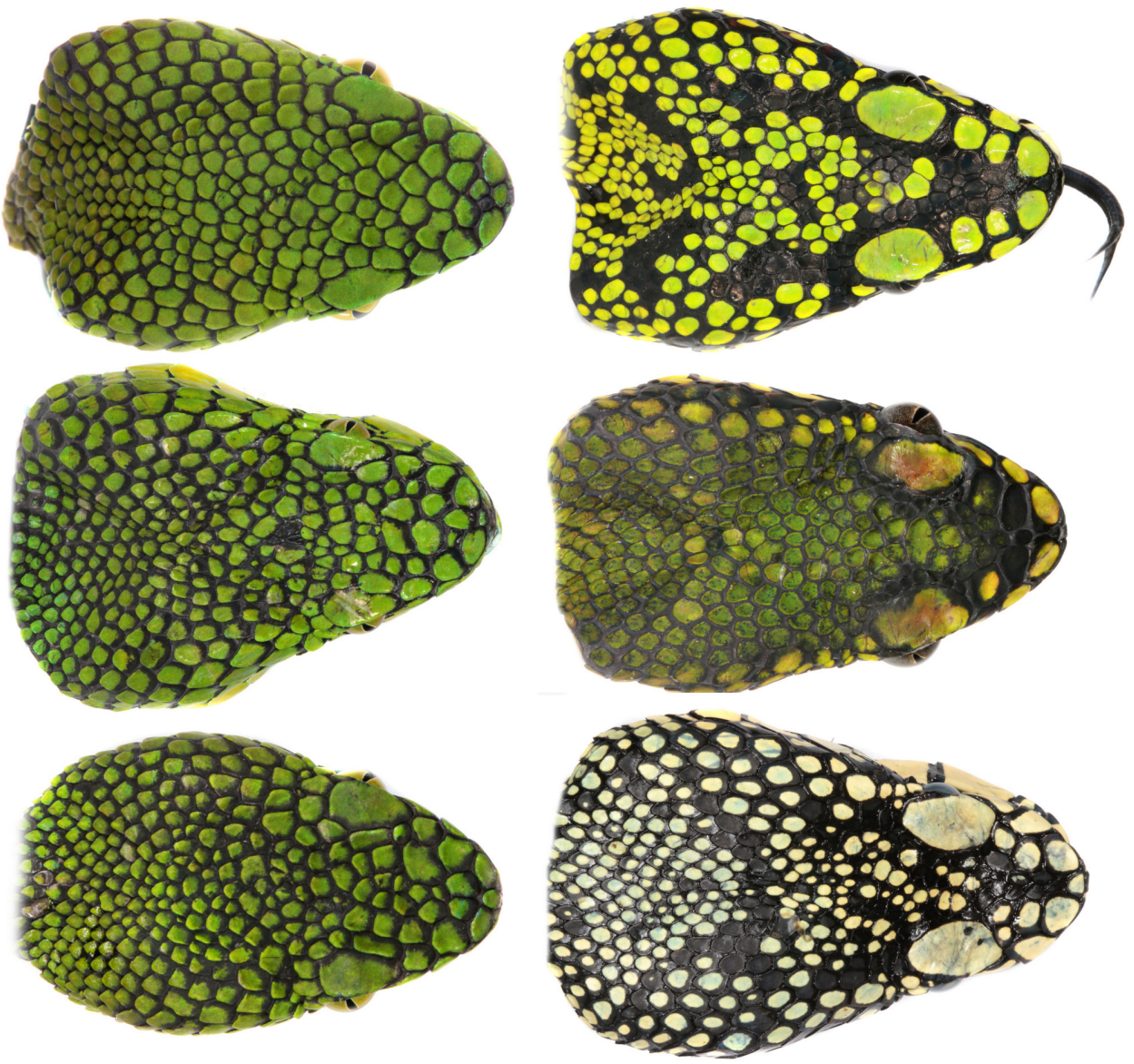

Comparative dorsal view of the head of *Trimeresurus gunaleni* spec. nov. (left) and *T. sumatranus* (right). Left from above: male, female (holotype), male, all alive, from Sumatra Utara Province, Sumatra. Right: adult female alive from Bengkulu Province, Sumatra, adult male alive from Bengkulu Province, Sumatra, preserved female from Borneo. *Photos: N. Maury.*

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On *Trimeresurus sumatranus* (Raffles, 1822), with the designation of a neotype and the description of a new species of pitviper from Sumatra (Squamata: Viperidae: Crotalinae)

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***Abstract.*—Variation in morphological characters were investigated among 126 specimens from at least 67 populations covering the whole range of the large pitviper currently known as *Trimeresurus sumatranus* (Raffles, 1822). The results showed that two distinct taxa are involved. Herein *Trimeresurus sumatranus* is redefined. In order to fix the status of this species, a neotype is selected and described. Its type locality is restricted to the vicinity of Bengkulu, Bengkulu Province, Sumatra. The second taxon represents a distinct, previously unnamed species, which is described. The new species differs from *Trimeresurus sumatranus* by a lower number of ventrals in males (162–179 against 178–185) and females (164–171 vs. 175–191); a distinctly longer tail in males (value of the ratio tail length/total length: 0.201–0.210 vs. 0.150–0.168), the color of the tail (see the description), the color of the eyes: green in the new species, vs. dark grey in *T. sumatranus*, the color of the ventrals, which are green with a pale posterior suture in the new species and pale with dark posterior suture in *T. sumatranus*. The new species lives in higher elevations than *T. sumatranus* and seems to be endemic to the higher mountain ranges of western Sumatra.**

Key words. Sumatra, West Malaysia, Borneo, *Trimeresurus gunaleni* spec. nov., *Trimeresurus malcolmi*, *Trimeresurus sumatranus*

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Introduction

The genus *Trimeresurus* Lacépède, 1804 is currently composed of 46 species, of which 12 were described since the year 2000 (David et al. 2011). This genus and most of its species have complex systematic and nomenclatural histories. For example, the generic nomen *Parias* Gray, 1849 was regarded as a valid subgenus only recently (David et al. 2011). This extensive series of confusions arose from the fact that many species of this genus are arboreal; green snakes that are superficially similar in color and scalation. This factor is exemplified by the case of *Trimeresurus sumatranus* (Raffles, 1822) and its relatives. *Trimeresurus sumatranus* (Raffles, 1822) was one of the first species of this genus of Asian pitvipers to have been described (as *Coluber sumatranus*), a point that is quite surprising as it is a rather uncommon species with a limited distribution in the Sunda Islands. Sir Thomas Stamford Raffles (1781–1826), best known as the founder of Singapore, made a long stay in Bencoolen, now Bengkulu, a city of south-western Sumatra, between March 1818 and August 1824, although this stay was interrupted several times for trips to Nias and, especially Singapore. He held the position of Governor-General of Bencoolen from 1818 to 1822. An account on the activities of Sir T. Raffles in Sumatra can be found in Raffles (1835). Sir Raffles was definitely not a scholarly naturalist but had a strong interest in local plants and animals which he described himself (Raffles 1821, 1822).

Trimeresurus sumatranus has been extensively confused in the literature with *Trimeresurus hageni* (Van Lidth de Jeude, 1886), a related but distinct species that inhabits lower elevations in Sumatra, Borneo, and the Malay Peninsula. Both species share similar scalation, and juvenile specimens of both species are uniformly green in color. However, although the adults are very different in coloration, the similarities in scalation led Boulenger, the leading herpetologist of his time, to synonymize these two species (Boulenger 1896). A reason for this misinterpretation was the fact that at that time, the British Museum of Natural History, the place where Boulenger was working, had only a single specimen of the species *T. sumatranus* which unfortunately was a juvenile and thus shared the green color with *T. hageni*.

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Boulenger's appraisal was followed by subsequent workers, until the works of van Lidth de Jeude (1922) and especially Brongersma (1933). This latter author was the first to show that *T. sumatranus* and *T. hageni* were valid, distinct species, and he provided new characters separating both species from one another.

Furthermore, it is worth noting that Schlegel (1826) described the taxon *Cophias wagleri* (nec *Cophias wagleri* Boie, 1827) as a replacement name for *Coluber sumatranus* (Raffles, 1822). We refer to Savage et al. (2012) for a discussion on the early confusion between these species. Nevertheless, other authors such as Schlegel (1837), Gray (1842: 48; 1849: 10), Cantor (1847: 1042, Pl. 40: Fig. 9), Günther (1858: 266), Peters (1862: 671) and later as Ouwens (1916: Pl. 15: Fig. 22 and 22a) also confused in part or totally *Coluber sumatranus* with *Cophias wagleri* Boie, 1827, a totally different species now known as *Tropidolaemus wagleri*.

Loveridge (1938: 45) described *Trimeresurus sumatranus malcolmi* (Type locality: "Sungii River, near Bunduntuan, Mount Kinabalu, British Nord Borneo," a river in the vicinity of Bundu Tuhan, on the southern slopes of Mt. Kinabalu, state of Sabah, Borneo, Federation of Malaysia). This subspecies was regarded as valid by all subsequent authors for some populations of northern Borneo whereas other populations of this island were referred to the nominative subspecies (David and Ineich 1999; McDiarmid et al. 1999; Malkmus et al. 2002). Subsequently, *Trimeresurus sumatranus malcolmi* was raised to full species status by Stuebing and Inger (1998). As a consequence, *Trimeresurus sumatranus* was subsequently considered monotypic.

More recently, two revisions of the systematics of these two species were published by Sanders et al. (2002, 2004). Results of the first publication, which was based on scalation characters, pattern and coloration, can be summarized as follows: (1) *T. sumatranus* and *T. hageni* are clearly separate as shown by canonical multivariate analysis; (2) *T. sumatranus* inhabits South Thailand, Borneo, and central western Sumatra, whereas *T. hageni* is living in North and South Sumatra, Thailand, Malaysia, Singapore, Nias, and Siberut; (3) the authors showed clear differences between populations of *T. sumatranus* inhabiting the central part of western Sumatra and that one living on Borneo; and (4) morphological differences, especially in males, were pointed out between populations of the islands of Nias and Siberut on the one hand, and all other populations on the other hand. In these islands, specimens referable to *Trimeresurus hageni* show some characters of the pattern typical to *T. sumatranus*, such as black dorsal crossbars and the presence of dark edges on head scales. This partial similarity has led to erroneous records of *T. sumatranus* from these islands.

In contrast, Sanders et al. (2004) included molecular analyses and considered all species of the subgenus *Parias* Gray, 1849 as defined by Malhotra and Thorpe (2004) (as a genus). For the species treated here, the results of Sanders et al. (2004) can be summarized as follows: (1) *T. hageni* has an expanded distribution compared with Sanders et al. (2002), i.e. populations of southern Thailand, West Malaysia, and the islands of Bangka, Siberut, Nias, and all islands of the Mentawai Archipelago are referred to this species; (2) little morphological variation was found between populations of *T. hageni*, in contrast to results presented by Sanders et al. (2002); (3) without justification, populations of South Thailand and West Malaysia were no longer referred to *T. sumatranus* but to *T. hageni*; as a consequence, the range of *T. sumatranus* was restricted to a narrow area covering mid elevations between 650 and 800 m—the central and southern parts of the Barisan Range, western Sumatra, and a wide range throughout Borneo mainly below 300 m; (4) populations of Sumatra and Borneo are separated by a genetic distance of 3.3%; (5) differences in ecology were pointed out between the Bornean and Sumatran populations; and (6) ecological adaptation has led to a convergence in the pattern between *T. hageni* and *T. sumatranus* in Sumatra. Sanders et al. (2004) considered that this convergence made useless some characters which used to be considered diagnostic; for example the separation of the fourth and fifth supralabial with the suboculars (see Brongersma 1933). Sanders et al. (2004) provided quite a different definition of *T. sumatranus* compared with Brongersma (1933). However, it must be emphasized that only two populations of *T. hageni* and two populations of *T. sumatranus*, both from Bengkulu Province for this latter species, were compared in molecular analyses.

In the frame of a revision of the subgenus *Parias* in the Sunda Islands, namely of populations referred in the literature to *T. sumatranus*, *T. hageni*, and *T. malcolmi*, we examined specimens referred to as *Trimeresurus sumatranus* originating from throughout the range of this taxon, including material not investigated previously. Our data suggest that the combination of several characters, both of pattern and scalation, allow a clear distinction between *T. sumatranus* and *T. hageni*. Definitions of these two species will be presented in a subsequent paper. In the first step of this revision, presented here, we put emphasis on the morphology of the various populations referred to as *T. sumatranus auctorum*. Our data also show that two distinct forms of *T. sumatranus auctorum* can be defined in Sumatra, both deserving to be recognized as full species.

Material and Methods

The present paper is based on 126 preserved specimens examined by us from 67 localities covering the whole range of *T. sumatranus auctorum* and *T. hageni*, and several live specimens of both species. Preserved examined specimens of the two forms of *T. sumatranus* are listed under their respective account; specimens of *T. hageni* are listed in Appendix I.

Selection of morphological characters

We retained standard morphological characters used in the genus *Trimeresurus* by Brongersma (1933), Pope and Pope (1933), and Regenass and Kramer (1981), along with other morphometric characters adapted from Vogel et al. (2004). We made a pre-selection of characters with a limited number of specimens. Characters not suitable, due to variability or uniformity were deleted and a set of 30 characters was retained (Table 1).

Measurements, except body and tail lengths, were taken with a slide-calliper to the nearest 0.1 millimeter (mm); all measures on body were taken to the nearest mm. In order to minimize inter-observer error, all measurements considered here were made by Gernot Vogel (GV). Ventral scales were counted according to Dowling (1951). The first subcaudal was defined as the first scale posterior to the vent that touched the opposite scale. The terminal scute is excluded from the number of subcaudals. The numbers of dorsal scale rows are given at one head length behind the head, at midbody (i.e., at the level of the ventral plate corresponding to half of the total number of ventrals), and at one head length anterior to the vent respectively. Values for symmetric head characters are given in left/right order. The real coloration of body and eyes were observed only on living animals or freshly preserved specimens.

Morphometric, meristic, and coloration characters retained for this study are listed in Table 1. Altogether, 30 variables were considered, either standing on their own or derived from the raw characters listed above. Not all variables listed in this table proved to be useful to separate at least one taxon of the *Trimeresurus sumatranus* group from the others, but all were investigated and used in combinations of characters and/or were used in univariate analyses.

Table 1. List of morphological characters and variables used in this study and their abbreviations.

Number	Abbreviation	Character
Morphometry		
1	SVL	Snout-vent length
2	TaL	Tail length
3	TL	Total length
4	TaL/TL	Ratio tail length/Total length
Scalation		
5		Dorsal scale rows
6	Do	Dorsal scale rows at midbody
7		Dorsal scale rows at midbody
8	Ven	Ventral plates
9	Sc	Subcaudal plates
10	Cep	Cephalic scales (scales on a line between the middle of supraoculars)
11	InN	Internasal scale(s)
12	InN sep	Internasal scales touching each other
13		Keeling of the occipital scales
14		Supralabial scales
15		Number of scales between third supralabial and subocular
16		Number of scales between fourth supralabial and subocular
17		Number of scales between fifth supralabial and subocular
18	CtotSL	Total number of supralabials touching subocular
19	IL	Infralabials
Pattern		
20		Presence of black margins on dorsal scales of the head
21		Upper labials being lighter than other parts of the head
22		Ventrals with dark margins
23		Subcaudals with dark margins
24		Presence of bands on the body
25		Presence of dorsolateral light spots on the body
26		Coloration and presence of a ventrolateral stripe
27		Coloration and presence of a temporal streak
28		Color of eyes
29		Posterior part of the tail reddish
30		Pattern of the tail

The analyses of external morphological data were based on comparisons of statistical values (mean value and standard deviation). A test of Mann-Whitney (*U* test; see Siegel 1956) was applied as necessary. Calculations were run online on the website: http://elegans.som.vcu.edu/~leon/stats/utest.html (last accessed on 14 July 2014). Abbreviations are: *n*: number of specimens; $\bar{x}$: mean value; *s*: standard deviation; *P*: probability of occurrence of a value as extreme as or more extreme than the observed value; *U*: the statistic in the Mann-Whitney test.

The color of the eyes is shown here to be a taxonomic character. However, it is problematic as it cannot be observed in preserved specimens. According to our observations, the eye color in adult animals is stable for each species and sex (Vogel et al. 2004). In the species treated here, there was no sexual dimorphism in eye coloration. The color of the tail is diagnostic and we recognize two patterns: "uniform reddish-brown with dark margins," or "mottled," for specimens with a mixture of brown and green colors on the tail.

Museum abbreviations

BMNH: The Natural History Museum, London, UK; CAS: California Academy of Sciences, San Francisco, USA; FMNH: Field Museum of Natural History, Chicago, USA; IRSNB: Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium; MNHN: Muséum National d'Histoire Naturelle, Paris, France; NHMB: Naturhistorisches Museum, Basel, Switzerland; NHMW: Naturhistorisches Museum Wien, Austria; MZB: Museum Zoologicum Bogoriense, Bogor à Cibinong, Java, Indonesia; OMNH: Osaka Museum of Natural History, Osaka, Japan; PSGV: Gernot Vogel's private collection, Heidelberg, Germany; RMNH: Nationaal Natuurhistorisch Museum (Naturalis), Leiden, Netherlands; SMF: Natur-Museum und Forschungs-Institut Senckenberg, Frankfurt-am-Main, Germany; ZFMK: Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany; ZMB: Zoologisches Museum für Naturkunde der Humboldt-Universität zu Berlin, Berlin, Germany; ZMH: Zoologisches Institut und Museum, Universität Hamburg, Hamburg, Germany; ZRC: Zoological Reference Collection, National University of Singapore, Singapore; ZSM: Zoologische Staatssammlung, München, Germany.

Other abbreviations

Measures and ratios: ED: vertical diameter of the eye. HL: Head length, SVL: Snout-vent length, TaL: Tail length, TL: Total length, TaL/TL: Ratio tail length/total length.

Meristic characters: DSR: Formula of dorsal scale rows, IL: Infralabials, SC: Subcaudals, SL: supralabials, VEN: Ventrals.

Results

In our sample of 53 specimens referred to *Trimeresurus sumatranus*, as currently defined, we noticed that nine specimens from western Sumatra differed in several morphological characters from other populations. *Trimeresurus sumatranus* (Raffles, 1822) was briefly described (as *Coluber sumatranus*) without any designation of a name-bearing type. Therefore, we first redefine this species and note intraspecific variation of the characters examined. We then designate a neotype for this species in agreement with Art. 75.3.1 to 75.3.7 of the *International Code of Zoological Nomenclature* (I.C.Z.N. 1999; merely designated below as the *Code*).

***Trimeresurus sumatranus* (Raffles, 1822) Fig. 1–7**

***Coluber sumatranus* Raffles, 1822: 334.**

Type locality. By virtue of neotype designation: "SW Sumatra" (original type locality: implicitly "Sumatra;" restricted to vicinity of Bengkulu city, Bengkulu Province, Sumatra *fide* Wallach et al. [2014: 527]; see also the discussion given below).

Neotype. ZFMK 76340, adult female; deposited by Andreas Gumprecht (holotype not traced according to McDiarmid et al. 1999: 345, considered to be lost).

Trigonocephalus formosus Müller and Schlegel, 1842 (*in* 1842–1845): Pl. 7 [dated 1842]; text [dated 1845]: 52 and 55.

Type locality. "*Aan de westkust van het eiland Sumatra, in de omstreken van het dorp Limomanis, eenige uren beoosten Padang*…," i.e.: on the west coast of Sumatra Island, in the vicinity of Limomanis, a few hours east of Padang, now near Limau Manis, Province of Sumatera Barat, Sumatra, Indonesia.

Holotype. RMNH 1583, adult male; deposited by S. Müller, 1835.

Status. Junior subjective synonym of *Coluber sumatranus* Raffles, 1822. Synonymized by Lidth de Jeude (1886: 51).

Material Examined (*n* = 44)

Indonesia

Sumatra. Bengkulu Province. MZB 1035, Gunung Gedang; MZB 2180, "Muara Aman, North Bengkulu;" MZB 3718, ZMB 66177–8; ZMB 76340, ZMB 70490, "Bengkulu;" ZMH R06936, Lebong-Tandai (3°01'S–101°5'E). Jambi Province. MZB 457, "Jambi." Lampung Province. MZB 2166, Rimba; MZB 2219, "Propinsi Lampung." Sumatera Barat Province. OMNH R2135–6,

Kambot, Ulu Gadut, Mt. Gadut, ca. 800 m; MZB 2443, MZB 2445, Anai River. No locality. ZFMK 76340 (neotype), South-western Sumatra.

Borneo (Kalimantan). Kalimantan Barat Province. MZB 1052, Sungai Mentawit Balik; ZSM 283/1977-1–2, Landak River; MZB 2138a–b, Tangung Lokang, Kapuas Hulu Regency. Kalimantan Tengah Province. MZB 2647, Maruwai. Kalimantan Timur Province. MZB 1340, Mapa Kelai River. Unidentified locality. MZB 2424, Sungai Auge.

Federation of Malaysia

Borneo (East Malaysia). State of Sabah. FMNH 239949–52, FMNH 239957–8, Tenom District; FMNH 239959, Sipitang District. State of Sarawak. BMNH 91.8.29.33, Mt. Dulit, Miri District, Miri Division; BMNH 1978.1879, Gunung Mulu National Park, Miri District, Miri Division; FMNH 138687–8, FMNH 138690, FMNH 148829, Kapit District, Kapit Division; FMNH 158671, Bintulu, Bintulu Division.

West Malaysia. State of Johore. BMNH 1971.1532, Panti Forest Reserve, South Johore. State of Pahang. ZRC 2.2929, Kuala Tahan; ZMB 69982, "Pahang." State of Trengganu. BMNH 1974.5001–3, Gunong Lawit.

Thailand

Yala Province. BMNH 1936.9.12.3, "Betong, Pattani."

Taxonomic and nomenclatural comments

There is no doubt about the distinct specific status of *T. sumatranus* and *T. hageni*. Our material shows that, in contrast to the conclusions of Sanders et al. (2004), *Trimeresurus sumatranus* is a rather wide-ranging species. We examined several specimens from West Malaysia and one from extreme southern Thailand, and they are morphologically identical with specimens originating from most populations of Sumatra and Borneo. There is no reason for assigning them to any other species of the subgenus *Parias*, and definitely not to *T. hageni*.

Furthermore, *T. sumatranus auctorum* is here shown to be composed of two species in Sumatra. Some populations of Sumatera Barat Province, in the northern part of the range of the species, are here referred to a new species that is described below. We examined the holotype of *T. formosus* Müller and Schlegel (1842: Fig. 2). We confirm that this specimen is definitely referred to *Trimeresurus sumatranus* and not to the new species described below that inhabits the same region. *Trimeresurus sumatranus*, as here redefined, is monotypic.

Raffles (1822) described this species on the basis of a single specimen. As he was posted in "Bencoolen," and according to S. Raffles (1835: 102–104), his widow, T. Raffles was interested in local "wonders in natural history." Furthermore, T. Raffles announced in a letter dated on 14 March 1820 that he planned to ship home, (England) the whole of his zoological collection "in a few days." This collection was shipped before 29 March. So, by all evidence, the holotype of *Coluber sumatranus* originated from Bengkulu or its vicinity. On the basis of these historical considerations, Wallach et al. (2014) restricted the type locality of *Coluber sumatranus* to this city on the south-western coast of Sumatra. Considering that the description of the new species was published in 1822, we may ascertain that the holotype was included in this shipment and originated from the vicinity of Bengkulu. However, the fate of the specimen is unknown and, by all evidence, it should be considered lost. As a consequence, we here designate a neotype for *Coluber sumatranus* (Raffles, 1822).

Designation and Description of the Neotype of *Coluber sumatranus* Raffles, 1822

The designation is made on the following basis and in agreement with the following articles of the *Code*: (1) the neotype is designated in order to fix the status of *Coluber sumatranus* (Raffles, 1822) according to its current definition in the literature, especially in regards to populations described below as a new species and of other species of the subgenus *Parias* (Art. 75.3.1 of the *Code*); (2) diagnostic characters of *Coluber sumatranus* for which we designate this neotype, are given below (Art. 75.3.2); (3) the neotype is designated in details below (Art. 75.3.3); (4) a holotype has never been mentioned in the literature, for example by Boulenger (1896). It could not be traced in the collections of the Natural History Museum (London), in contrast to Cox et al.'s (2012) statement, or of the Zoological Reference Collection of the National University of Singapore. For these reasons, we consider the holotype to be lost (Art. 75.3.4); (5) we select a specimen, the morphology of which i.e., scalation, pattern, and coloration, that agrees with characters provided in the original description (Art. 75.3.5); (6) as shown above, the holotype most probably originated from Bengkulu Province. We select a neotype from an area of Sumatra that encompasses Bengkulu Province (Art. 75.3.6). For these reasons, and in agreement with Art. 75.3.7 of the *Code*, we here designate as the neotype of *Coluber sumatranus* as the following specimen:

ZFMK 76340, an adult female, from "Southwestern Sumatra" (Fig. 1)

Morphology and measurements

Body elongate, compressed; head elongate, relatively narrow seen from above, massive seen from the side, distinctly triangular, wide at its base, clearly distinct from the neck, flattened but thick, 1.8 times as long as wide; snout quite long, round when seen from above, strongly obliquely truncated when seen from the side, with a mod-

Fig. 1 A-C. *Trimeresurus sumatranus*, ZFMK 76340, neotype of *Coluber sumatranus* Raffles, 1822, southwest Sumatra, Bengkulu Province, Sumatra. **A.** dorsal view of the body, **B.** ventral view of the body, **C.** lateral view oft the head. *Photo: G. Vogel.*

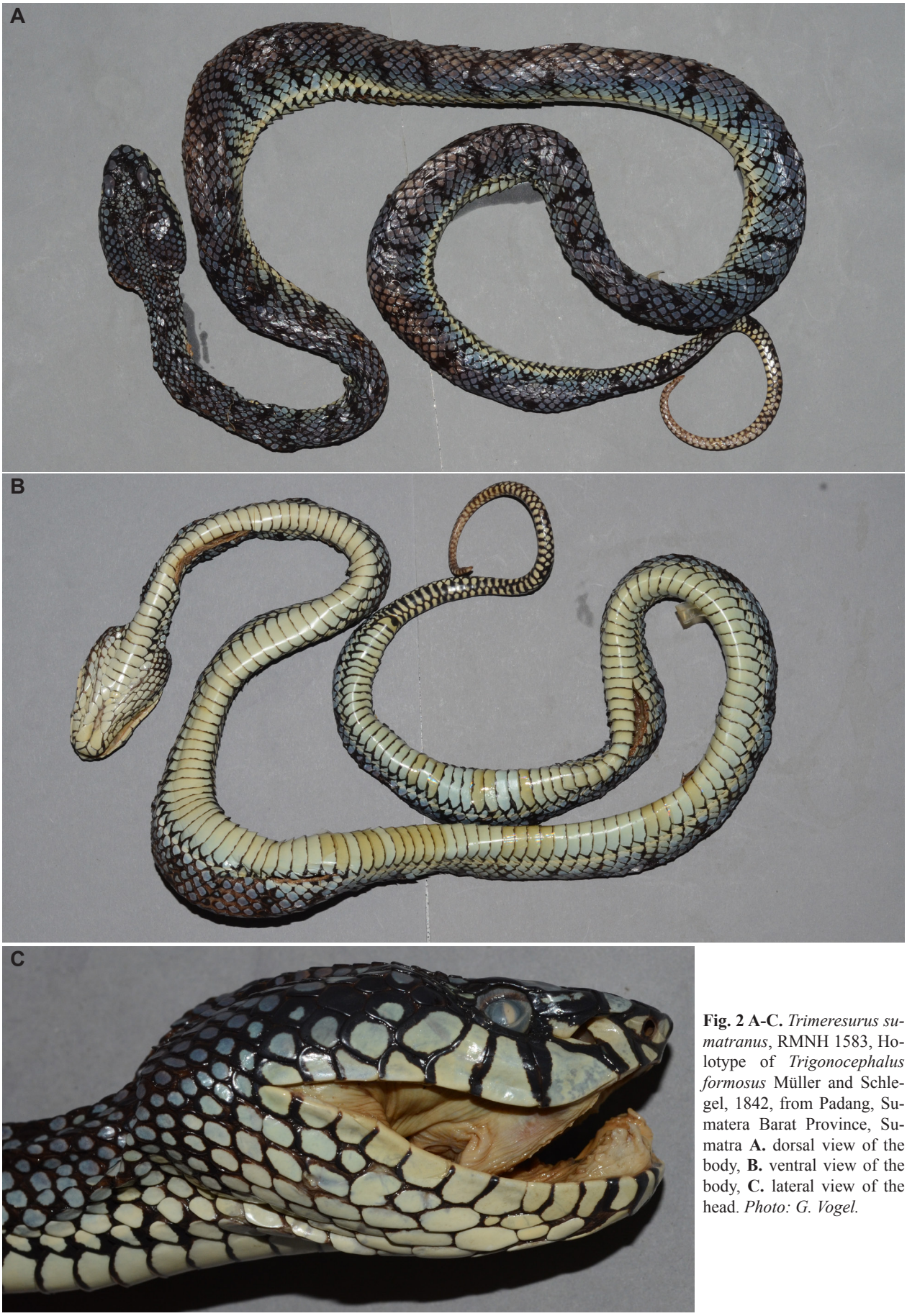

Fig. 2 A-C. *Trimeresurus sumatranus*, RMNH 1583, Holotype of *Trigonocephalus formosus* Müller and Schlegel, 1842, from Padang, Sumatera Barat Province, Sumatra **A.** dorsal view of the body, **B.** ventral view of the body, **C.** lateral view of the head. *Photo: G. Vogel.*

Fig. 3A. MZB.Ophi.5452 live holotype of *Trimeresurus gunaleni* spec. nov. from Mt. Sibayak, ca. 1,800 m a.s.l., west of Brastagi, Sumatera Utara Province, Sumatra, adult female. *Photo: G. Vogel.*

Fig. 3B. MZB.Ophi.5452 live holotype of *Trimeresurus gunaleni* spec. nov. from Mt. Sibayak, ca. 1,800 m a.s.l., west of Brastagi, Sumatera Utara Province, Sumatra, adult female. *Photo: G. Vogel.*

Fig. 4A. Live male of *Trimeresurus gunaleni* spec. nov. from Mt. Singkut, 1,600 m a.s.l., Sumatra Utara Province, Sumatra. *Photo: G. Vogel.*

Fig. 4B. Live male of *Trimeresurus gunaleni* spec. nov. from Mt. Singkut, 1,600 m a.s.l., Sumatra Utara Province, Sumatra. *Photo: G. Vogel.*

Fig. 5. Comparative dorsal view of the head of *Trimeresurus gunaleni* spec. nov. (left) and *T. sumatranus* (right). Left from above: Male, female (holotype), male, all from Sumatra Utara Province, Sumatra alive, right adult female alive from Bengkulu Province, Sumatra, adult male alive from Bengkulu Province, Sumatra, preserved female from Borneo. *Photos: N. Maury.*

Fig. 6. Comparative lateral view of the head of *Trimeresurus gunaleni* spec. nov. (left) and *T. sumatranus* (right). Left from above: Male, female (holotype), male, all from Sumatra Utara Province, Sumatra alive, right adult female alive from Bengkulu Province, Sumatra, adult male alive from Bengkulu Province, Sumatra, preserved female from Borneo. *Photos: N. Maury.*

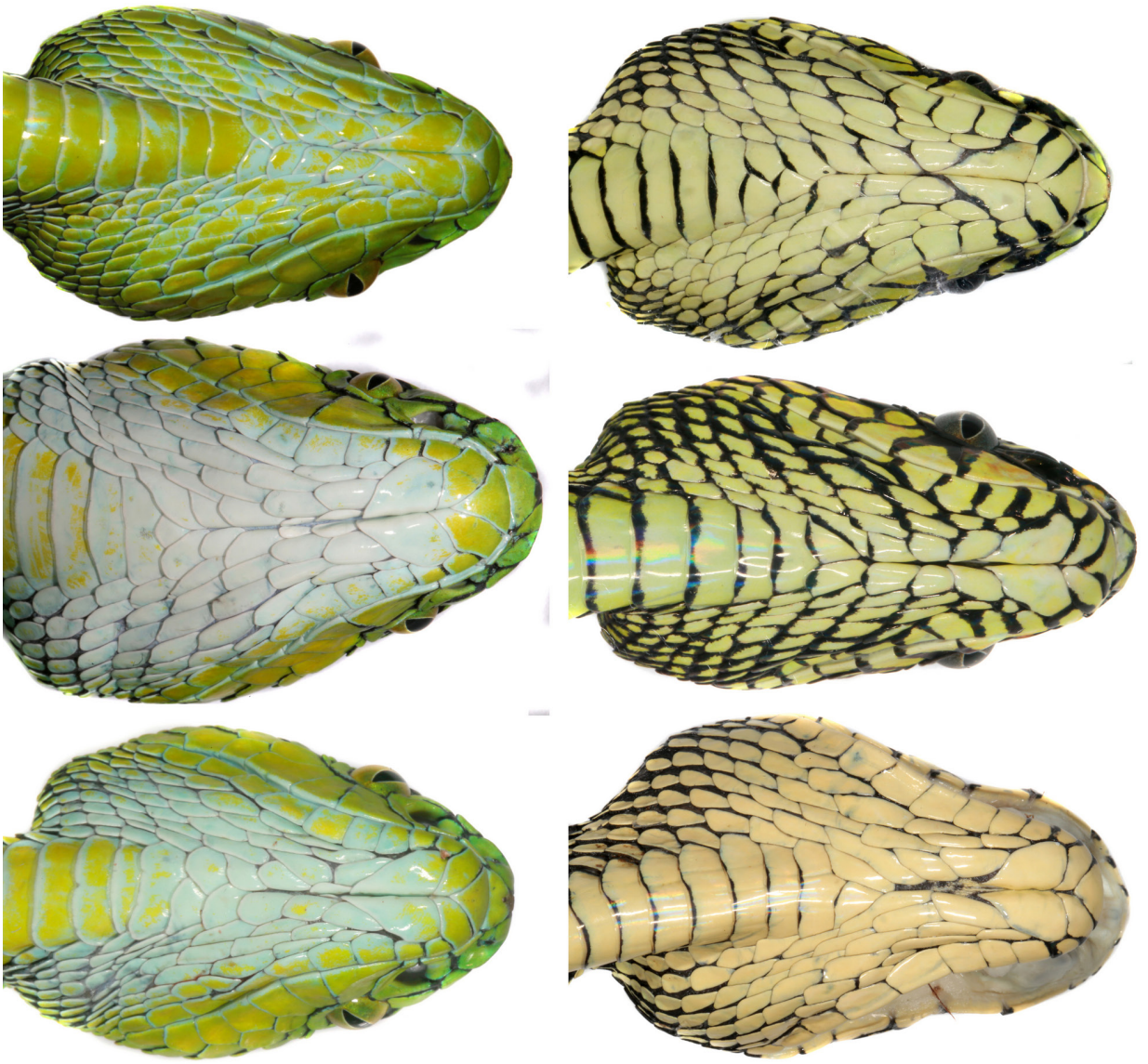

Fig. 7. Comparative ventral view of the head of *Trimeresurus gunaleni* spec. nov. (left) and *T. sumatranus* (right). Left from above: Male, female (holotype), male, all from Sumatra Utara Province, Sumatra alive, right adult female alive from Bengkulu Province, Sumatra, adult male alive from Bengkulu Province, Sumatra, preserved female from Borneo. *Photos: N. Maury.*

erate *canthus rostralis*, totalling 28% of head length and 1.9 times as long as diameter of eye; a large, oval nostril piercing in the middle of nasal scale; nostril-loreal pit distance about 0.4 times the distance between the nostril and the eye; eye average, amounting for 0.6 times the distance between the lower margin of eye and upper lip border; tail, tapering and prehensile. SVL 895 mm, TaL 155 mm, TL 1,050 mm; ratio TaL / TL 0.148.

Body scalation

DSR: 21–21–15 scales, rhomboid, very weakly keeled with the exception of scales of first dorsal scale row which is smooth and not enlarged; 186 ventrals (+ two pre-ventrals); 61 subcaudals, all paired; anal entire.

Head scalation

Rostral barely visible from above, triangular, about as high as broad; nasals subrectangular, large, elongate, entirely divided by a furrow; two subrectangular, laterally elongate internasals, about 1.8 times wider than long, separated each from the other by one small scale; each internasal followed on each side by one very large scale on the snout, much larger than internasals, broader than long, separated each from the other by two longitudinal series of small scales; 2/2 canthal scales bordering the *canthus rostralis* between internasal and corresponding supraocular, i.e., the very large scale behind internasal followed by a small scale smaller than adjacent snout scales between the largest canthal scale and the supraoculars respectively; on each side, one elongate loreal scale between nasal and the upper preocular; 2/2 preoculars above the loreal pit, the upper one visible from above, both scales elongate and in contact with loreal; lower preocular forming the lower margin of loreal pit; 1/1 thin, elongated, crescent-like subocular; 2/2 small postoculars; 1/1 large supraocular, broad, 2.2 times as long as wide, about 1.3 times as wide as internasal, not indented by upper head scales; scales on upper snout surface much enlarged, smooth, juxtaposed, subrectangular, with four scales on a line between the scale separating the internasals and a line connecting the anterior margins of eyes; six cephalic scales on a line between supraoculars, smooth, flat, and juxtaposed; occipital scales flat, smooth; temporal scales in two or three rows, smooth, lower ones much enlarged; 9/9 SL, first SL triangular, rather short, completely separated from the nasal; second SL tall, bordering entirely the loreal pit and anteriorly in contact with nasal; third SL longest and highest, about 1.1 times longer than high, in contact on both sides with subocular; fourth SL barely shorter than third SL, in contact with the subocular; fifth SL barely shorter than fourth one, also in contact with the subocular; 10/11 infralabials, those of the first pair not longitudinally in contact, shortly separated by the apex of the mental scale, first–second IL in contact with anterior chin shields; four rows of smooth gular scales; throat shields irregularly arranged.

Coloration and pattern

The body is olive-green on third–eleventh DSR, slightly paler on the bottom of the sides; most dorsal scales distinctly edged with black producing a reticulate pattern; 46 irregular black crossbars on each side of the body, either symmetrical, forming black rings or more or less set off from each other on each side across vertebral line; scales of the first DSR and lower half of those of the second DSR pale greenish-yellow with black edges, producing a pale, diffuse ventrolateral stripe extending from the area just behind the neck up to vent; scales of the first DSR with a broad, irregular black edge on their anterior lower part. The tail is olive-green on its anterior half, with scales strongly edged with black, producing a strongly reticulate pattern, and two or three more or less distinct black crossbars anteriorly, becoming progressively rusty red, strongly reticulate with black.

The head is olive-green above and on the temporal region, with cephalic, occipital, and temporal scales strongly edged with black; on each side, another long streak extends from internasals to the posterior part of the head along the inner edge of supraoculars; two oblique black streaks on the occiput forming an inverted V, its apex pointing forward; supraoculars olive green, broadly edged with black; some other cephalic and occipital scales entirely black, so as to produce black blotches and streaks between supraoculars; upper snout surface heavily marked with pure black, producing broad edges around olive-green prefrontals and internasals; scale behind and between internasals black; black vertical and horizontal streaks on the rostral; supralabials yellowish-green, distinctly paler than upper head surface, strongly edged with black, with a broader streak at the limit between third–fourth supralabials; preoculars olive-green strongly edged with black; a black postocular streak extending from the eye to the area above the corner of the mouth on lower postocular and the upper rows of temporals. Chin and throat pale greenish-yellow; an irregular dark grey spot on each infralabials of the first pair; all infralabials edged with black on their posterior margin; gular scales below the corner of the mouth also narrowly edged with black.

The venter is pale greenish-yellow; each ventral narrowly edged with black, especially on their central part, sometimes on the whole of their posterior margin; tips of ventrals narrowly edged with black on each side, producing an irregular, zigzag-like black ventral stripe below the pale ventrolateral stripe. The tail is yellowish-green or greyish-yellow below on its anterior half, with subcaudal scales broadly edged with black producing a conspicuous reticulation, turning more or less abruptly to rusty red, strongly reticulated with black.

Diagnosis

A large species of pitviper of the genus *Trimeresurus*, characterized by the combination of (1) body elongate, head long and massive in adults; (2) body deep green or dark green with conspicuous, black crossbars on the sides in adults, with a broad, pale ventrolateral stripe, and without sexual dimorphism in coloration; (3) 21 (exceptionally 23) DSR at midbody; (4) first supralabial distinct from nasal scale; (5) large internasals, most usually separated by one scale, only exceptionally in contact; (6) three supralabials, third, fourth, fifth SL in contact with subocular, or fifth exceptionally separated by one scale; (7) supraoculars broad, separated by 3–7 (usually 5–6) scales; (8) tail average, with a ratio TaL/TL between 0.150 and 0.168 in males and 0.128 and 0.160 in females; (9) 175–191 VEN; (10) 54–68 SC (males: 66–71; females: 54–68); (11) eye dark grey in life, rather bronze, brown, dark greyish-brown or golden-brown in preservative; (12) supralabials and cephalic scales strongly and broadly edged with black; (13) a black postocular streak; (14) venter is yellowish-green or pale green, with each ventral narrowly edged with black posteriorly; and (15) tail green as the body on its anterior half, becoming more or less abruptly salmon, pinkish-red, or rusty-red on its posterior half, strongly and broadly reticulate with black.

Characters separating *Trimeresurus sumatranus* from the new species and *T. malcolmi* are discussed below and summarized in Table 2.

Description and Variation of *T. sumatranus* (Fig. 5–9)

According to Brongersma (1933), Sanders et al. (2002), Gumprecht et al. (2003), Das (2010), and our material, this large species reaches a maximum total length of 1,355 mm. Gumprecht et al. (2003) mentioned a total length of 1,400 mm. Males are seemingly shorter, the longest male seen by us being only 878 mm long. Adults reach usually a maximum total length of 90–110 cm.

The body is robust but elongate in both males and in females, or slightly thinner in males. In adults, the snout is 24.0–28.0% as long as head or 1.8–2.6 times as long as diameter of eye. Eye average, amounting for 0.6–1.0 times the distance eye–lower edge of the lip in both sexes. Ratio TaL/TL: 0.128–0.168, with a weak sexual dimorphism: males: 0.150–0.168; females: 0.128–0.160.

Hemipenis

After Gumprecht et al. (2004: 304: Fig. IV), hemipenes are long and slender, deeply forked, extending up to twenty-secondth subcaudal, forked opposite ninth subcaudal, smooth at its base and after the forking point, for about a third of the organ, then strongly papillose and spinose, with longitudinal folds.

Body scalation

DSR: 21–25 one head length posterior to the head; 21 (exceptionally 23) at midbody; 15 (exceptionally 13 or 17) scales one head length before vent, weakly or dis-

Table 2. Main characters to distinguish between the species of the *Trimeresurus sumatranus* complex, source specimens from Appendix I, if not noted different.

Characters	*Trimeresurus gunaleni* spec. nov.	*Trimeresurus sumatranus* Sumatra	*Trimeresurus sumatranus* Borneo	*Trimeresurus sumatranus* Peninsular Malaysia	*Trimeresurus malcolmi*[1]
N males/females	5/4	2/13	3/19	2/5	3/4
Middorsal scale rows	21	21	21	21	19
Ventrals males	162–179	179–182	182–185	178–183	169–173
Ventrals females	164–174	175–186	176–191	180–186	168–174
Subcaudals males	71–72	66–70	66–71	69–70	64–81
Subcaudals females	58–66	57–68	54–64	61–66	61–64
Total length	1170	1152	1350	1220	1330
Relative tail length males	0.201–0.210	0.160–0.166	0.154–0.168	0.150–0.161	0.160–0.179[4]
Relative tail length females	0.144–0.180	0.130–0.159	0.128–0.150	0.134–0.160	0.158[5]
White lateral line[3]	Thin	Broad	Broad[2]	Broad	Absent
Ventrals with dark margins	No	Yes	Yes	Yes	Yes
Subcaudals with dark margins	No	Yes	Yes	Yes	Yes
Tail reddish	No	Yes	Yes	Yes	Yes
Eye in life	Green	Dark grey	Dark grey	Dark grey	Dark grey

[1]From Stuebing and Inger (1998).
[2]In two specimens there is no real ventrolateral stripe visible, but the outer row of dorsals is pale.
[3]Sometimes there is a faint black line below the white lateral line.
[4]Holotype and one paratype only according to Loveridge (1938).
[5]One paratype only according to Loveridge (1938).

tinctly keeled, smooth on first DSR; VEN: 175–191 (plus 1–2 preventrals); SC: 54–68, all paired, with a sexual dimorphism (males: 66–71; females: 54–68); anal entire.

In our sample of 44 specimens, we have not examined any specimen with 23 DSR at midbody but this value has been recorded in the literature by Brongersma (1933) from a specimen from Borneo. In our material, two specimens had 13 scale rows before vent and only one had 17 rows before vent.

Head scalation

Rostral barely visible from above, triangular, wider than high; nasals subrectangular, divided; one large, subrectangular or nearly square internasal on each side; internasals usually separated by one scale or in contact (in 11/44 examined specimens); two (rarely three) canthal scales bordering the *canthus rostralis*, one larger than the large adjacent snout scales and one (or two) of similar size; two (exceptionally one) postoculars on each side; one very large and wide supraocular on each side, about 1.8–2.2 times as long as wide, 1.0–1.3 times as wide as internasal, not indented by adjacent cephalic scales; 4–7 much enlarged scales on upper snout surface on a line between the scale separating the internasals and a line connecting the anterior margins of eyes, smooth and juxtaposed; 3–7 (usually 5–6) cephalic scales on a line between supraoculars, large, smooth, flat, and juxtaposed; occipital scales larger than cephalic scales, smooth; temporal scales smooth, large, subequal, in two rows anteriorly, three rows posteriorly; 8–11 (usually 9–10) supralabials; first SL always separated from nasal; second SL tall, entirely bordering the anterior margin of the loreal pit, always in contact with nasal; third SL longest and highest, 1.1–1.4 times as long as high, always in contact with subocular; fourth SL as long as high, as high or barely shorter than third SL, always in contact with subocular; fifth SL usually in contact with subocular, exceptionally separated by one scale (on one side in 3/44 specimens); 9–15 (usually 10–12) IL; scales of the first pair longitudinally in contact or barely separated by the apex of the long mental scale; first two or three pairs of infralabials in contact with anterior chin shields; 5–9 rows of smooth gular scales; throat shields irregularly arranged.

Coloration and pattern

In live adult specimens, the dorsum is yellowish-green, grass green, deep emerald green, or olive green (deep green, bluish-green, or dark brown in preservative); many scales of the body narrowly edged with black; usually a series of about 45–50 irregular, black crossbars one or two dorsal scales in length, reaching downwards to the third or second dorsal scale rows on each side of the body. These crossbands are either symmetrical, forming black rings, or offset from each other on each side of the vertebral line. Each crossbar includes one or two entirely black scales, the other dorsal scales are strongly edged in black. The interstitial skin between the large dorsal scale is also black, making an overall distinctly barred and reticulate pattern. A more or less conspicuous, cream, greenish-yellow, or pale yellow ventrolateral stripe on the first and lower half to whole of the second dorsal scale rows, extends from the base of the neck to the vent. This pale stripe is bordered below by a narrow dark stripe created by the black edge of the outer tips of the ventral scales. The background color of the tail is as green as the body on its anterior half, with scales distinctly edged with black, producing a strongly reticulate pattern. There are 2–5 irregular black crossbars on each side of the tail which, becomes more or less abruptly greenish-orange, salmon, pinkish-red, or rusty-red on its posterior half.

The upper head surface and temporal regions are as green as the body, the sides of the head and temporals are slightly paler and usually more yellowish-green or paler green. The rostral is green with black vertical and horizontal streaks. Scales of the upper snout surface are also green, broadly edged with black, and may be entirely black with the exception of a large, round green blotch on each internasal and each scale behind the internasal. Supraoculars green, broadly edged with black; many scales of the cephalic and occipital regions black, producing a pattern of black blotches or streaks. On each side of the head, a long streak usually extends from internasals to the posterior part of the head along the inner edge of supraoculars; two oblique black streaks on the occiput forming an inverted V; its apex pointing forward. Supralabials greenish-yellow, pale green, yellowish-green, or bluish-green, paler than the upper head surface, strongly edged with black, black edges at the limits between third–fourth and fourth–fifth supralabials broader and more conspicuous; preoculars and postoculars green and black or entirely black; a black postocular streak extends from the eye to the corner of the mouth on the postoculars or lower postocular and the upper rows of temporals, more or less broadly blotched with the green background color. The chin and throat are white, cream, pale greenish-yellow, or yellowish-green, uniform or with scattered dark grey dots. The infralabials are white, pale bright yellowish-green, or pale green, with or without a few dark grey spots, edged with black on their posterior margin; gular scales below the corner of the mouth narrowly edged with black. In life, the eye is rather dark, bronze, brown, dark greyish-brown, or golden-brown.

The venter is yellowish-green, pale greenish-yellow, or pale green; each ventral is narrowly edged with black posteriorly, the edge usually broader on their central part tips of ventrals narrowly edged with dark grey or black, producing an irregular, zigzag-like dark ventral stripe below the pale ventrolateral stripe. The under surface of the tail is green or greenish-yellow on its anterior half, with subcaudal scales broadly edged with black producing a conspicuous reticulation, becoming more or less abruptly greenish-orange, salmon or pinkish-red, strongly reticulated with black.

Fig. 8. Live female of *Trimeresurus sumatranus* from vincity of Padang Panjang, Sumatera Barat Province, Sumatra. *Photo: G. Vogel.*

Juveniles show a rather different pattern. The dorsum is usually bright or grass-green, with only faint and narrow black spots or edges of dorsal scales producing faint, diffuse crossbars. The head is speckled with black dots but without dark lines and streaks on the edges of scales; no black edges on the suture of supralabials but with scattered black spots. The orange, salmon color or rusty red color of the tail is brighter than in adults.

Distribution (Fig. 8)

Indonesia

Sumatra. Known from the provinces of Sumatera Barat, Jambi, Bengkulu, and Lampung, in Barisan Range.

Borneo (Kalimantan). Seemingly throughout the island.

Federation of Malaysia

Borneo. Known from the States of Sabah and Sarawak.

West Malaysia. Definitely recorded from the States of Perak (Sukumaran 2002 as *Tropidolaemus wagleri*, pers. comm.), Johore, Pahang, and Trengganu.

Thailand

Recorded only from Yala Province.

In contrast to Sanders et al. (2004), we confirm the occurrence of *T. sumatranus* in extreme southern Thailand and West Malaysia. Examined specimens present the combination of all scalation and pattern characters, both of the head and body, in full agreement with the definition of this species. They all differ from *Trimeresurus hageni* and we could not find any reason for not referring them to *T. sumatranus*. The range of *T. sumatranus* in Sumatra is wider than indicated in Sanders et al. (2004) but the records from the Indonesian islands of Bangka, Belitung, Nias, Simeulue, and the Mentawai Archipelago (see, for example, Brongersma 1933; Dring et al. 1990), are now referred to the *T. hageni* group.

Natural History

This beautiful species inhabits regions typically covered with equatorial rainforests, lowland tropical wet forests, and tropical wet submontane forests, from sea level up to about 1,000 m. The species shows a predilection for lowlands in Borneo but, seemingly, only for hilly areas at elevations between 650 and about 900 m in Sumatra (Ryabov et al. 2002; Gumprecht et al. 2003; Sanders et al. 2004). This pitviper is found in tropical forests, along clearings, in bamboo thickets, mangroves, swamps, plantations, and cultivated fields such as coffee and tea estates. However, in Sumatra, all specimens recorded by Ryabov et al. (2002) and Gumprecht et al. (2003) in Bengkulu Province (Sumatra) were found in forest, none in cultivated areas or near villages.

Fig. 9. Live female of *Trimeresurus sumatranus* from Bengkulu Province, Sumatra. *Photo: G. Vogel.*

Fig. 10. Live female of *Trimeresurus malcolmi* from Mount Kinabalu, Sabah, Borneo. *Photo: M. Dehling.*

Fig. 11. Live female of *Trimeresurus malcolmi* from Mount Kinabalu, Sabah, Borneo. *Photo: M. Dehling.*

Fig. 12. Live male of *Trimeresurus toba* from vincity of Padang Panjang, Sumatera Barat Province, Sumatra, a species sympatric with *T. gunaleni* spec. nov. *Photo: G. Vogel.*

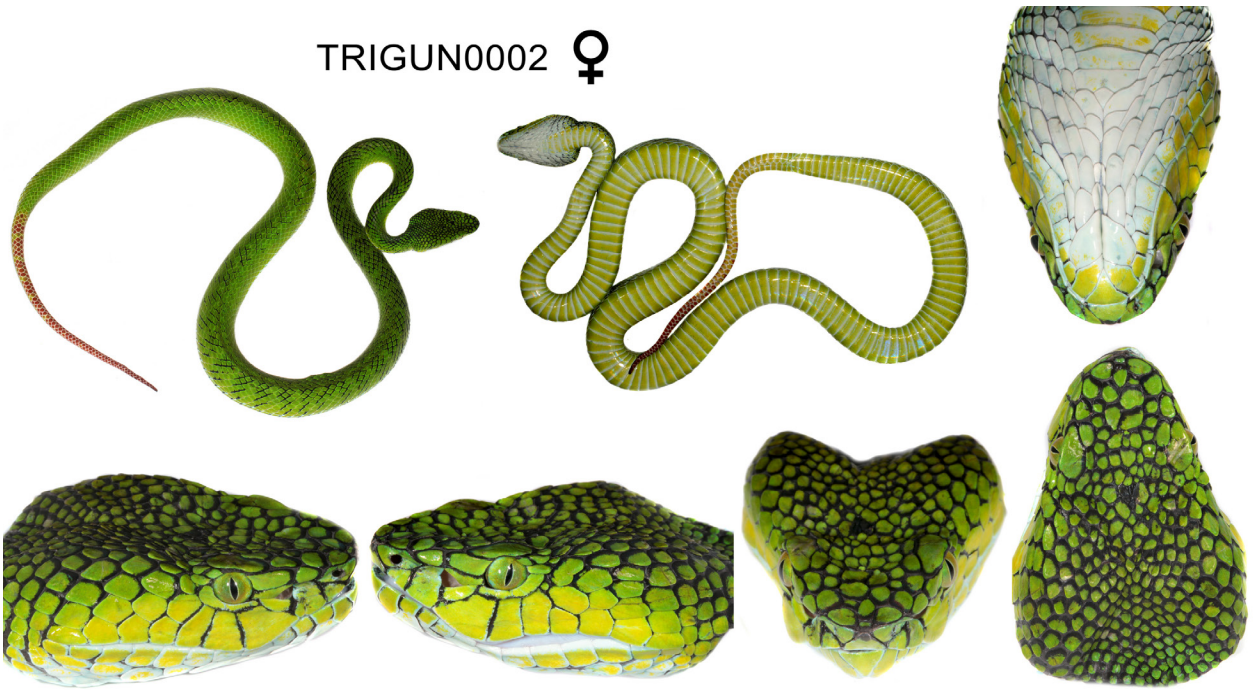

Fig. 13. MZB.Ophi.5452 holotype of *Trimeresurus gunaleni* spec. nov., adult female. *Photo: N. Maury.*

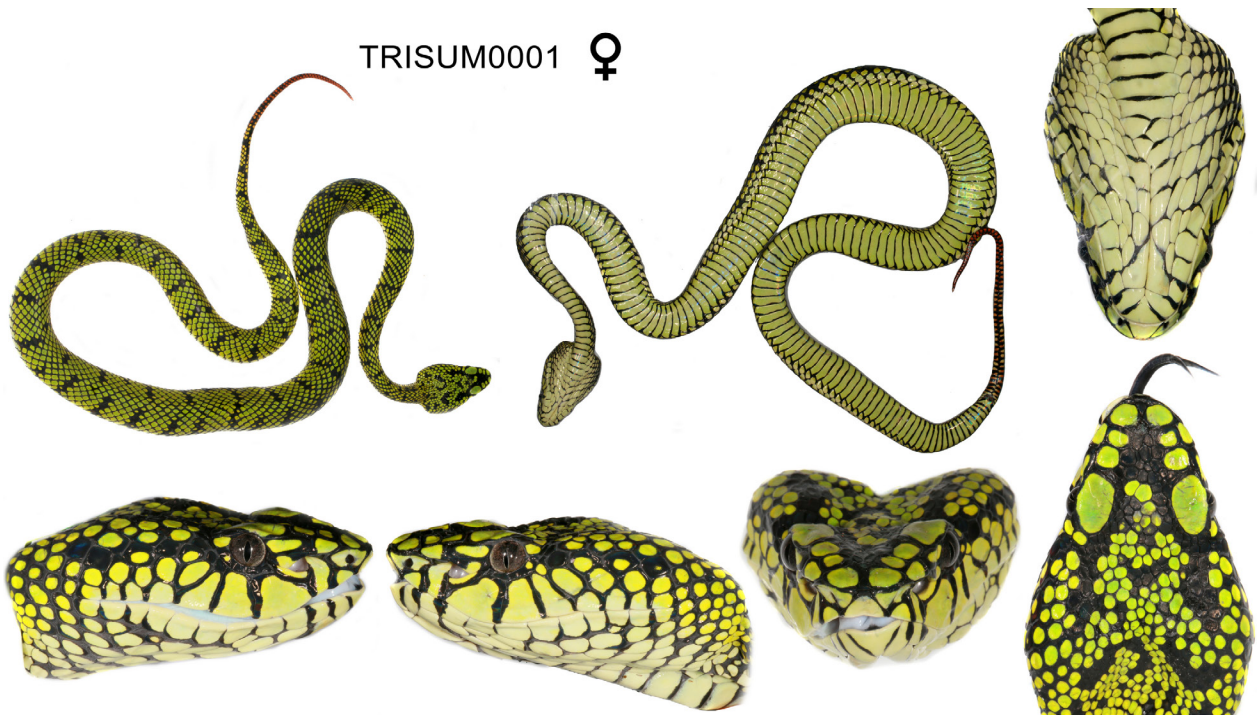

Fig. 14. Live female of *Trimeresurus sumatranus* from Bengkulu Province, Sumatra. *Photo: N. Maury.*

Trimeresurus sumatranus often occurs along the banks of rivers, ponds, and other watered areas. This diurnal and nocturnal species is chiefly arboreal but lives in the lower vegetation such as in thick bushes, shrubs, and the tangled lower tree foliage up to 2.5 m above the ground, where it proves to be a skilled climber. Ryabov et al. (2002) found specimens basking in early morning. *Trimeresurus sumatranus* feeds on small mammals, frogs, lizards, and frogs. It is oviparous, but little is known on its breeding habits. Ryabov et al. (2002) mentioned a clutch of 17 eggs that were guarded by the female; we refer to Ryabov et al. (2002) and Gumprecht et al. (2003) for additional data on the biology of this species.

In our sample of specimens identified in collections as *Trimeresurus sumatranus*, we identified a total of six specimens that present noteworthy morphological differences with the species as defined above. We also noted the same differences in three specimens that were kept alive. As these differences with *T. sumatranus* are constant, we consider these specimens to be referable to a distinct species that we here describe as:

Trimeresurus gunaleni spec. nov.
Fig. 3–7, 13

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Trimeresurus sumatranus (nec *Coluber sumatranus* Raffles, 1822): Sanders et al. (2002: 107, part.; 2004: 722, part.).

Holotype

MZB.Ophi.5452, adult female, from Mt. Sibayak, ca. 1,500–2,200 m a.s.l., west of Brastagi (Berastagi), Karo Regency (Kabupaten Karo), Sumatera Utara Province, Sumatra, Indonesia. Collected by the team of Danny Gunalen, Hidekazu Miyake, Cho Sangyeon, and Moon Suk Cha.

Paratypes (six specimens)

NHMW 28159:1 (male), ZMB 29642 (male), NHMW 23909:4, NHMW 28159:2 (females), "Padang, Sumatra;" NHMB 2599 (male), "Solok, Sumatra;" SMF 52844 (female), "Padang Mountains, Sumatra, 1,700 m," all from Sumatera Barat Province, Sumatra.

Non-type material (two live male specimens)

Mt. Singkut, 1,600 m a.s.l., Karo Regency, Sumatra Utara Province, Sumatra.

Diagnosis

A large species of pitviper of the genus *Trimeresurus*, characterized by the combination of (1) body elongate, head long and massive in adults; (2) an overall green coloration with interstitial skin forming irregular, hollow, black dorsal crossbands, with a thin, pale ventrolateral line; (3) 21 DSR at midbody; (4) first supralabial totally separated from nasal scale; (5) large internasals, most usually separated by one scale, only exceptionally in contact; (6) three supralabials, third, fourth, fifth SL in contact with subocular; (7) supraoculars large but elongate, separated by 5–7 cephalic scales; (8) tail long, with a ratio TaL/TL between 0.201 and 0.210 in males and 0.144 and 0.180 in females; (9) 162–179 VEN; (10) 58–72 SC (males: 71–72; females: 58–66); (11) eye yellowish-green in life and preservative; (12) cephalic scales strongly and broadly edged with black but not forming streaks; (13) no black postocular streak; (14) venter greenish-yellow or pale green, uniform, with posterior margin of ventrals paler green; and (15) tail greyish-red, rusty brown or reddish-brown, mottled with green crossbars anteriorly.

Main characters separating *T. gunaleni* spec. nov. from other taxa of the complex of *T. sumatranus* are summarized in Table 2. *Trimeresurus gunaleni* spec. nov. mainly differs from *T. sumatranus* by (1) a lower number of ventrals in males (162–179, $\bar{x}$ = 168.4 vs. 178–185, $\bar{x}$ = 181.5; U = 33.5, $P < 0.005$) and females (164–171, $\bar{x}$ = 169.5 vs.175–191, $\bar{x}$ = 183.3); (2) a higher value of the ratio TaL/TL in males (0.201–0.210, $\bar{x}$ = 0.206 vs. 0.150–0.168, $\bar{x}$ = 0.161); (3) the color of the tail with hues of red throughout mottled with green crossbars anteriorly vs. green as the body on its anterior half, becoming more or less abruptly red (see above description) posteriorly, strongly reticulate with black; (4) the color of the eyes: green or yellowish-green in *T. gunaleni* spec. nov. vs. dark brown, dark grey, or bronze in *T. sumatranus*; (5) the color of the ventral scales, which are green with a paler posterior margin in *T. gunaleni* spec. nov. vs. pale green with a dark grey or black posterior margin in *T. sumatranus*.

Trimeresurus gunaleni spec. nov. differs from *T. malcolmi* by (1) the number of dorsal scales around midbody (21 vs. 19); (2) a higher value of TaL/TL in males (0.201–0.210, $\bar{x}$ = 0.206 vs. 0.160–0.179, $\bar{x}$ = 0.162, s = 0.009); (3) the presence of a white lateral stripe in *T. gunaleni* spec. nov., missing in *T. malcolmi*; (4) the color of the tail: greyish-red, rusty brown or reddish-brown, mottled with green crossbars anteriorly in *T. gunaleni* vs. greenish-orange, salmon or pinkish-red, strongly reticulated with black in *T. malcolmi*; below, the tail is yellowish green anteriorly, turning to brown posteriorly in *T. gunaleni* spec. nov. vs. green or greenish-yellow on its anterior half, with subcaudal scales broadly edged with black producing a conspicuous reticulation; (5) the color of the eyes: yellowish-green in *T. gunaleni* spec. nov. vs. dark grey in *T. malcolmi*.

Trimeresurus gunaleni spec. nov. differs from *T. hageni* by (1) a lower number of ventrals in males (162–179, $\bar{x}$ = 168.4 against 177–189, $\bar{x}$ = 181.8; U = 139.5, $P <$ 0.001) and females (164–171, $\bar{x}$ = 169.5 vs.176–196, $\bar{x}$ =

186.7); (2) by the internasals being separate (in eight out of nine specimens) against being most usually in contact in *T. hageni* (in 66 out of 73 specimens; $U = 545.5$, $P < 0.001$); (3) by the number of supralabials, usually being nine (in 14 out of 18 cases, only exceptionally 8 or 10, $\bar{x} = 9.11$) in *T. gunaleni* spec. nov. vs. usually 10 or 11 (in 123 of 148 occurrences, exceptionally 9, 12, or 13, $\bar{x} = 10.54$; $U = 637.0$, $P < 0.001$) in *T. hageni*; (4) by the total number of supralabials (on both sides) touching the subocular, six (in one case in seven, $\bar{x} = 6.1$) vs. usually being 2–4 (in 56 out of 74 cases, exceptionally 0, 1, 5, 6, $\bar{x} = 2.9$; $U = 632.0$, $P < 0.001$) in *T. hageni*; (5) by the number of infralabials, usually 11 (in 11 out of 16 occurrences, only exceptionally 10 or 12, $\bar{x} = 10.93$) vs. usually 12–14 (in 120 of 148 cases, exceptionally 11, 15, or 16, $\bar{x} = 13.08$; $U = 710.0$, $P < 0.001$) in *T. hageni*; (6) the lack of a pale temporal streak in *T. gunaleni* spec. nov., usually present in *T. hageni*, especially in males (in 27 of 29 males of *T. hageni*); and (7) the missing of dorsolateral white dots in *T. gunaleni* spec. nov., are usually present in *T. hageni* especially in males (in 27 of 29 males of *T. hageni*).

Etymology

The specific nomen is dedicated to Mr. Danny Gunalen, who was the first to find the species alive and who greatly supported the work resulting in the description of this new species. Suggested common names: English: Gunalen's Pitviper. Bahasa Indonesia: Ular Hijau Gunung. Karo: Nipe Ratah. Padang (Minang): Ular Ijo Babiso. French: Trimérésure de Gunalen. German: Gunalen's Grubenotter.

Description of the holotype (Fig. 3, 5–7, 13)

Body elongate, compressed; head elongate, distinctly triangular, wide at its base, clearly distinct from the neck, flattened anteriorly, thick posteriorly, 1.6 times as long as wide; snout long, round when seen from above, strongly obliquely truncated when seen from the side, with a moderate *canthus rostralis*, totaling 32.0 % of head length, and 2.7 times as long as diameter of eye; a large oval nostril piercing in the middle of nasal scale; nostril-loreal pit distance about 0.5 times the distance between the nostril and the eye; eye average, totaling 0.65 times the distance between the lower margin of eye and upper lip border; tail rather long, tapering, and prehensile.

SVL 995 mm, TaL 195 mm, TL 1,170 mm; largest head width 35.0 mm; ratio TaL / TL 0.167.

Body scalation

DSR: 21–21–13 scales, rhomboid, distinctly keeled with the exception of scales of first DSR which are smooth; 171 VEN (+ two preventrals); 60 SC, all paired; anal entire.

Head scalation

Rostral barely visible from above, triangular, much broader than high; nasals pentagonal, partly divided by a shallow furrow; on each side, one large, subtriangular internasal, the rounded apex pointing outwards; internasals separated by one small scale; 2/2 canthal scales bordering the *canthus rostralis*, not larger than the large adjacent snout scales on each side, one elongate loreal scale between nasal and the upper preocular; 2/2 preoculars above the loreal pit, the upper one visible from above, both scales elongated and in contact with loreal; lower preocular forming the lower margin of loreal pit; 1/1 thin, elongated, crescent-like subocular; 2/2 small postoculars, followed by 2/3 small scales between postoculars and first temporals; 1/1 large, subtriangular, elongate supraocular on each side, 1.8 times as long as wide, 1.1 times as wide as internasal, not indented by adjacent cephalic scales; three much enlarged scales on upper snout surface on a line between the scale separating the internasals and a line connecting the anterior margins of eyes, smooth and juxtaposed; seven cephalic scales on a line between supraoculars, smaller than upper snout scales, smooth, flat, and juxtaposed; occipital scales not larger than cephalic scales, smooth; temporal scales smooth, large, subequal, arranged in two rows anteriorly, three rows posteriorly; 9/9 supralabials, third–fifth SL in contact with subocular; first SL entirely separated from nasal; second SL tall, entirely bordering the anterior margin of the loreal pit, in contact with nasal; third SL longest and highest, 1.4/1.5 times longer than high; fourth SL tall and relatively narrow, 1.1/1.2 times higher than long, as high as third SL; fifth SL relatively narrow; 12/12 IL; scales of the first pair longitudinally in contact; first three pairs of infralabials in contact with anterior chin shields; six rows of smooth gular scales; throat shields irregularly arranged.

Coloration and pattern

The body is uniformly deep green (bright emerald green in life), with some scales narrowly edged with black, more strongly on the fore part of the body; a faint, diffuse pattern of black, hollow crossbars resulting from irregular areas of interstitial skin around dorsal scales, more conspicuously visible on the fore part of the body, producing about 25 crossbars, three or four DSR long and separated by one or two scales around which the skin is grey, reaching downwards the first or second DSR; from about midbody, the black skin is progressively restricted to the eighth or ninth DSR, producing irregular dorsal bars, disappearing entirely before the vent; a narrow ventrolateral stripe, pale blue in life, white in preservative, extends from the neck to the vent on the upper edge of scales of the first DSR, and lower edge of scales of the second DSR; posterior edge of scales of the first DSR also pale blue. The tail is greyish-red throughout, with scales narrowly edged with pale grey and with five pale green incomplete rings anteriorly.

The head is deep green above (bright emerald green in life) and on the temporal region, with scales of the snout, preoculars, supraoculars, cephalic, occipital, and lower temporal scales narrowly edged with black and surrounded with black interstitial skin, producing a conspicuous pattern of a "mixed" black background with bright green spots; no cephalic or occipital streaks; supraoculars narrowly edged with black; top of rostral black; anterior supralabials greenish-yellow, distinctly paler than upper head surface, others supralabials bright yellow in life; first–third SL narrowly edged with black posteriorly; no postocular streak; upper temporals green as the upper head surface. Chin and throat pale bluish-grey (cream in preservative); mental and first three infralabials greenish-yellow; other infralabials more or less marbled with greenish-yellow; posterior gular scales dotted with green.

The venter is uniformly yellowish-green, with the posterior edge of each ventral pale bluish-grey, distinctly paler than the background color of the venter. The tail is greenish-yellow on the first two subcaudals then greyish-red throughout as the upper surface of tail, with scales narrowly edged with pale grey.

Description of the paratypes

A summary of morphological and meristic data of the paratypes is given in Table 3. None of the paratype significantly differs from the description given for the holotype.

Description and variation

The maximal confirmed total length known is 1,170 mm (SVL 995 mm, TaL 195 mm; holotype). The second largest female has a length of 1,154 mm (SVL 972 mm, TaL 182 mm; NHMW 28159:2, from Padang). The largest known male is 927 mm long (SVL 732 mm, TaL 195 mm; NHMW 28159:1, from Padang). In our sample of nine specimens, there is a noteworthy difference of size between males and females (see below, sexual dimorphism).

The body is robust but elongate in both males and in females. In adults, the snout is 28.0–32.8 % as long as head or 2.3–2.8 times as long as diameter of eye. Eye average, amounting for 0.7–0.9 times the distance eye–lower edge of the lip in both sexes. Ratio TaL/TL: 0.144–0.210, with a sexual dimorphism (see below).

Hemipenis

Unknown.

Body scalation

DSR: 21–22 one head length posterior to the head, 21 at midbody, 13–15 scales one head length before vent, distinctly keeled, smooth on first DSR; VEN: 162–179 (plus preventrals), without sexual dimorphism; SC: 58–72, all paired, with a sexual dimorphism (see below); anal entire.

In our sample of nine specimens, only one specimen has 22 DSR on the neck, all others have 21 rows. Furthermore, all males have 13 rows before the vent but two females have 15 rows.

Head scalation

As described for the holotype, with the following variation for major characters: internasals separated by one small scale in 8/9 specimens, in contact only in specimen ZMB 29642; only two canthal scales on each side in all specimens, not larger than adjacent snout scales or slightly smaller, bordering the *canthus rostralis* between the internasal and corresponding supraocular; two small postoculars, in contact with first temporals or followed by 2–3 small scales between postoculars and first temporals; one large, elongate, subtriangular supraocular on each side, 1.6–2.1 times as long as wide, 1.0–1.3 times as wide as internasal, not indented by adjacent cephalic scales; 3–4 enlarged scales on upper snout surface on a line between the scale separating the internasals and a line connecting the anterior margins of eyes, smooth, and juxtaposed; 5–7 cephalic scales (5: 1/9 specimens; 6: 5/9; 7: 3/9) on a line between supraoculars, smaller than upper snout scales, smooth, flat, and juxtaposed; occipital scales not enlarged and smooth; temporal scales smooth, large, subequal, in two or three rows; 8–10 supralabials (8: 2/18 occurrences; 9: 12/18; 10: 4/18); third, fourth, fifth SL in contact with subocular in all specimens; first SL always separated from nasal; second SL tall, entirely bordering the anterior margin of the loreal pit, always in contact with nasal; third SL longest and highest, 1.2–1.5 times as long as high; fourth SL higher than long; fifth SL tall and narrow; 10–12 IL (10 or 11 in most specimens); scales of the first pair longitudinally in contact; first three

Table 3. Morphological characters of the paratypes of *Trimeresurus gunaleni* spec. nov. M: male, F: female, for other abbreviations see Table 1.

Collection number	Sex	SVL (mm)	TaL (mm)	TaL/ TL	VEN	SC	SL	SL touching sublabial	Cep	IL	Do
NHMW 28159:1	M	732	195	0.210	162	71	9/9	6	6	11/10	21
NHMB 2599	M	651	inc.	inc.	175	inc.	9/9	6	6	11/11	21
ZMB 29642	M	638	165	0.205	179	inc.	9/9	6	6	11/11	21
NHMW 23909:4	F	309	52	0.144	174	58	10/10	7	6	11/11	21
NHMW 28159:2	F	972	182	0.158	169	58	9/10	6	6	11/11	21
SMF 52844	F	400	88	0.180	164	66	9/9	6	7	?*/ ?*	21

inc.: Tail incomplete or partly destroyed.

*Destroyed.

pairs of infralabials in contact with anterior chin shields; 5–8 rows of smooth gular scales; throat shields irregularly arranged.

Coloration and pattern

The body is bluish-green or deep green (bright green or emerald green in life) with most of the dorsal scales narrowly edged with black, usually more strongly on the anterior part of the body; a faint, diffuse pattern of dark, hollow crossbars created by irregular areas of black interstitial skin surrounding three or four rows of dorsal scales, most conspicuous and extensive on the fore part of the body, separated by one or two scales around which the skin is grey; these dark crossbands reach downwards the first or second DSR on the anterior part of the body, progressively restricted to the upper DSR posteriorly, producing irregular dorsal bars and disappearing entirely before the vent; a narrow ventrolateral, stripe, white, cream, or pale yellow in preservative (cream or pale blue in life), extends from the neck to the vent on the upper half of scales of the first DSR and sometimes on lower edge of scales of the second DSR; posterior edge of scales of the first DSR also white or cream (cream or pale blue in life). The tail is greyish-red or rusty-red throughout, with scales narrowly edged with cream to pale grey, and mottled with incomplete cream, pale grey or pale greenish-grey rings (pale greyish-green in life), present on the anterior half of the tail or throughout.

The head is deep green above and on the temporal region; scales of the snout, preoculars, supraoculars, cephalic, occipital and lower temporal scales narrowly edged with black and entirely surrounded with interstitial black skin, producing a conspicuous pattern made of a black background "mixed" with bright green spots; no cephalic, occipital, or postocular streaks; supraoculars narrowly edged with black; top of rostral usually black; anterior supralabials green or yellowish-green, distinctly paler than upper head surface, others supralabials yellow, greenish-yellow or green; first–third SL usually narrowly edged with black on their posterior edge; upper temporals green as the upper head surface. Chin and throat cream (pale bluish-grey in life); mental and first three infralabials greenish-yellow or pale yellowish-green; other infralabials more or less marbled with greenish-yellow; posterior gular scales sometimes dotted with greyish-green or green spots.

Fig. 15. Habitat of *Trimeresurus gunaleni* spec. nov. *Photo: D. Gunalen.*

The venter is uniformly bluish-green or yellowish-green in preservative (yellow, greenish-yellow, or green in life), with the posterior edge of each ventral pale bluish-grey or greyish-green, distinctly paler than the background color of the venter. The tail is greenish-yellow or green anteriorly on a distance varying from the first subcaudals to the middle of the tail then greyish-red or rusty-red throughout as the upper surface of tail, with scales narrowly edged with pale grey and with cream, pale grey or pale greenish-grey blotches (pale greyish-green in life) corresponding to the rings of the upper surface.

Sexual dimorphism

Males and females differ in the relative length of the tail, in total length, and in the number of subcaudals:

(1) Strong difference in the ratio TaL/TL:
males: 0.201–0.210 ($\bar{x}$ =0.206); females: 0.144–0.180 ($\bar{x}$ =0.162).

(2) Total length:
Largest male: 927 mm vs. largest female 1,170 mm.

(3) Differences in the number of subcaudals:
71–72 ($\bar{x}$ =71.5) in two males vs. 58–66 ($\bar{x}$ =60.5) in four females.

There is no difference in the numbers of ventral scales or in other scalation characters, nor in pattern or in eye color.

Distribution

Indonesia

Sumatra. Endemic; *Trimeresurus gunaleni* spec. nov. is known only from two provinces: Sumatera Barat (Solok and Padang Mountains) and Sumatera Utara (Mt. Sibayak, Mt. Sinabung and Mt. Singkut near Berastagi).

This species can be expected in higher elevations all over the mountainous areas of Sumatra.

Natural History

Trimeresurus gunaleni spec. nov. inhabits regions typically covered with tropical moist montane forests, from 1,500 m to as high as at least 2,000 m, perhaps as much as 2,200 m, where it has been observed by local insect collectors (Figs. 15 and 16). There is no record of populations lower than 1,500 m. On Mount Sibayak, Danny Gunalen collected specimens of *Trimeresurus hageni* at elevation of 500 m, and *Tropidolaemus wagleri* at 200 m. *Trimeresurus gunaleni* is clearly isolated as a high montane dweller.

The female holotype of *T. gunaleni* spec. nov. was collected during the daytime in dense humid montane forest scattered with tiny springs. The snake was resting on the ground under tree roots. In another instance, a male was seen perched at night on a tree branch at about two m above the ground. None of the specimens were found near open water, the biotopes are dense humid montane forests.

Based on regurgitated prey items and direct observations in the wild, the diet includes rodents, amphibians, and lizards (*Gonocephalus lacunosus* Manthey and Denzer, 1991; E. Manik, pers. comm.). In captivity, *T. gunaleni* spec. nov. feeds on mice, birds, and lizards (D. Gunalen, pers. comm). Reproductive habits are still unknown.

Discussion

The differences in pholidosis and coloration, together with the fact that *T. gunaleni* spec. nov. and *T. sumatranus* are living in close proximity, leaves no doubt that *T. gunaleni* spec. nov. deserves full species status. Although *T. sumatranus* and *T. gunaleni* spec. nov. have been recorded from the same mountain ranges in Sumatera Barat Province, it is not yet known whether these two species are living in sympatry or syntopy. However *T. sumatranus* seems to live at lower elevations than *T. gunaleni* spec. nov. Too little is known about the exact ranges of both species in western Sumatra to ascertain if there is a zone of true sympatry.

The recognition of *T. gunaleni* brings the number of species in the subgenus *Parias* on Sumatra to three. Sumatra is inhabited by *T. sumatranus*, *T. hageni*, and *T. gunaleni* spec. nov., whereas Borneo is the home of *T. sumatranus* and *T. malcolmi*. This latter species is obvi-

Fig. 16. Habitat of *Trimeresurus gunaleni* spec. nov. *Photo: D. Gunalen.*

ously the highland equivalent of *T. gunaleni* spec. nov. In the Malay Peninsula, only *T. sumatranus* is known, although this species is rarely collected there. The relationship between the Malayan population and the other two populations of *T. sumatranus* are not known. In former reviews of this complex (Sanders et al. 2004), the existence of *T. sumatranus* in Peninsular Malaysia was denied, despite the fact that there are five specimens available in the collections of the Natural History Museum of London. Re-examination of these specimens and new specimens leave no doubt about the occurrence of *T. sumatranus* in West Malaysia and extreme southern Thailand. So far no highland population corresponding to *T. gunaleni* spec. nov. or *T. malcolmi* have been found in Peninsular Malaysia.

A rather similar scheme of relationships between zoogeographical entities of the Sunda Shelf can also be defined in other pitvipers. In the subgenus *Popeia* of the genus *Trimeresurus*, i.e., the complex of *Trimeresurus popeiorum* Smith, 1937 (see Vogel et al. 2004), the species *T. barati* Regenass and Kramer, 1981 is known from western and south-western Sumatra whereas *T. toba* David, Petri, Vogel and Doria, 2009, inhabits mountains of central northern Sumatra. In Peninsular Malaysia, *T. fucatus* Vogel, David, and Pauwels, 2004 is widespread but *T. nebularis* Vogel, David, and Pauwels, 2004 is currently considered endemic to the Cameron Highlands. However, only *T. sabahi* Regenass and Kramer, 1981 is known in Borneo. As in the subgenus *Parias*, there is no species of the subgenus Popeia known from Java. The situation is slightly different for the subgenus Craspedocephalus, i.e., the complex of *Trimeresurus puniceus* (see David et al. 2006). Here we do have *T. puniceus* (Boie, 1827) widely distributed in Java and in southern Sumatra, but also a distinct species, *T. andalasensis* David, Vogel, Vijayakumar, and Vogel, 2006 in northern Sumatra. Another species, *T. wiroti* Trutnau, 1981 is known from Peninsular Malaysia and southern Thailand, whereas *T. borneensis* Peters, 1872 is widespread in Borneo.

Trimeresurus hageni and *T. purpureomaculatus* are both distributed on Sumatra and Peninsular Malaysia (David and Vogel 1996) but not in Borneo. The systematics of both species is not resolved and there might be more taxa hidden under these names. The distribution of *T. purpureomaculatus* is restricted to mangrove areas. Lastly, *Trimeresurus albolabris* lives in the south of Sumatra (David and Vogel 2000) and on Java (Creer et al. 2003) but is unknown from West Malaysia and Borneo.

These species or complexes of pitvipers show the close zoogeographic relationships of the islands of Borneo and Sumatra with Peninsular Malaysia. Furthermore, it can also be seen that Sumatra is split into a northern and a southern region, with the larger northern region closely connected to Western Malaysia and Borneo, and the smaller southern region connected with Java. The limit between these two regions seems to be located between Padang and Bengkulu. Previously, these species complexes were regarded as widely distributed species, obscuring the zoogeographical relations of these regions. We are not confident that the taxonomy of the genus *Trimeresurus* is fully resolved and previously mentioned taxa might still prove to be endemic for one of the regions.

The finding of such a large and venomous pitviper as *T. gunaleni* spec. nov. in a group that was supposed to be well known is quite surprising. It is hard to understand that it was overlooked for such a long time despite the fact that the three specimens in the collection of Vienna have been available for a long time (collected 1899) and were already examined by other groups of herpetologists. The mountainous areas of Sumatra are still very incompletely known and further research in these areas is highly desirable.

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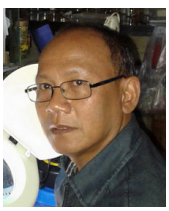
Appendix I. Additional specimens examined

Trimeresurus hageni (*n*=73). **INDONESIA.** ***Sumatra.*** BMNH 89.12.26.20, District of Deli; BMNH 93.6.5.11, East coast of Sumatra; MNHN 1880.0042, Sumatra; MZB 446, Pulau Batu, west Sumatra; MZB 1740, Padang Bukit Sebelah; MZB 1892a, b, Ketambe Aceh Tenggara; MZB 1898, Aceh Barut; MZB 2886, a, b Kembang Manis, Bengkulu; MZB 3716, Kubu Peraka Primer; NHMB 5108, Pelambeng, South Sumatra; NHMB 9423, Sumatra; NHMW 23909:1–2, Medan; NHMW 23909:3, Deli; NHMW 28150:1–3; Padang; NHMW 28150:4, Pagay; NHMW 28155:3, Medan; RMNH 5587A, Deli; RMNH RENA 819 (lectotype), Deli; ZFMK 32508, Sumatra; ZMB 15884, Sukuranda, Oberer Langkat, O-Sumatra; ZMB 29642, Padang; ZMB 32193a, b, Sumatra; ZMB 62699, Aceh; ZMB 66176, Bengkulu province; ZMH R06937, Serdang; ZSM 109/1927, Goenoeng Rintels, S. Deli; ZSM 202–1979a, Lau Rakit, near Deli; ZSM 202–1979b, Gunoeng Rinteh. ***Banka***. RMNH 4697, Banka; ZSM 365/1907 (4), ZSM 365/1908 (1–3) Simpang, Banka. **SINGAPORE**. BMNH 80.9.10.6, Singapore. **MALAYSIA**. ***West Malaysia***. BMNH 1936.9.12.5, "Kualla Taku, Malay Penin;" BMNH 1936.9.91, Perak; BMNH 1967.2290–1, Gunong Benom; CAS 16831, Silensing, Pahang; MNHN 1899.0269, Peninsular Malaysia; MNHN 1974.0044, Kuala Lumpur; NHMW 28158:1–2, Kedah; PSGV 393, Kuala Lumpur; S 0117 "West Malaysia;" SMF 64464–5, Perak; ZFMK 16680, Yombak; ZFMK 68522, north of Kuala Lumpur; ZMB 70235, frim, Selangor; ZRC 2.2928, Tasik Bera, Pahang; ZRC 2.2930, Tembeling, Pahang; ZRC 2.2932, Bukit Lagong Forest, Selangor; ZRC 2.2933–4, Ulu Langat, Selangor; ZRC 2.2935, Cameron Highlands, Pahang; ZRC 2.2943, Negeri Sembilan, Gunung Angsi; ZRC 2.5362, Bellum, Perak; ZRC 2.5397, Kepong, Frim, Selangor. **THAILAND**. BM 1936.9.12.4, Betong, Yala; BM 1988.858–62, Trang; IRSNB 3059 Betong. no locality: ZFMK 18835, no locality; ZFMK 21497, Sunda Islands.

Gernot Vogel was born in Heidelberg, Germany and received a Ph.D. in Chemistry. Dr. Vogel is now working as a chemist at an international company, doing research and registration of plant protection products in Hirschberg, close to Heidelberg. Beginning as a reptile keeper, Dr. Vogel developed a great interest in the snake fauna of the Oriental region. He has concentrated his work on southwestern China, Indonesia, and tropical India. Dr. Vogel has revised large snake genera with a wide distribution, and this has been achieved through international collaborations with, for example, the institutes of Chengdu and Kunming in China, with Lipi and KPH Salvator in Indonesia, and with various Indian groups including ARRS and ANET. His research is based on specimen collections all over the world and on field research in the regions cited above. Dr. Vogel has authored or co-authored the following books: *The Snakes of Sumatra*; *The Snakes of Sulawesi*; *Amphibians and Reptiles of Mount Kinabalu*; and parts I to III in the Terralog Series on the venomous snakes of the world.

Patrick David (born in 1959 near Paris, France), received a Ph.D. in polymers chemistry at the University of Paris-Orsay. Dr. David developed an early interest in herpetology as a reptile keeper and then turned to the systematics of Asian reptiles. He is, or has been a member of several international herpetological societies. Dr. David has been involved for nearly 25 years, mostly with Gernot Vogel, in systematic research on several groups of Asian reptiles, especially the *Trimeresurus*-complex and the genera *Oligodon*, *Amphiesma*, *Xenochrophis*, and *Cyrtodactylus*. His geographic areas of interest include India, Thailand, China, Vietnam, and especially Laos and Sumatra (Indonesia). Dr. David has also addressed problems of nomenclature affecting various taxa of snakes and lizards. As of July 2014, Dr. David is the author or co-author of 121 publications, including five monographs or books. He has co-authored the description of a total of 31 new species of amphibians and reptiles. Along with Gernot Vogel, Dr. David is preparing a monograph on Asian pitvipers and the snake fauna of Sumatra.



Irvan Sidik was born in Bandung, West Java Province, Indonesia. Irvan obtained a Masters of Science degree in the field of phylogenetics at the Institute Technology of Bandung. Since 1992 Irvan has worked as a staff researcher in the laboratory of herpetology at the Museum Zoologicum Bogoriense, Indonesian Institute of Sciences (LIPI) in the Cibinong Science Center. Beginning as an auxiliary field survey researcher, and then as a local CITES officer, Irvan became interested and developed a great interest in the snakes of the region of Sundaland. Irvan has continued with more scholarly work on the mountainous areas of the western part of Indonesia. Irvan's research is based on museum collections of specimens and field research in Indonesia's regions mentioned above. Irvan has been involved in several international research collaborations, and is currently working with the University of Texas at Arlington, USA on research of amphibians and reptiles in the mountains of Java and Sumatra. Irvan has published on the herpetofauna of Kalimantan and his first book was about snakes that are traded in Indonesia (CITES appendices I, II, and III) written in Indonesian. Currently, Irvan is studying the phylogeography of the reed snake genera *Calamaria* for his Ph.D. at the University of Brawijaya, Malang.

In accordance with the *International Code of Zoological Nomenclature* new rules and regulations (ICZN 2012), we have deposited this paper in publicly accessible institutional libraries. The new species described herein has been registered in *ZooBank* (Polaszek 2005a, b), the official online registration system for the ICZN. The *ZooBank* publication LSID (Life Science Identifier) for the new species described here can be viewed through any standard web browser by appending the LSID to the prefix "http://zoobank.org/". The LSID for this publication is: urn:lsid:zoobank.org:pub:27336534-BAFC-40BE-84F7-43E0334596CD.

Separate print-only edition of paper(s) (reprint) are available upon request as a print-on-demand service. Please inquire by sending a request to: *Amphibian & Reptile Conservation* (amphibian-reptile-conservation.org; arc.publisher@gmail.com).

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Citations

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