

河南伏牛山发现宁陕脊蛇指名亚种

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摘要: 本文运用形态学和分子系统学方法将采自河南省伏牛山的脊蛇样本鉴定为宁陕脊蛇指名亚种 (*Achalinus ningshanensis ningshanensis*)。基于线粒体 *COI* 基因序列, 伏牛山样本与模式产地宁陕脊蛇指名亚种存在一定的遗传分化 (0.4%)。形态比较显示, 伏牛山样本第 2 对颌片之间有 2 枚小鳞、腹鳞 181 枚、背鳞 25-23-23, 宁陕脊蛇指名亚种第 2 对颌片之间无小鳞、腹鳞 161~165、背鳞为 23-23-23。宁陕脊蛇指名亚种在河南省的发现, 可为蛇类多样性保护和谱系地理研究提供基础资料。

关键词: 宁陕脊蛇指名亚种; 形态学; 分子系统学; 伏牛山; 河南

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Achalinus ningshanensis ningshanensis found in Funiu Mountain of Henan, China

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Abstract: *Achalinus ningshanensis* was first described as a new species of the genus *Achalinus* in 2022. It consists of *A. ningshanensis ningshanensis* and *A. ningshanensis occidentalis*. This study provides morphological and molecular information of *A. n. ningshanensis* collected from Funiu Mountain, Henan Province, China and determines the taxonomic status of *A. n. ningshanensis* in Henan. In this study, 22 morphological indexes were selected for morphological analysis. Length was measured by a vernier caliper, and the number of scales was described manually. Genomic DNA was extracted from the liver tissue preserved in 95% alcohol by the FastPure Gel DNA Extraction Mini Kit, and cytochrome *c* oxidase subunit I

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(COI) was selected as the target fragment, which was amplified with primers Chmf4 and Chmr4. COI gene sequences of 26 species of *Achalinus* and three outgroups (*Parafimbrios lao*, *Fimbrios klossi*, *Xenodermus javanicus*) were downloaded from GenBank (Appendix 1). Sequence alignment and calculation of uncorrected pairwise distances (*p*-distance) among congeners were performed in MEGA 7.0 software. A phylogenetic tree was constructed by maximum likelihood estimation (MLE) analysis via PhyloSuite v1.2.3 software. Morphological comparisons showed that the specimen from Funiu Mountain had two pairs of chin shields with two small scales between the second pair, 181 ventral scales, and dorsal scales of 25-23-23, while *A. n. ningshanensis* lacked small scales between the second pair of chin shields and had 161 ~ 165 ventral scales and dorsal scales of 23-23-23 (Table 1). The phylogenetic tree indicated that the specimen closely clustered with the topotype of *A. n. ningshanensis* (Ningshan, Shaanxi, China) (Fig. 3). The genetic distance between them was 0.4%, significantly smaller than the interspecific genetic distance of *Achalinus* (2.8% ~ 18.8%) (Appendix 2). Combining morphological and molecular phylogenetic methods, we identified the specimen of *Achalinus* collected from Funiu Mountain, Henan Province as *A. n. ningshanensis*, representing a new provincial record of snake in Henan.

Key words: *Achalinus ningshanensis ningshanensis*; Morphology; Molecular systematics; Funiu Mountain; Henan

脊蛇属 (*Achalinus*) 蛇类隶属于有鳞目 (Squamata) 蛇亚目 (Serpentes) 闪皮蛇科 (Xenodermidae), 体型较细小, 多营穴居生活且主要在夜间活动。截至 2006 年, 该属仅知 9 种、中国 7 种 (赵尔宓 2006)。随着野外调查的深入和整合分类学的运用, 脊蛇属的物种多样性被逐渐揭示, 仅近十年便有 20 个物种被发现和描述。目前, 脊蛇属已知 29 种, 广泛分布于亚洲东部的中国、日本和东南部的越南, 其中, 中国记录有 22 种 (Uetz et al. 2025)。

河南省地处动物地理区系古北界与东洋界过渡地带, 西以伏牛山与陕西接壤、为秦岭东延余脉, 南以大别山与安徽相连, 蛇类多样性呈现过渡性特征 (陈晓虹等 2006a, b, 雷隽和丁利 2013, 赵海鹏等 2018, 王同行等 2026)。刘清熔等 (2024) 将采自大别山西北部河南省商城县的脊蛇鉴定为大别山脊蛇 (*A. dabieshansis*), 为河南省脊蛇属的首次记录, 提示河南省蛇类多样性有待进一步研究。2023 和 2024 年, 作者在河南省伏牛山开展为期两年的考察, 采到 1 条路杀的脊蛇属物种标本, 综合分子系统学和形态学方法鉴定该样本为宁陕

脊蛇指名亚种 (*A. ningshanensis ningshanensis*), 为河南省蛇类分布新记录种。本文对其形态进行描述, 为河南省蛇类多样性保护和谱系地理学研究提供基础资料。

1 材料与方法

1.1 样本采集

2023 年 10 月在河南省伏牛山区南阳市内乡县采集到 1 条路杀脊蛇标本 (标本号: HNNU 2310I002)。取其肝组织用 95%乙醇溶液固定、-20 °C 保存。标本用 10%福尔马林固定, 保存于河南师范大学两栖爬行动物研究室。

1.2 形态鉴定

形态性状测量与鳞片计数参考赵尔宓 (2006) 及 Xu 等 (2024)。使用电子游标卡尺 (桂林广陆数字测控有限公司, 111-802-30A, 量程 0 ~ 200 mm, 精确到 0.01 mm) 测量。

1.3 分子系统发育分析

取 10 mg 保存在 95%乙醇溶液中的肝组织, 使用 DNA 试剂盒 (FastPure® Cell/Tissue DNA Isolation Mini Kit, 南京诺唯赞生物科技股份有限公司) 提取基因组 DNA。使用引物

COI-Chmf4/Chmr4，其扩增条件和方法参照Che 等（2012）。将 PCR 扩增产物送至上海生工生物工程有限公司进行测序，获取的伏牛山脊蛇样本线粒体 COI 序列提交到 GenBank 数据库（登录号：PV461361）。从 GenBank 数据库下载脊蛇属 26 个物种及 3 个外群 COI 基因序列（附录 1）。使用 MEGA 7.0（Kumar et al. 2016）进行序列比对，通过 PhyloSuite v1.2.3（Zhang et al. 2020, Xiang et al. 2023）中的 Modelfinder v2.2.0（Kalyaanamoorthy et al. 2017）筛选最适模型 TIM + F + I + I + R3，使用 IQ-TREE v2.2.0（Nguyen et al. 2015）构建最大似然树，bootstrap 重复 1 000 次，FigerTree v1.4.3

（Rambaut and Drummond 2016）对系统发育树进行可视化处理。基于 MEGA 7.0 中 *p*-distance 模型计算脊蛇属物种间及外群物种间未校正遗传距离。

2 结果

2.1 形态鉴定

标本 HNNU 2310I002，雄性成体，全长 510.32 mm，头体长 422.90 mm，尾长 87.42 mm，尾长/全长为 0.17（表 1）；尾短而细；头颈区分不明显；眼小；鼻间鳞沟长度（1.21 mm）短于前额鳞沟长度（1.95 mm）（表 1）；吻鳞小，呈三角形；1 枚眶上鳞；颊鳞 1 枚，入眶；无眶

表 1 本研究样本与宁陕脊蛇指名亚种、宁陕脊蛇 *occidentalis* 亚种的形态比较

Table 1 Morphological comparison of the specimen in this study with *Achalinus ningshanensis ningshanensis* and

A. n. occidentalis

	宁陕脊蛇 <i>occidentalis</i> 亚种, ♂ <i>Achalinus ningshanensis occidentalis</i>	宁陕脊蛇指名亚种, ♂ <i>A. n. ningshanensis</i>	本研究样本, ♂ Specimen in this study
全长 Total length (mm)	178 ~ 421	363 ~ 412	510.32
尾长 Tail length (mm)	36 ~ 95	72 ~ 87	87.42
尾长/全长 Tail length/total length	0.202 ~ 0.226	0.198 ~ 0.211	0.17
头宽/头长 Head width/head length	0.47 ~ 0.54	0.48 ~ 0.52	0.70
眼径 Eye diameter (mm)	0.70 ~ 1.56	0.70 ~ 1.00	1.10
上唇鳞 Supralabials	6	6	6
下唇鳞 Infralabials	5 or 6	5	5
颌片 Chin-shield (pairs)	2	3-4	2
颊鳞 Loreal	1	1	1
颊鳞高/颊鳞长 Height of loreal/length of loreal	0.760 ~ 0.946	0.544 ~ 0.617	0.461
鼻间鳞沟长 Length of the suture between internasals (mm)	—	—	1.21
前额鳞沟长 length of the suture between prefrontals (mm)	—	—	1.95
鼻间鳞沟长/前额鳞沟长 Length of the suture between internasals/length of the suture between prefrontals	< 1	1	< 1
颞鳞 Temporals	2 + 2 + 2/3/4	2 + 2/3 + 3/4	2 + 1 + 4/2 + 1 + 3
前颞鳞入眶 Anterior temporals-eye	2	2	2
背鳞 Dorsal scale rows	23-23-23	23-23-23	25-23-23
最外侧背鳞排列方式 Keeling state of the outer-most dorsal scale rows	S + K + K or S + S + K*	K + K + K	K + K + K
腹鳞 Ventrals	155 ~ 160	161 ~ 165	181
尾下鳞 Subcaudals	60 ~ 65	51 ~ 56	52
肛鳞 Cloacal plate	1	1	1

“—” 无相应数据；* “S” 最外侧背鳞排列方式平滑，“K” 最外侧背鳞排列方式起棱。
“—” Data is unavailable; * “S” The keeling state of the outer-most dorsal scale rows is smooth, “K” The keeling state of the outer-most dorsal scale rows is keeled.

前鳞和眶后鳞；颞鳞 2 + 1 + 4 / 2 + 1 + 3(图 1a, b)；上唇鳞 6 枚，第 4、5 枚入眶，由前向后依次增大，第 6 枚约等于前 5 枚之和；颞鳞 1 枚且与第 1 对下唇鳞相切；下唇鳞 5 枚且第 1 对下唇鳞相互接触；颌片 2 对，第 2 对颌片中间夹 2 枚小鳞、这 4 枚鳞片均与第 1 枚腹鳞相切（图 1c）；前额鳞 1 对；额鳞 1 枚，顶鳞 1 对，右侧额鳞与顶鳞之间有 1 枚小鳞；2 枚顶鳞的后外侧各有 1 枚长鳞片、在顶鳞后由 2 枚小鳞片隔开。（图 1d）；背鳞窄长披针形，不呈瓦覆状，25-23-23 行，起棱，两侧最外一行平滑而扩大；腹鳞 181 枚；肛鳞 1 枚，完整；尾下鳞 52 枚，单行。生活时通体黑色、腹面颜色略浅（图 2a）。甲醛浸泡后，体背黑褐色（图 2b），腹部颜色稍浅（图 2c）。

2.2 分子系统发育分析

基于线粒体 COI 基因序列构建的最大似然树显示，脊蛇属聚为一个单系，伏牛山脊蛇样本与宁陕脊蛇指名亚种的姊妹群关系得到支持

（支持率 85%），二者与宁陕脊蛇 *occidentalis* 亚种聚为一支（支持率 99%）（图 3）。伏牛山的脊蛇样本与宁陕脊蛇指名亚种模式产地样本（QHU 2023006）的遗传距离为 0.4%，与宁陕脊蛇 *occidentalis* 亚种正模式标本（QHU 2023013）的遗传距离为 3.6%，脊蛇属物种间的遗传距离 2.8% ~ 18.8%，与外群物种间的遗传距离 16.5% ~ 22.6%（附录 2）。因此，伏牛山的脊蛇样本与宁陕脊蛇指名亚种的遗传距离为亚种内水平，远小于脊蛇属物种间差异，鉴定为宁陕脊蛇指名亚种。

2.3 生境描述

伏牛山脊蛇标本发现地（111°52'59" E，33°31'35" N）海拔 770 m，周围植被以栓皮栎（*Quercus variabilis*）、麻栎（*Q. acutissima*）、槲栎（*Q. aliena*）等为主的落叶阔叶林，还分布有青檀（*Pteroceltis tatarinowii*）、牛鼻栓（*Fortunearia sinensis*）和铜钱树（*Paliurus hemsleyanus*）等。林下灌丛以荆条（*Vitex*

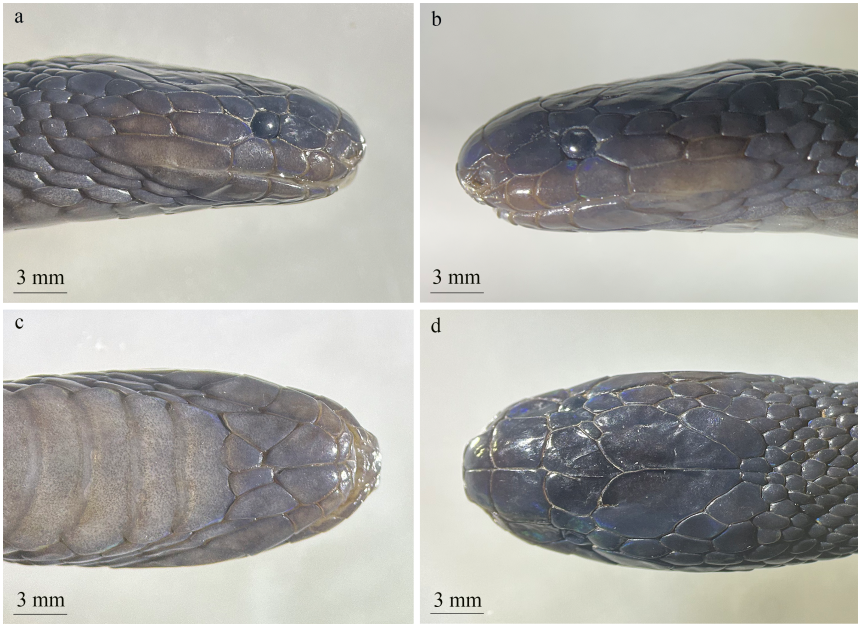


图 1 河南伏牛山宁陕脊蛇指名亚种（HNNU 2310I002）头部形态

Fig. 1 Head morphology of *Acalinurus ningshanensis ningshanensis* (HNNU 2310I002) in Funiu Mountain, Henan Province

a. 头部右侧；b. 头部左侧；c. 头部腹面；d. 头部背面。
a. Right side of the head; b. Left side of the head; c. Ventral surface of the head; d. Dorsal surface of the head.



图 2 河南伏牛山宁陕脊蛇指名亚种 (HNNU 2310I002) 及生境

Fig. 2 *Acalinus ningshanensis ningshanensis* and its habitat in Funiu Mountain, Henan Province

a. 路杀标本背面观; b. 浸制标本背面观; c. 浸制标本腹面观; d. 生境。

a. Dorsal view of the road-killed specimen; b. Dorsal view of the specimen in preservation; c. Ventral view of the specimen in preservation; d. Habitat.

chinensis)、连翘 (*Forsythia suspensa*)、杜鹃 (*Rhododendron simsii*)、粗榧 (*Cephalotaxus sinensis*) 等为主, 草本主要有阿拉伯黄背草 (*Themeda triandra*)、艾 (*Artemisia argyi*)、狗尾草 (*Setaria viridis*)、白茅 (*Imperata cylindrica*) 等。环境阴凉潮湿, 土壤湿润松软,

适于脊蛇栖息 (图 2d)。

3 讨论

宁陕脊蛇包含两个亚种, 指名亚种模式产地在秦岭南麓陕西安阳县旬阳坝镇 (108°32'38" E, 33°32'36" N) (Yang et al. 2022), 已知分布

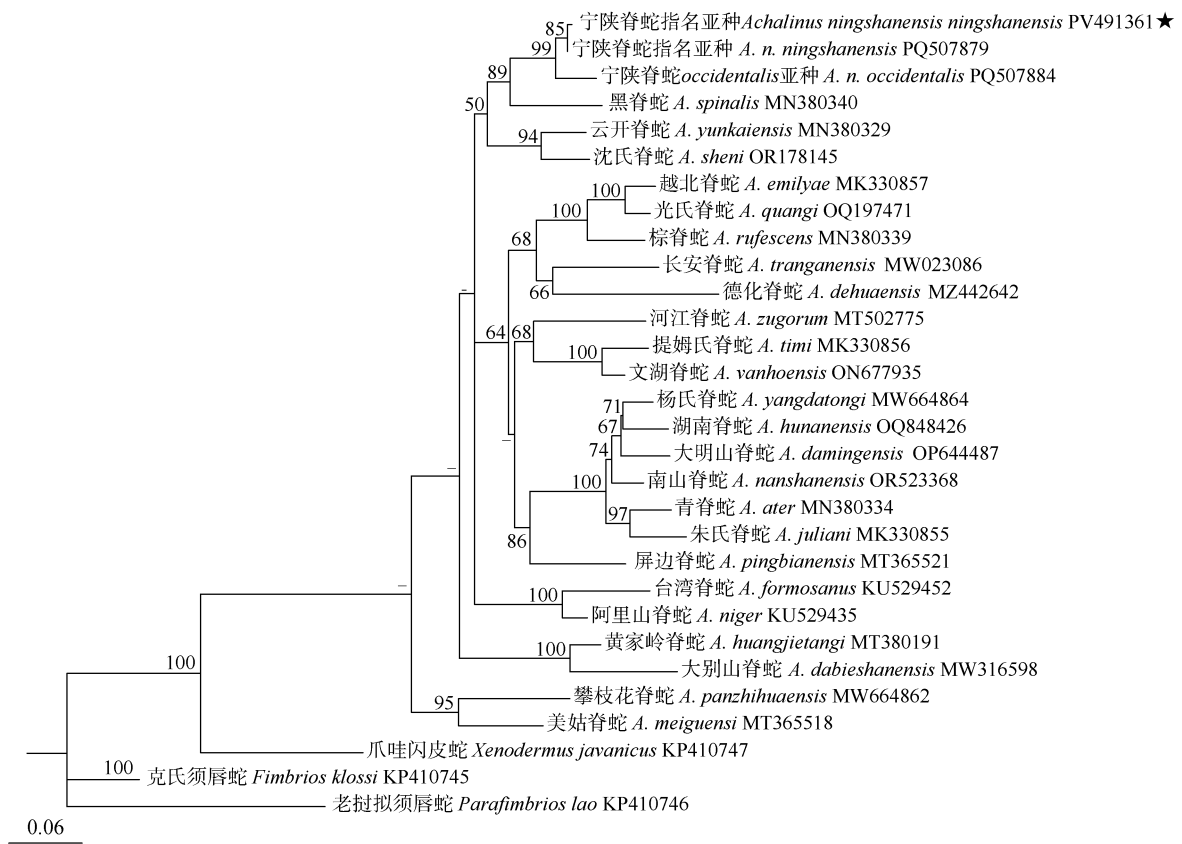


图 3 基于线粒体 COI 基因序列构建的脊蛇属最大似然树

Fig. 3 Maximum likelihood tree of *Acalinus* genus based on mitochondrial *COI* gene sequences
分支节点上数值为自展支持值，小于 50 的标注为“-”。标尺表示序列之间的差异。物种学名后为 GenBank 登录号。★ 本研究样本
The value on the branch node is the bootstrap support value, and the values lower than 50 are displayed as “-”. The scale bar indicates the difference between sequences. GenBank accession number is labeled behind the species name. ★ Specimen in this study

范围为陕西省宁陕县向南至四川省万源县：*occidentalis* 亚种模式产地在四川成都市龙泉驿（104°19'18.12" E，30°32'19.67" N），已知分布范围自陕西省太白县向西南至四川西部（Xu et al. 2024）。伏牛山的脊蛇样本发现地与宁陕脊蛇指名亚种模式产地种群相差 3 个经度，二者不仅存在遗传分化（0.4%），也呈现明显的形态变异。前者第 2 对颌片之间有 2 枚小鳞，腹鳞 181 枚、背鳞 25-23-23，后者第 2 对颌片之间无小鳞，腹鳞 161~165 枚、背鳞 23-23-23。另外，第 2 对颌片之间有 2 枚小鳞是伏牛山的宁陕脊蛇指名亚种样本独有的特征，这一形态特征是个体变异还是地理种群分化，有待深入研究。

脊蛇属物种属于古老的中小型穴居蛇类，活动能力受到限制，斑块化的栖息地环境容易导致各种群间产生地理隔离，从而在遗传和外部形态上产生分化（张佳琦等 2023）。大别山西北坡河南黄柏山发现的大别山脊蛇与大别山东南麓安徽岳西鹞落坪、霍山佛子岭大别山脊蛇模式产地种群同样存在遗传分化和形态变异（刘清熔等 2024）。宁陕脊蛇指名亚种在伏牛山的发现，补充了该物种的已知地理分布范围，可为蛇类多样性保护及谱系地理学研究提供基础资料。

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附录 1 本研究物种 COI 序列信息及数据来源
Appendix 1 Information and references for COI sequences used in this study

物种 Species	采集地 Locality	标本号 Voucher No.	GenBank 登录号 GenBank accession number	参考文献 Reference
宁陕脊蛇指名亚种 <i>Achalimus ningshanensis ningshanensis</i>	中国河南南阳 Nanyang, Henan, China	HNNU23101002	PV491361	本研究 This study
	中国陕西宁陕 Ningshan, Shaanxi, China	QHU 2023006	PQ507879	Xu et al. 2024
宁陕脊蛇 <i>occidentalis</i> 亚种 <i>A. n. occidentalis</i>	中国四川龙泉驿 Longquanyi, Sichuan, China	QHU 2023013	PQ507884	Xu et al. 2024
青脊蛇 <i>A. ater</i>	中国广西桂林 Guilin, Guangxi, China	SYS000852	MK064760	Li et al. 2020a
大别山脊蛇 <i>A. dabieshanensis</i>	中国安徽六安 Lu'an, Anhui, China	AHU2018EE0710	MW316598	Zhang et al. 2023
大明山脊蛇 <i>A. damingsensis</i>	中国广西南宁 Nanning, Guangxi, China	ANU20220009	OP644487	Yang et al. 2023
德化脊蛇 <i>A. dehuaensis</i>	中国福建德化 Dehua, Fujian, China	YBU13013	MZ442642	Li et al. 2021
越北脊蛇 <i>A. emilyae</i>	越南广宁横浦 Hoanh Bo, Quang Ninh, Vietnam	IEBR4465	MK330857	Ziegler et al. 2019
台湾脊蛇 <i>A. formosanus</i>	中国台湾 Taiwan, China	RN2002	KU529452	NCBI
黄家岭脊蛇 <i>A. huangjietangii</i>	中国安徽黄山 Huangshan, Anhui, China	HSR18030	MT380191	Huang et al. 2021
湖南脊蛇 <i>A. hunanensis</i>	中国湖南宁乡 Ningxiang, Hunan, China	CIB119040	OQ848426	Ma et al. 2023a
朱氏脊蛇 <i>A. juliani</i>	越南高平河朗 Ha Lang, Cao Bang, Vietnam	IEBRA.2018.9	MK330855	Ziegler et al. 2019
美姑脊蛇 <i>A. meiguensis</i>	中国四川绵阳 Mianyang, Sichuan, China	GP836	MT365518	Li et al. 2020b
南山脊蛇 <i>A. nanshanensis</i>	中国湖南怀化 Huaihua, Hunan, China	HNNU230901	OR523368	Li et al. 2024
阿里山脊蛇 <i>A. niger</i>	中国台湾 Taiwan, China	RN1159	KU529435	NCBI
攀枝花脊蛇 <i>A. panzhihuaensis</i>	中国四川延边 Yanbian, Sichuan, China	KIZ040189	MW664862	Hou et al. 2021
屏边脊蛇 <i>A. pingbianensis</i>	中国云南红河 Honghe, Yunnan, China	YBU18273	MT365521	Li et al. 2020b
光氏脊蛇 <i>A. quangii</i>	越南北部 Northern Vietnam	sp4	OQ197471	Pham et al. 2023
棕脊蛇 <i>A. rufescens</i>	中国香港 Hong Kong, China	SYR5001527	MN380339	Wang et al. 2019
沈氏脊蛇 <i>A. sheni</i>	中国湖南涟源 Lianyuan, Hunan, China	ANU20230012	OR178145	Ma et al. 2023b
黑脊蛇 <i>A. spinalis</i>	中国湖南八大公山 Badagongshan, Hunan, China	SYS001327	MN380340	Wang et al. 2019
提姆氏脊蛇 <i>A. timi</i>	越南山萝顺州 Thuan Chau, Son La, Vietnam	IEBRA.2018.10	MK330856	Ziegler et al. 2019
长安脊蛇 <i>A. tranganensis</i>	越南宁平长安 Trang An, Ninh Binh, Vietnam	VNUFR.2018.21	MW023086	Luu et al. 2020

续附录 1

物种 Species	采集地 Locality	标本号 Voucher No.	GenBank 登录号 GenBank accession number	参考文献 Reference
文湖脊蛇 <i>A. vanhoensis</i>	越南山萝木州 Van Ho, Son La, Vietnam	VNUFR.2019.13	ON677935	Ha et al. 2022
杨氏脊蛇 <i>A. yangdatongi</i>	中国云南文山 Wenshan, Yunnan, China	KIZ034327	MW664865	Hou et al. 2021
云开脊蛇 <i>A. yunkaiensis</i>	中国广东大雾岭林场 Dawuling Forestry Station, Guangdong, China	SYSt001443	MN380329	Wang et al. 2019
河江脊蛇 <i>A. zingorum</i>	越南河江北迷 Bac Me, Ha Giang, Vietnam	IEBR4698	MT502775	Miller et al. 2020
克氏须唇蛇 <i>Fimbrios klossi</i>	越南嘉莱 Gia Lai, Vietnam	IEBRA.2013.56	KP410745	Teynié et al. 2015
老挝拟须唇蛇 <i>Parafimbrios lao</i>	老挝琅勃拉邦 Louangphabang, Laos	MNHN2013.1002	KP410746	Teynié et al. 2015
爪哇闪皮蛇 <i>Xenodermus javanicus</i>	印度尼西亚苏门答腊 Sumatera Barat, Indonesia	—	KP410747	Teynié et al. 2015

“—” 无相应数据 “—” Data is unavailable

续附录 2

物种 Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
22.提姆氏脊蛇 <i>A. timi</i>	11.8	11.4	13.1	12.7	16.5	12.5	14.8	12.9	13.3	14.6	12.3	14.0	15.9	13.1	11.8	15.4	12.0	12.5	12.7	13.3	14.0									
23.长安脊蛇 <i>A. tranganensis</i>	13.3	13.3	13.3	12.5	15.4	13.9	13.9	12.3	16.9	13.1	14.8	14.2	16.3	13.5	14.4	16.5	13.5	11.8	11.4	14.2	15.6	13.5								
24.文湖脊蛇 <i>A. vanhoensis</i>	11.6	11.2	12.9	12.0	15.6	11.8	14.6	11.8	13.7	14.2	11.2	13.3	15.7	12.0	12.5	15.4	10.6	11.6	12.5	12.7	12.3	4.6	12.0							
25.杨氏脊蛇 <i>A. yangdatongi</i>	12.7	12.3	13.7	6.5	16.7	5.7	14.2	12.7	14.2	14.6	5.1	7.4	17.3	4.6	12.9	15.7	10.8	12.5	11.4	14.0	14.2	12.7	12.9	10.8						
26.云开脊蛇 <i>A. yunkaensis</i>	9.9	9.9	11.0	12.9	15.0	12.3	14.6	13.1	12.0	12.1	12.3	13.3	15.9	12.5	12.0	15.9	10.8	13.7	12.9	6.6	12.0	13.3	14.0	12.3	12.5					
27.河江脊蛇 <i>A. zigorum</i>	12.0	11.6	13.7	13.3	15.4	12.3	14.0	12.9	13.5	14.2	12.1	13.9	15.0	12.7	13.1	15.2	10.2	13.1	13.3	10.4	13.5	13.5	11.8	11.8	12.1	10.4				
28.克氏须唇蛇 <i>Fimbrios klassi</i>	19.5	19.2	19.2	19.2	20.5	17.3	19.9	20.7	20.7	19.5	19.7	19.0	19.7	19.2	18.8	18.4	19.9	20.5	19.9	18.0	20.3	19.2	19.5	19.0	19.5	19.5	19.9			
29.老挝拟须唇蛇 <i>Parafimbrios lao</i>	20.7	20.3	20.1	19.9	22.4	21.6	19.7	20.7	21.3	21.1	20.3	19.5	22.6	19.9	20.9	21.6	21.4	21.1	21.1	20.9	20.7	20.7	20.7	19.7	19.4	21.1	20.7	15.6		
30.爪哇冈皮蛇 <i>Xenodermus javanicus</i>	17.6	17.3	17.1	16.5	19.4	17.8	16.9	17.1	19.0	17.6	17.5	18.0	19.5	17.3	17.6	18.2	18.0	17.6	18.4	16.9	17.3	17.1	17.3	16.9	17.6	17.3	17.5	15.6	20.1	