separated from all other snakes by the following unique suite of characters: Teeth small, subequal, about 14 in each maxillary. Head distinct from neck, covered with large shields; nostrils directed forwards; nasal shield undivided; eye small, with round pupil. A pair of very narrow internasals; a pair of large praefrontals, separated from the frontal and supraoculars by a series of small scales; frontal a little broader than long, a little shorter than the parietals; supraocular very small; narrow parietals nearly twice as long as the frontal; a large praeocular and two postoculars; eye very prominent, with vertically subelliptic pupil, nostril very large temporals small, scale-like; a single pair of small chin-shields, in contact with three lower labials. Scales in 30 rows, dorsals separated by naked skin, laterals larger and juxtaposed. Ventrals about 210 in females; anal single. Body slender, compressed; scales elliptical, juxtaposed, strongly keeled, increasing in size towards the ventrals, which are well developed. Tail long; subcaudals single.

Distribution: Known only from hillier parts of the northern half of the island of Borneo, mainly, but not exclusively on the Malaysian side.

Etymology: Named *Parastoliczkia* as it isn't exactly *Stoliczkia* Jerdon, 1870.

Content: *Stoliczkia* (*Parastoliczkia*) *borneensis* Boulenger, 1899 (monotypic).

NOTES ON THE DESCRIPTIONS FOR ANY POTENTIAL REVISORS

Unless mandated by the rules of the *International Code of Zoological Nomenclature*, none of the spellings of the newly proposed names should be altered in any way. Should one or more newly named taxa be merged by later authors to be treated as a single species, the order of prority of retention of names should be the order (page priority) of the formal descriptions within this text.

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CONFLICT OF INTEREST

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