

A new species of green rat snake (Squamata: Colubridae: *Ptyas*) from Vietnam

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ABSTRACT

Rat snakes (genus *Ptyas*) include 13 large Asian species with sizes reaching 3.8 m. For more than 100 years, no new species have been discovered in this genus. Here, we describe a new *Ptyas* from central Vietnam based on morphological data and nucleotide sequences from the MT-CYB gene. *Ptyas bachmaensis* **sp. nov.** is diagnosed by the following morphological characters: large-sized snake (largest total length 2401 mm in adult male); body scale rows in even numbers, 16-16-14 rows; two medial vertebral scale rows distinct; two and two or four medial scale rows keeled on middle and posterior parts of body, respectively; ventrals 194–199; subcaudals 132–138; supralabials 8, fourth and fifth entering orbit; maxillary teeth 28 or 29; hemipenis spinose and unforked, reaching 12th subcaudal; cloacal plate divided; lateral side of tail black, without a bright stripe. The new species forms an independent clade on the phylogenetic tree and differs from its congeners by an uncorrected *p*-distance in MT-CYB sequences of at least 5.7%.

Keywords: Bach Ma National Park; Thua Thien - Hue

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Province; Kon Tum; *Ptyas bachmaensis*; *Ptyas nigromarginata*; *Zaocys*

INTRODUCTION

The genus *Zaocys* was established by Cope in 1860 for a group of large Asian colubrid snakes (up to 3.8 m (David & Das, 2004)) that have two medial series of dorsal scales, lateral scales in quincunx, and two preoculars (Cope, 1861). Three species, including *Coluber dhumnades* Cantor, 1842 (type species), *Coluber nigromarginatus* Blyth, 1855, and *Coryphodon carinatus* Günther, 1858, were arranged into this genus (Cope, 1861). Subsequently, two opinions concern to this arrangement. Many authors, such as Günther (1864), Boulenger (1890, 1893), Stejneger (1907), Pope (1935), Bourret (1936), Smith (1943), Campden-Main (1970), Zhao & Adler (1993), Zhao (2006), etc., followed this designation. However, other authors, such as Wall (1923) and Taylor (1965), considered *Zaocys* as a synonym of *Ptyas*, which was antedated (*Ptyas* Fitzinger). According to Taylor (1965), the main difference between the two genera was presumed to be that *Zaocys* has body scale rows in even number while *Ptyas* has an odd number of body scale rows. Nevertheless, *Ptyas*

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mucosa (Linnaeus) was frequently found to have the body scale rows in even numbers on a part or even over very much of the body. The difference between the two genera, therefore, was unclear (Taylor, 1965). However, Taylor (1965) did not consider the character of “two medial series of dorsal scales” as defined by Cope (1861) for the genus *Zaocys*. Anatomical data also supported the synonymy of *Zaocys* and *Ptyas* (David & Das, 2004). A recent molecular phylogenetic analysis (Figueroa et al., 2016) also supported the synonymization. Further, species of *Cyclophiops* Boulenger fall onto *Ptyas* and therefore this paraphyly caused Figueroa et al. (2016) to synonymize *Cyclophiops* into *Ptyas*. Consequently, *Ptyas* now includes species previously included in *Ptyas*, *Zaocys*, and *Cyclophiops*. Although species in *Zaocys sensu stricto* were not monophyletic (Figueroa et al., 2016), this group is still diagnosed morphologically by possessing (1) an even number of dorsal scale rows and (2) having two distinct medial series of dorsal scales throughout (which is absent in *Ptyas mucosa*).

Nowadays, *Ptyas* includes 13 species (Uetz et al., 2024) distributed throughout central, southern and south-eastern Asia: *P. carinata* (Günther) occurs in Myanmar, China, Thailand, Laos, Vietnam, Cambodia, Malaysia, Indonesia, Singapore, and Philippines; *P. dhumnades* (Cantor) occurs in China and Vietnam; *P. dipsas* (Schlegel) occurs in Indonesia; *P. doriae* (Boulenger) occurs in India, Myanmar, and China; *P. fusca* (Günther) occurs in Thailand, Malaysia, Singapore, Indonesia, and Brunei; *P. herminae* (Boettger) occurs in Japan; *P. korros* (Schlegel) occurs in India, Bangladesh, Bhutan, Myanmar, China, Thailand, Laos, Vietnam, Cambodia, Malaysia, Singapore, and Indonesia; *P. luzonensis* (Günther) occurs in Philippines; *P. major* (Günther) occurs in China, Vietnam, and Laos; *P. mucosa* (Linnaeus) occurs in Iran, Turkmenistan, Afghanistan, Pakistan, India, Sri Lanka, Nepal, Bhutan, Bangladesh, Myanmar, China, Thailand, Laos, Vietnam, Cambodia, Malaysia, and Indonesia; *P. multicincta* (Roux) occurs in Thailand, China, Vietnam, and Laos; *P. nigromarginata* (Blyth) occurs in India, Nepal, Bhutan, Bangladesh, Myanmar, China, Thailand, Laos, and Vietnam; and *P. semicarinata* (Hallowell) occurs in Japan (Uetz et al., 2024). The last species in this genus, *P. multicincta*, was described in 1907 (Uetz et al., 2024). Thus, no new species of *Ptyas* has been discovered for more than 110 years. Herein, we describe a new species of *Ptyas* (belonging to the *Zaocys sensu stricto*) based on morphological and molecular data of two adult specimens and one juvenile collected from Thua Thien-Hue and Kon Tum provinces, central Vietnam.

MATERIALS AND METHODS

All specimens were collected by hand in the daytime on Bach Ma Mountain, Thua Thien-Hue Province, and Kon Plong, Kon Tum Province, Vietnam. Following photography, the animals were euthanized and then fixed in 90% ethanol, with subsequent storage in 70% ethanol (Simmons, 2002) in the Institute of Tropical Biology Collection of Zoology (ITBCZ), Ho Chi Minh City, Vietnam, and in Zoological Institute, Russian Academy of Sciences, St. Petersburg (ZISP). Hemipenes were forcibly everted by injecting water directly into the tail base of a freshly killed specimen. Terminology for hemipenis follows Dowling & Savage (1960), Pope (1935), and Smith (1943). Maxillary teeth were counted by removing a maxillary bone from the specimen and observing under a zoom stereo microscope (Akeiyo, Hong Kong) at 7X–45X.

Morphological analysis

The following morphological characters taken from the literature (Nguyen et al., 2023; Pope, 1935; Smith, 1943) were recorded from the new specimens:

Measurements: snout to vent length: measured from the tip of the snout to the vent; tail length: measured from the vent to the tip of the tail; total length: sum of snout–vent length and tail length; head length: measured from the tip of the snout to the posterior margin of the mandible; head width: measured at the widest point; head height: vertical height between dorsal and ventral surfaces of head measured at the highest point; eye diameter: horizontal diameter of eye; snout length: distance between the tip of the snout and anterior edge of eye; eye to nostril: distance between anterior margin of eye and the nostril; rostral width: greatest width of rostral; rostral height: greatest height of rostral; internasal length: greatest length of internasal; prefrontal length: greatest length of prefrontal; frontal length: length of frontal along middorsal line; frontal–snout distance: distance from the anterior margin of the frontal to the tip of the snout; parietal length: greatest length of parietal; loreal height: greatest height of loreal; loreal length: greatest length of loreal; anterior chin shield length: greatest length of anterior chin shield; posterior chin shield length: greatest length of posterior chin shield.

Scale counts: supralabials; infralabials; loreals; preoculars; presuboculars; postoculars; anterior temporals: number of scales immediately behind postocular between supralabials and parietal; posterior temporals: number of scales behind anterior temporals between supralabial and parietal; ventral scales: counted following Dowling (1951); preventral: number of preventral which is distinctly wider than long; dorsal scales at neck: number of scale rows at one head length behind the head; dorsal scales at midbody: number of scale rows at ventral/2; dorsal scales before vent: number of scale rows at one head length prior to the vent; first scale reduction: position (given as number of ventral scale) of the first dorsal scale row reduction; second scale reduction: position (given as number of ventral scale) of the first dorsal scale row reduction; subcaudal scales: number of subcaudal scales excluding the terminal spine.

In addition, the following characters were also obtained: number of maxillary teeth; supralabial entering the orbit; number of infralabials in contact with the anterior chin shield; cloacal plate: single or divided; hemipenis length: length that the hemipenes extend in terms of numbers of subcaudal scales; keeled dorsal scale rows: number of keeled dorsal scale rows observed at neck (at one head length behind the head), midbody (at ventral/2), and before vent (at one head length prior to the vent); number of supralabials entering orbit; bright lateral stripe: at two head-lengths prior to the vent and on tail.

Values of paired characters are given in order of left/right. Measurements (in millimeters), except for snout–vent length and tail length, were taken with digital calipers (Exploit 150 mm, China) to the nearest 0.1 mm.

For comparison, morphological characters of species of *Ptyas* were taken from the literature (Boulenger, 1893; Campden-Main, 1970; Pope, 1935; Smith, 1943; Stejneger, 1907; Vogel & Hauser, 2013) and examined specimens (Appendix I).

DNA analysis

A fragment of mitochondrially encoded cytochrome *b* (MT-CYB) was sequenced in both directions. Liver sample taken

from specimen ITBCZ 8507 was used for sequencing. DNA extraction, PCR, and sequencing followed the recent protocol (Nguyen et al., 2023).

A new nucleotide sequence of MT-CYB was manually verified using SeqMan (DNASTAR Lasergene 7, USA) and then combined with available sequences of *Ptyas* selected from GenBank. Obtained sequences were then aligned using ClustalW (Thompson et al., 1994) integrated in MEGA5 (Tamura et al., 2011) with default parameters. Uncorrected inter- and intraspecific *p*-distances were calculated using MEGA5. The MT-CYB dataset consisted of 32 ingroup samples including our new sequence and 31 published sequences selected from the literature (Brown et al., 2012; Dubey et al., 2012; Figueroa et al., 2016; Kambayashi et al., 2022; Li et al., 2020; McLeod et al., 2011; Nagy et al., 2004; Sun et al., 2017) and unpublished data available from GenBank, which covered 10 of 13 species of *Ptyas* (Table 1). *Liopeltis frenata* (Günther) (GenBank accession number MW 199809) was used as the outgroup taxon (Figueroa et al., 2016).

Phylogenetic trees from MT-CYB sequences were constructed using Bayesian Inference (BI) and Maximum Likelihood (ML) approaches. The best-fit evolutionary model used for BI was GTR+I+G as selected by MrModeltest v.2.3

(Nylander, 2004) under the Akaike Information Criterion. BI was performed in MrBayes v.3.1.2 (Ronquist & Huelsenbeck, 2003). Bayesian posterior probabilities (BPP) were estimated using a Markov chain Monte Carlo sampling approach with 1 000 000 generations, saving one tree every 100 generations. The runs were stopped when the average standard deviations reached 0.0067. The initial 25% of the samples were discarded as burn-in. The remaining trees were combined, and a 50% majority consensus tree was generated. ML analysis was implemented in the IQ-TREE webserver (Nguyen et al., 2015; Trifinopoulos et al., 2016) using the substitution model selected above. One-thousand bootstrap pseudoreplicates via the ultrafast bootstrap (UFB; Hoang et al., 2018) approximation algorithm were employed. We considered nodes having BPP of $\geq 95\%$ and UFB of $\geq 95\%$ as being strongly supported (Hillis & Bull, 1993; Minh et al., 2013). The resulting trees were visualized in FigTree v.1.4.3 (<http://tree.bio.ed.ac.uk/software/figtree>) and rooted based on the above outgroup.

RESULTS

Sequence variation and genetic distances

The successfully sequenced MT-CYB fragment of our green

Table 1 List of samples of *Ptyas* used for molecular analyses in this study

Species	Voucher	GenBank Accession No. (MT-CYB)	Locality	References
<i>Ptyas bachmaensis</i> sp. nov.	ITBCZ 8507	PP764835	Bach Ma, Thua Thien - Hue, Vietnam	This study
<i>Ptyas carinata</i>	LSUHC 10004	KX660508	–	Figueroa et al. (2016)
<i>Ptyas carinata</i>	LSUHC 7600	KX660509	–	Figueroa et al. (2016)
<i>Ptyas dhumnades</i>	–	KP876003	–	(Unpubl. data)
<i>Ptyas dhumnades</i>	–	NC028049	–	(Unpubl. data)
<i>Ptyas dhumnades</i>	–	KP876004	–	(Unpubl. data)
<i>Ptyas dhumnades</i>	CHS 230	MK201352	Zhoushan, Zhejiang, China	Li et al. (2020)
<i>Ptyas dhumnades</i>	–	KP876005	–	(Unpubl. data)
<i>Ptyas dhumnades</i>	CHS 225	MK201348	Zhoushan, Zhejiang, China	Li et al. (2020)
<i>Ptyas dhumnades</i>	–	KP876006	–	(Unpubl. data)
<i>Ptyas dhumnades</i>	–	KP876001	–	(Unpubl. data)
<i>Ptyas dhumnades</i>	–	KP876002	–	(Unpubl. data)
<i>Ptyas dhumnades</i>	–	KP876000	–	(Unpubl. data)
<i>Ptyas dhumnades</i>	–	KP875999	–	(Unpubl. data)
<i>Ptyas fusca</i>	ADM 0006	KX660442	–	Figueroa et al. (2016)
<i>Ptyas korros</i>	CAS 205259	AY486929	Pyin Si, Mandalay, Myanmar	Nagy et al. (2004)
<i>Ptyas korros</i>	CHS 303	MK201385	Shaoguan, Guangdong, China	Li et al. (2020)
<i>Ptyas korros</i>	CHS 228	MK201351	Huangshan, Anhui, China	Li et al. (2020)
<i>Ptyas luzonensis</i>	KU 330134	KX660522	Norte, Luzon, Philippines	Figueroa et al. (2016); Brown et al. (2012)
<i>Ptyas luzonensis</i>	KU 329295	KX660521	Bulacan, Luzon, Philippines	Figueroa et al. (2016); Vertnet (2023)
<i>Ptyas major</i>	CHS 742	MK201497	Guangdong, China	Li et al. (2020)
<i>Ptyas major</i>	RE 03064	NC028048	Huang Mt., Anhui, China	Sun et al. (2017)
<i>Ptyas mucosa</i>	CAS 208434	AF471054	Kyaukse Pyaw Bwe, Mandalay, Myanmar	Dubey et al. (2012)
<i>Ptyas mucosa</i>	–	GQ225655	Jabalpur, Madhya Pradesh, India	Sun et al. (2017)
<i>Ptyas multicincta</i>	FMNH 255569	KX660471	Con Cuong, Nghe An, Vietnam	Figueroa et al. (2016); Vertnet (2023)
<i>Ptyas multicincta</i>	KU 291939	KX660511	Jing Xin, Guangxi, China	Figueroa et al. (2016); Vertnet (2023)
<i>Ptyas multicincta</i>	AMNH 153707	KX660435	Van Ban, Lao Cai, Vietnam	Figueroa et al. (2016); Vertnet (2023)
<i>Ptyas nigromarginata</i>	CHS 223	MK201347	Yunan, China	Li et al. (2020)
<i>Ptyas nigromarginata</i>	CHS 226	MK201349	Yunan, China	Li et al. (2020)
<i>Ptyas nigromarginata</i>	CAS 241947	KX660459	Gongshan, Yunnan, China	Figueroa et al. (2016); Vertnet (2023)
<i>Ptyas nigromarginata</i>	CAS 236202	KX660458	Fugong, Yunnan, China	Figueroa et al. (2016); Vertnet (2023)
<i>Ptyas cf. semicarinata</i>	KUZ 28049	LC640370	East Asia	Kambayashi et al. (2022)

Table 2 Average uncorrected *p*-distance (%) in MT-CYB between and within species of *Ptyas*

Taxon	1	2	3	4	5	6	7	8	9	10	11
1. <i>Ptyas bachmaensis</i> sp. nov.	-										
2. <i>Ptyas carinata</i>	9.9	1.0									
3. <i>Ptyas dhumnades</i>	6.3	9.9	1.9								
4. <i>Ptyas fusca</i>	13.3	12.1	13.2	-							
5. <i>Ptyas korros</i>	16.7	15.3	16.4	13.8	3.2						
6. <i>Ptyas luzonensis</i>	13.7	13.1	14.0	11.3	16.9	0.0					
7. <i>Ptyas major</i>	8.5	10.9	8.7	14.3	16.6	14.9	2.7				
8. <i>Ptyas mucosa</i>	13.6	13.0	12.9	14.9	17.1	16.1	14.9	0.3			
9. <i>Ptyas multicincta</i>	14.9	13.4	15.4	12.6	17.5	12.6	14.8	13.4	3.3		
10. <i>Ptyas nigromarginata</i>	5.7	10.7	5.1	14.0	17.3	14.3	7.6	14.7	15.5	0.9	
11. <i>Ptyas</i> cf. <i>semicarinata</i>	9.6	13.0	9.9	15.0	16.2	15.6	10.4	14.8	13.8	9.6	-

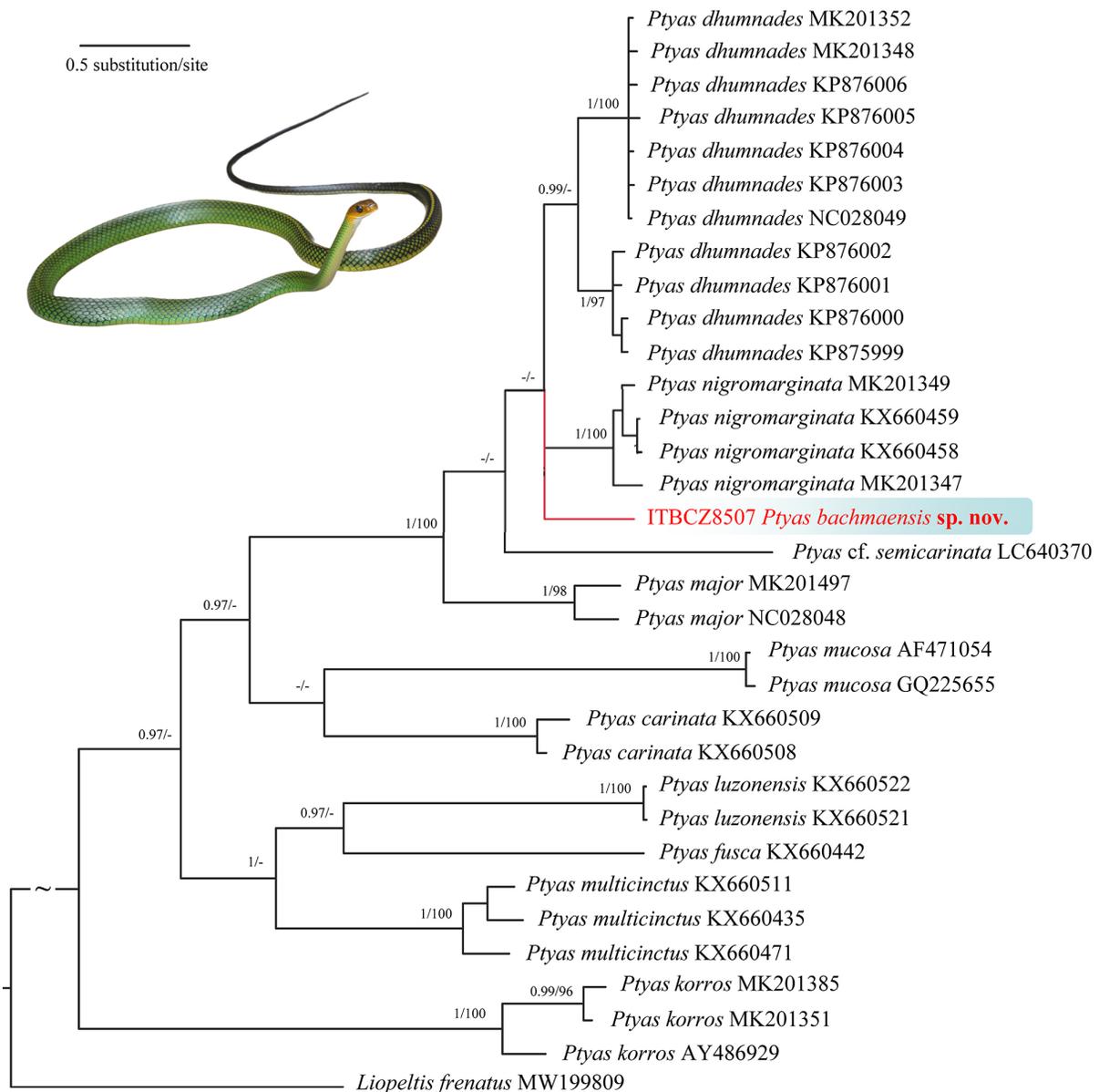


Figure 1 The Bayesian inference (BI) tree reconstructed from the MT-CYB gene for species of *Ptyas*

Branch support values from BI and Maximum Likelihood (ML), respectively (BI/ML). A hyphen indicates an un-supported node. Inserted photo is *Ptyas bachmaensis* sp. nov. Photo by Sang N. Nguyen.

rat snake had 1071 bp, which was deposited in GenBank (Table 1). The final matrix of MT-CYB consisted of 33 sequences with 335 potentially parsimony-informative

characters. Detailed information for each individual was given in Table 1.

The uncorrected intraspecific *p*-distances in MT-CYB between



Figure 2 Holotype of *Ptyas bachmaensis* sp. nov. (ITBCZ 8628) in life
Photo by Sang N. Nguyen.

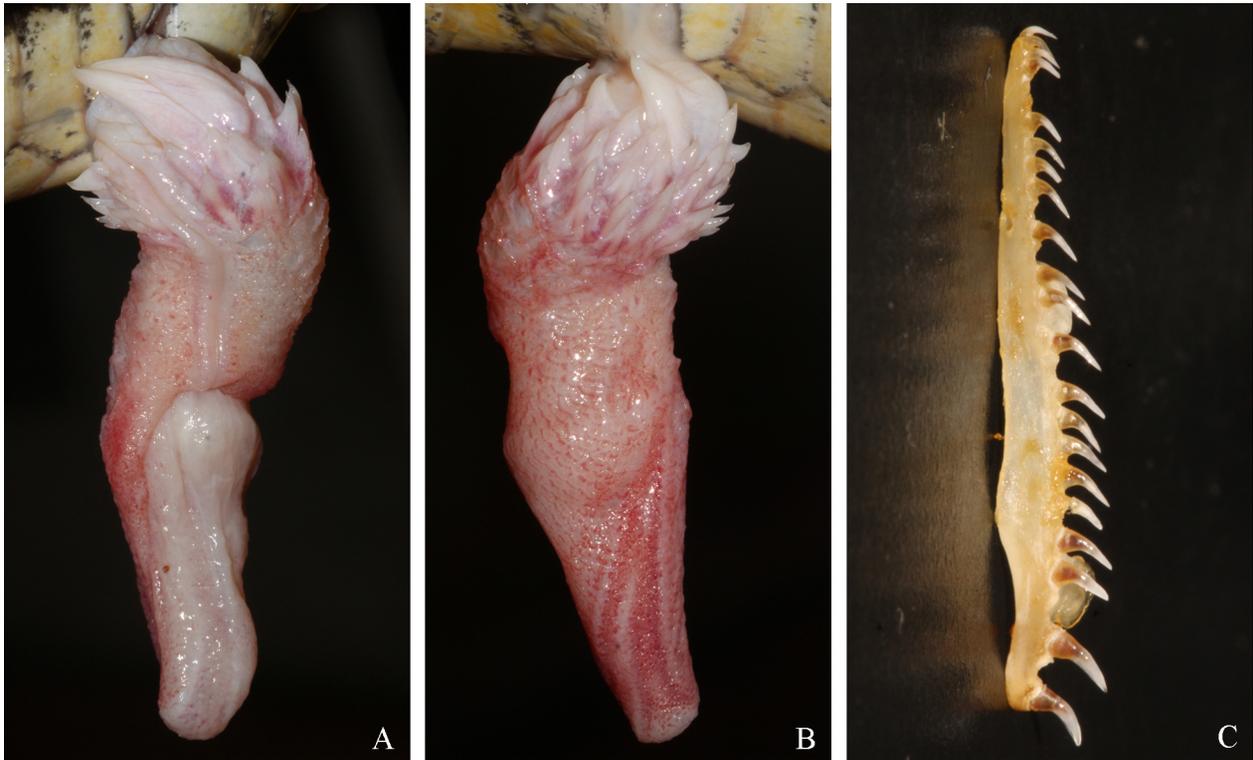


Figure 3 Hemipenis and maxillary teeth of the holotype of *Ptyas bachmaensis* sp. nov. (ITBCZ 8628)

A, B: Sulcal and asulcal views of the hemipenis, respectively; C: Lateral view of right maxillary teeth. Photos by Sang N. Nguyen.

species of *Ptyas* ranged from 5.1% (between *P. dhumnades* and *P. nigromarginata*) to 17.5% (between *P. korros* and *P. multincincta*), averaging $13.1 \pm 0.3\%$. The uncorrected *p*-distances between our green rat snake and its congeners varied from 5.7% (vs. *P. nigromarginata*) to 16.7% (vs. *P. korros*). Interspecific *p*-distances ranged from 0.0% (in *P. luzonensis*) to 3.3% (in *P. multincincta*). The uncorrected intra- and interspecific *p*-distances in *Ptyas* were shown in Table 2.

Phylogenetic trees

The BI and ML trees reconstructed from MT-CYB sequences were similar to each other in topology and differed only in their resolution of poorly supported nodes. Only the 50% majority rule consensus tree from the BI analysis is shown in Figure 1, but with branch support values from both BI and ML. Phylogenetic trees supported all species with high values of both BI and ML analyses. Our green rat snake clustered

strongly (BI=1; ML=100%) with *P. dhumnades*, *P. major*, *P. nigromarginata*, and *P. cf. semicarinata* (Figure 1). This tree depicted a polytomy for these taxa, yet each taxon was strongly supported from both analyses. Because our green rat snakes formed an independent clade on the phylogenetic tree and differed morphologically and genetically from other congeners, we describe them as a new species.

Taxonomy

Ptyas bachmaensis sp. nov.

Holotype: ITBCZ 8628, adult male, collected from Bach Ma Mountain, Bach Ma National Park, Phu Loc District, Thua Thien-Hue Province, Vietnam; coordinates N16°11'40", E107°51'40", elevation 1330 m above sea level (a.s.l.) by Cao Van Nguyen, Ba Dinh Vo, Khanh Duy Phan, and Sang Ngoc Nguyen, on 26 September 2023 (Figures 2, 3).

Paratypes: ITBCZ 8507, gravid female, also collected from Bach Ma Mountain, Bach Ma National Park, Phu Loc District, Thua Thien-Hue Province, Vietnam, coordinates N16°11'36", E107°51'11", elevation 1260 m a.s.l. by Ba Dinh Vo, on 4 October 2023; ZISP 32661, juvenile specimen, collected from Kon Du Village, Mang Canh Commune, Kon Plong District, Kon Tum Province, Vietnam, coordinates N14°41'25", E108°19'31", elevation 1210 m a.s.l. in October 2018 (Figure 4).

Diagnosis: *Ptyas bachmaensis* sp. nov. is distinguished from all congeners by the unique combination of the following morphological characters: large-sized snake (largest TL 2401 mm in adult male); body scale rows in even numbers, 16 rows at neck and midbody, 14 rows before vent; two medial vertebral scale rows keeled on middle and posterior parts of body, respectively; ventrals 194–199; subcaudals 132–138; supralabials 8, fourth and fifth entering orbit; maxillary teeth 28 or 29; hemipenis spinose and unforked, reaching 12th subcaudal; cloacal plate divided; lateral side of tail black, without a bright stripe.

Description of holotype: Adult male, 2401 mm in total length; head elongate (head length/head width=0.56), distinct from neck; eye large, with round pupil; body elongate and compressed, snout to vent length 1706 mm; tail long, equal to 28.9% of the total length.

Head scalation: head scales smooth; rostral broader than high (width 8.7 mm, height 5.9 mm), visible from above, touching nasals and 1st supralabials; internasals shorter than prefrontals; frontal bell-shaped, shorter than parietals as well as its distance from tip of snout; parietals bordered laterally by upper temporals and postocular and anteriorly by frontal and



Figure 4 Paratypes of *Ptyas bachmaensis* sp. nov. in life

A: Gravid female ITBCZ 8507; B: Juvenile ZISP 32661. Photos by Sang N. Nguyen (A) and Nikolai L. Orlov (B).

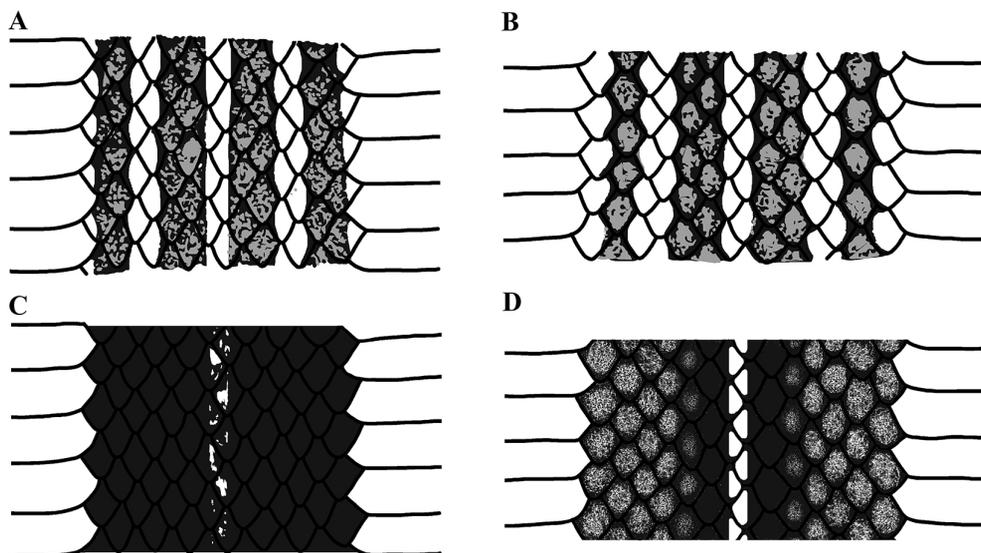


Figure 5 Difference in pattern at two-heads length before vent position of *Ptyas* species

A: *Ptyas nigromarginata* (re-drawn from Pope (1935)); B: *Ptyas dhumnades* (re-drawn from Pope (1935)); C: *Ptyas bachmaensis* sp. nov. (holotype ITBCZ 8628); D: *Ptyas bachmaensis* sp. nov. (paratype ITBCZ 8507).

supraoculars; 8/8 supralabials, first two in contact with nasal, 2nd and 3rd in contact with loreal, 4th and 5th bordering eye; 1/1 loreal, much longer than high (4.5 mm length vs. 2.4 mm height), touching nasal, prefrontal, preocular and 2nd and 3rd supralabials; 1/1 enlarged preocular; 1/1 small presubocular; 2/2 postoculars; 2+2/2+2 temporals; 10/10 infralabials, first pair medially in contact with each other, first five in contact with anterior chin shield, 5th and 6th largest and touching posterior chin shield; posterior chin shields longer than anterior ones (13.6 mm vs. 12.0 mm) and contacting each other anteriorly; one row of gular and one incomplete ventral (preventral) between anterior chin-shield and 1st complete

ventral.

Body scalation: Dorsal scales at neck in 16 rows and smooth, at midbody in 16 rows with two medial rows strongly keeled, before vent in 14 rows with four medial rows keeled (two medial series of dorsal strongly keeled and two lateral rows weakly keeled); two vertebral scale rows distinctly emerged; scale row reductions from 16 to 15 at ventral 114 on the left side and from 15 to 14 at ventral 115 on the right side; ventrals 199 (plus one preventral), broad, not keeled; a small scale between last ventral and cloacal plate; cloacal plate divided; subcaudals 138, all paired; terminal caudal scale forming a pointed cap.

Table 3 Morphological characters of the type series of *Ptyas bachmaensis* sp. nov.

Voucher	ITBCZ 8628 Holotype	ITBCZ 8507 Paratype	ZISP 32661 Paratype
Sex	Male	Female	Juvenile
Snout to vent length	1706	1150	329
Tail length	695	495	146
Total length	2401	1645	475
Tail length/Total length ratio	0.289	0.301	0.307
Head length	44.7	36.2	–
Head width	25.2	16.8	–
Head height	17.9	14.4	–
Eye diameter	8.9	6.9	–
Snout length	15.3	11.5	–
Eye to nostril	8.8	7.1	–
Rostral width	8.7	6.5	–
Rostral height	5.9	4.8	–
Internasal length	5.2	4.2	–
Prefrontal length	7.1	5.7	–
Frontal length	11.0	9.0	–
Frontal-snout length	11.9	9.5	–
Parietal length	13.5	11.4	–
Loreal length	4.5	3.6	–
Loreal height	2.4	2.3	–
Anterior chin shield length	12.0	8.6	–
Posterior chin shield length	13.6	11.6	–
Supralabial	8/8	8/8	8/8
Supralabials entering the orbit	4-5 th /4-5 th	4-5 th /4-5 th	4-5 th /4-5 th
Infralabial	10/10	10/10	10/10
Number of infralabials in contact with the anterior chin shield	5	5	5
Loreal	1/1	1/1	1/1
Preocular	1/1	1/1	1/1
Presubocular	1/1	1/1	1/1
Postocular	2/2	2/2	2/2
Anterior temporal	2/2	2/2	2/2
Posterior temporal	2/2	2/2	2/2
Dorsal scales at neck	16	16	16
Dorsal scales at midbody	16	16	16
Dorsal scales before vent	14	14	14
Keeled dorsal scale rows	0-2-4	0-2-2	0-2-4
Ventral scales (+ preventral)	199+1	198+1	194+1
1 st and 2 nd scale reductions	114-115	111-114	111-113
Subcaudal scales	138	132	132
Precloacal plate	Divided	Divided	Divided
Maxillary teeth	28	29	28
Hemipenis length	12	–	–
Bright lateral stripe on tail	Absent	Absent	Absent

Measurements in millimeters (mm).

Dentition: maxillary teeth 28, continuously, increasing slightly in size posteriorly (Figure 3C).

Hemipenis: hemipenis spinose and unforked, extending to 12th subcaudal, consists of three primary areas: basal part with curved spines gradually decreasing in size toward middle part; median part smooth with transversely arranged frounces, ending with sunken fold on sulcal side; and distal part smooth with transversal frounces and longitudinal folds. Sulcus spermaticus prominent, present on the basal and medial parts, ending at sunken fold. (Figure 3A, B).

Coloration: in life, eyes black; head brown; body green, gradually changing to black on posterior part of body; tail black without bright lateral longitudinal stripe (Figures 2, 5); body scales edged with black; vertebral stripe present on body, blur on neck, distinct on middle and posterior parts, ending at about one-head length before vent; lower side of head white; ventral greenish to yellow; lower side of tail cream with black dots. In preservation, head fade brown; dorsal and lateral parts of body changing to fade blue; edge of scales black; tail black; ventral cream; lower side of tail cream with black blotches and spots.

Variation: Paratype ITBCZ 8507 with two keeled dorsal scale

rows before vent and the vertebral stripe extending to about one-third of the tail (Figure 4A). Juvenile paratype ZISP 32661 has two black broad lateral stripes on anterior and middle parts of the body: first black longitudinal stripe on 3rd dorsal row and second one on 6th and 7th dorsal rows; lateral side on posterior part of body and tail black, without a bright stripe; vertebral stripe extending from neck to about one-third of tail (Figure 4B). Variation in size and scalation of the type series was summarized in Table 3.

Sexual dimorphism: Male much bigger than female (total length 2401 mm vs. 1645 mm) and with more subcaudals (138 vs. 132).

Etymology: The specific epithet *bachmaensis* is a toponym derived from the Bach Ma Mountain where the holotype of the new species was discovered. We recommend “Bach Ma green rat snake” and “Rắn ráo xanh Bạch Mã” as the common English and Vietnamese names of the new species, respectively.

Distribution: The new species is currently known only from its type locality in Bach Ma Mountain, Bach Ma National Park, Phu Loc District, Thua Thien-Hue Province, and from Kon Plong District, Kon Tum Province, Vietnam (Figure 6).

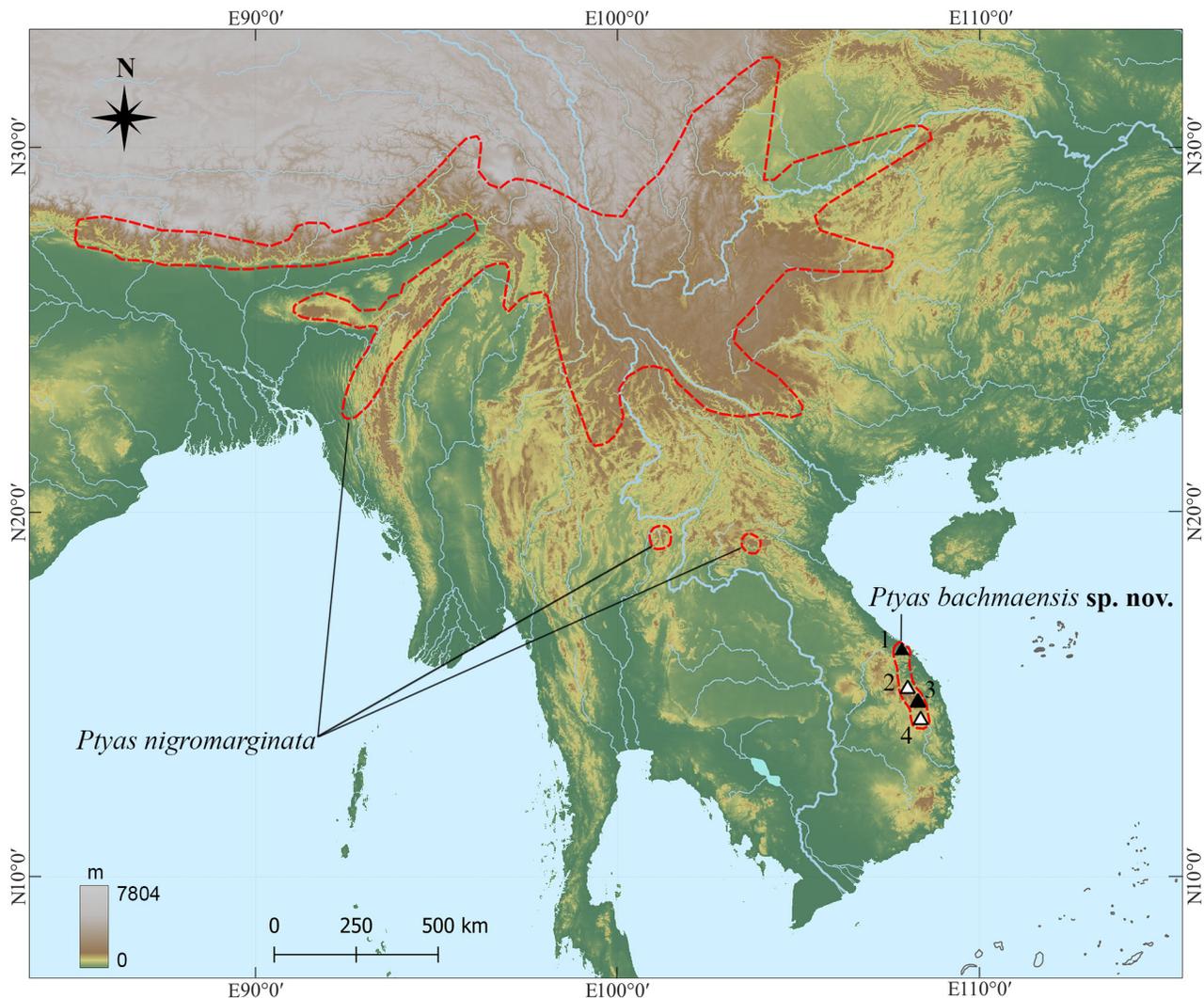


Figure 6 Distribution of *Ptyas bachmaensis* sp. nov. (triangle) and *P. nigromarginata* (red closed line)

1: Bach Ma, Phu Loc, Thua Thien-Hue; 2: Nam Tra My, Quang Nam; 3: Kon Plong, Kon Tum; 4: Kon Ka Kinh, Gia Lai. Black triangle is confirmed localities and white triangles are locations that need confirmation. Data taken from the literature (Duong et al., 2021; Lottier & David, 2022; Vogel & Hauser, 2013) and this study.

Field notes: The holotype was collected at about 1000h near the main road and forest station; surrounding habitat is montane evergreen forest. Paratype was collected at about 0930h near a restaurant; surrounding habitat is also montane evergreen forest. Paratype ITBCZ 8507 bears 10 eggs, size $(9.7\pm 0.4)\times(25.5\pm 2.1)$. Paratype ZISP 32661 was collected about 2200h on leaf litter on a forest path in a montane polydominant evergreen forest; temperature of 16–18°C; light rain.

Comparisons: *Ptyas bachmaensis* sp. nov. differs from *P. dipsas* (Schlegel), *P. doriae* (Boulenger), *P. herminae* (Boettger), *P. korros* (Schlegel), *P. major* (Günther), *P. multincincta* (Roux), *P. semicarinata* (Hallowell) by having even number of dorsal scale rows and two distinct medial series of dorsal scales throughout (Boulenger, 1893; Smith, 1943; Stejneger, 1907); from *P. carinata* (Günther) by having one (vs. 2–4) loreal, fewer ventrals (194–199 vs. 208–215), more subcaudals (132–138 vs. 110–118) (Boulenger, 1893; Smith, 1943); from *P. dhumnades* (Cantor) by having more subcaudals (132–138 vs. 108–116); absence (vs. presence) of longitudinal body stripes in adult, lateral side at two-heads length before vent black (vs. lateral side at two-heads length before vent with a white stripe forming two lateral longitudinal black bands), and first row of dorsal scale at two-heads length before vent black (vs. white) (Figure 5) (Boulenger, 1893; Pope, 1935); from *P. fusca* (Günther) by having keeled (vs. smooth) dorsal scales, one (vs. 3) loreals, fewer subcaudals (132–138 vs. 163–165), fewer supralabials (8 vs. 9), and supralabials 4 and 5 (vs. 5 and 6) entering orbit (Boulenger, 1893); from *P. luzonensis* (Günther) by having more dorsal scale rows at midbody (16 vs. 14), keeled (vs. smooth) dorsal scales, fewer ventrals (194–199 vs. 205), and more

subcaudals (132–138 vs. 119) (Boulenger, 1893); from *P. mucosa* (Linnaeus) by having more maxillary teeth (28 or 29 vs. 20–25), one (vs. 2 or 3) loreal, presence (vs. absence) of two distinct medial series of dorsal scales throughout, and presence (vs. absence) of green body and brown head (Campden-Main, 1970; Smith, 1943); and from *P. nigromarginata* (Blyth) by having more maxillary teeth (28 or 29 vs. 22–26), absence (vs. presence) of lateral longitudinal stripes on tail and posterior part of body, lateral side at two-heads length before vent black (vs. lateral side at two-heads length before vent with a white stripe forming two broad deep black bands), and first row of dorsal scale at two-heads length before vent black (vs. lower half of first dorsal scale row white) (Figure 5) (Boulenger, 1893; Pope, 1935; Smith, 1943; Vogel & Hauser, 2013). Selected morphological characteristics for *Ptyas* species are shown in Table 4.

DISCUSSION

Because of morphological similarity, *P. nigromarginata* was previously considered a junior synonym of *P. dhumnades* (e.g., Bourret, 1936). However, Pope (1935) pointed out many key characters in pattern to distinguish the two species, especially the bright longitudinal stripes on body and tail (Figure 5). Recent phylogenetic analyses using DNA sequences (Figuerola et al., 2016; Kambayashi et al., 2022; Wu et al., 2023) also supported the full status of both species as sister taxa. Our phylogenetic analyses cluster *P. bachmaensis* sp. nov. with *P. dhumnades*, *P. nigromarginata*, *P. major*, and *P. cf. semicarinata* with high support (BI=1; ML=100%) (Figure 1). The new species differs from *P. nigromarginata* by 5.7% in DNA sequence of MT-CYB gene, which is slightly higher than the difference between *P.*

Table 4 Selected scale counts, color pattern and other diagnostic characters of *Ptyas* species

Characters	1	2	3	4	5	6	7	8	9	10	11	References
<i>Ptyas bachmaensis</i> sp. nov.	16	194–199	132–138	1	8	28 or 29	4–5	2	present	absent	present	This study
<i>Ptyas carinata</i>	16 or 14	208–215	110–118	2–4	8–10	22–26	4–5, 5–6	2	present	present	absent	Boulenger (1893); Smith (1943)
<i>Ptyas dhumnades</i>	16	187–194	108–116	1	8	–	4–5	2 or 4	present	present	absent	Boulenger (1893); Pope (1935)
<i>Ptyas dipsas</i>	13	194–197	102–130	1	8	–	4–5	0	absent	absent	absent	Boulenger (1893)
<i>Ptyas doriae</i>	15	168–187	74–80	1	7 or 8	29–33	4–5	0	absent	absent	present	Boulenger (1893); Pope (1935); Smith (1943)
<i>Ptyas fusca</i>	16	189–198	163–165	3	9	–	5–6	0	present	present	absent	Boulenger (1893)
<i>Ptyas herminae</i>	17 or 19	159–162	47–60	1	8	–	4–5	0	absent	absent	absent	Stejneger (1907)
<i>Ptyas korros</i>	15 or 13	160–187	120–147	2 or 3	8	23–28	4–5	0	absent	absent	absent	Boulenger (1893); Smith (1943)
<i>Ptyas luzonensis</i>	14	205	119	1	8	–	4–5	0	present	absent	absent	Boulenger (1893); Smith (1943)
<i>Ptyas major</i>	15	154–178	70–92	1	8	20–23	4–5	0	absent	absent	present	Boulenger (1893); Stejneger (1907)
<i>Ptyas mucosa</i>	17 or 16	190–213	100–146	2 or 3	8	20–25	4–5	–	absent	absent	absent	Boulenger (1893); Campden-Main (1970); Smith (1943)
<i>Ptyas multincincta</i>	15	164–177	72–103	1	7 or 8	18–20	4–5	0	absent	absent	present	Pope (1935); Smith (1943)
<i>Ptyas nigromarginata</i>	16 or 14	190–209	123–142	1	8	22–26	4–5	4 or 6	present	present	present	Blyth (1855); Boulenger (1893); Pope (1935); Smith (1943)
<i>Ptyas semicarinata</i>	15	174–192	70–82	1	8	–	4–5	9	absent	absent/present	absent	Maki (1931); Stejneger (1907)

1: Number of body scale rows; 2: Number of ventrals; 3: Number of subcaudals; 4: Number of loreals; 5: Number of sublabials; 6: Number of maxillary teeth; 7: Sublabials entering eye; 8: Number of dorsal scale rows at midbody keeled; 9: Two distinct medial series of dorsal scales throughout; 10: Distinct longitudinal stripes on lateral side at two-heads length before vent position; 11: Anterior part of body green.

nigromarginata and *P. dhumnades* (5.1%). Morphologically, the new species is easily distinguished from its two sister taxa by its pattern on the tail and posterior part of body. Accordingly, both *P. dhumnades* and *P. nigromarginata* have four broad black stripes at the position of two-heads length before vent, while the new species has two broad black stripes or absolute black without stripes (Figure 5). In other words, the new species has no bright stripe on lateral sides of the tail and posterior part of body black, while these areas in the two sister taxa consist of a bright stripe forming two broad black lateral stripes.

Ptyas nigromarginata occurs widely in Asian countries, including Nepal, Bhutan, India, Bangladesh, Myanmar, Thailand, China, Laos, and Vietnam (Figure 6) (Lottier & David, 2022; Uetz et al., 2024), with the type locality from India (Vogel & Hauser, 2013). In Vietnam, *P. nigromarginata* was reported from the following locations: Sa Pa (Lao Cai Prov.), Mau Son (Lang Son Prov.), Ba Vi (Ha Noi City), and Kon Plong (Kon Tum Prov.) (Nguyen et al., 2009). Except for Kon Plong, which is south of Bach Ma, all other localities are in northern Vietnam. The occurrence of the snake from Kon Plong was then confirmed (Vogel & Hauser, 2013). Recently, *P. nigromarginata* was recorded from Tra My (Quang Nam Prov.) and K'Bang (Gia Lai Prov.) (Duong et al., 2021; Figure 6). Based on the photo of *P. "nigromarginata"* taken from Kon Tum and published in 2009 (Nguyen et al., 2009: p. 621), the tail of the juvenile snake has no bright lateral longitudinal stripe but black. This pattern differs from that of *P. nigromarginata* and is the same as the new species, *Ptyas bachmaensis* sp. nov. Hence, the records of *P. "nigromarginata"* from Gia Lai and Quang Nam provinces in central Vietnam (Duong et al., 2021) appear to be similar to the new species. Further studies using DNA sequences and morphological examination should be conducted on these populations to confirm the conspecific status of them with the new species.

The discovery of *Ptyas bachmaensis* sp. nov. increases the number of *Ptyas* species known from Vietnam to eight (Uetz et al., 2024). In addition to *P. nigromarginata* and the new species, other known *Ptyas* species from Vietnam are as follows: *P. carinata* occurs in Thua Thien-Hue, Da Nang, and Binh Phuoc provinces; *P. dhumnades* occurs in Lao Cai and Vinh Phuc provinces; *P. korros* occurs entirely in the country; *P. major* occurs in Lao Cai, Cao Bang, Vinh Phuc, Ha Noi City, and Quang Binh provinces; *P. mucosa* occurs in Dien Bien, Lao Lai, Yen Bai, Cao Bang, Thai Nguyen, Lang Son, Phu Tho, Vinh Phuc, Ha Noi, Son La, Hoa Binh, Ninh Binh, Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Da Nang, Quang Nam, Dak Lak, Dong Nai, Tay Ninh, Ho Chi Minh City, Kien Giang, and Ca Mau provinces; and *P. multicincta* occurs in Lai Chau, Lao Cai, Cao Bang, Bac Kan, Thai Nguyen, Vinh Phuc, Quang Ninh, Hai Duong, Hoa Binh, Ha Noi City, Ninh Binh, Ha Tinh, Quang Binh, Quang Tri, Thua Thien-Hue, Da Nang, Quang Nam, Kon Tum, and Lam Dong provinces (Vogel & Hauser, 2013; Nguyen et al., 2009). Due to their big size and/or beautiful outline, species in this genus have been traded in Vietnam. Further studies conducting in Gia Lai, Kon Tum, Thua Thien-Hue provinces and adjacent areas are needed to determine number of locations, extent of occurrence, decline of quality of habitat, etc. of *Ptyas bachmaensis* sp. nov. According to category B of the IUCN Red List Categories and Criteria (The International Union for Conservation of Nature, 2012), these data are necessary

criteria to assess the conservation status of the new species.

NONMENCLATURAL ACTS REGISTRATION

The electronic version of this article in portable document format represents a published work according to the International Commission on Zoological Nomenclature (ICZN), and hence the new names contained in the electronic versions are effectively published under that Code from the electronic edition alone (see Articles 8.5–8.6 of the Code). This published work and the nomenclatural acts it contains have been registered in ZooBank, the online registration system for the ICZN. The ZooBank LSIDs (Life Science Identifiers) can be resolved, and the associated information can be viewed through any standard web browser by appending the LSID to the prefix <http://zoobank.org/>.

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SCIENTIFIC FIELD SURVEY PERMISSION INFORMATION

Field work in Thua Thien-Hue Province, Vietnam, was conducted under permission number 114/VBM-KHHTQT, issued by Bach Ma NP., date 13 Sept. 2023.

DATA AVAILABILITY

Assembled mitochondrial genome sequence was deposited in the National Center for Biotechnology Information (NCBI) database (<https://www.ncbi.nlm.nih.gov>) under GenBank accession no. PP764835 and Science Data Bank (<https://doi.org/10.57760/sciencedb.11986>).

COMPETING INTEREST

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS

S.N.N., N.L.O., B.D.V., and J.C. designed the study; S.N.N., N.L.O., B.D.V., K.D.P., and A.T.T. collected materials for study; S.N.N., N.L.O., R.W.M., and J.C. prepared the manuscript; M.V.L., K.D.P., B.D.V., A.T.T., and J.C. performed morphological analyses; S.N.N. and L.T.N. performed molecular and phylogenetic analyses; S.N.N., R.W.M., and J.C. edited and revised the manuscript. All authors read and approved the final version of the manuscript.

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