

A New Species of the Genus *Sinomicrurus* Slowinski, Boundy and Lawson, 2001 (Squamata: Elapidae) from Hainan Province, China

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Abstract A new species of the coral snake genus *Sinomicrurus* is described based on four specimens from southern Hainan Island (three specimens from Tianchi, Jianfengling National Nature Reserve, one specimen from Diaoluoshan National Nature Reserve), Hainan Province, China. Morphologically, the new species is rather similar to *Sinomicrurus kelloggi*. However, it is distinct from *S. kelloggi* by the pattern on the head, the head length, head length/width, the number of infralabial scales, number of bands on dorsal body, and number of blotches on the belly.

Keywords Hainan, morphology, taxonomy, *Sinomicrurus kelloggi*, *Sinomicrurus houi* sp. nov.

1. Introduction

Coral snake is the common name for the often colorful venomous snakes belonging to several genera of the family Elapidae. Traditionally, coral snakes are divided into two clades: the New World coral snakes (the American coral snakes, dorsal scale rows 15 or 17) and the Old World coral snakes (the Asian coral snakes, dorsal scale rows 13 or 15) (McDowell, 1967, 1969; Keogh, 1998; Slowinski and Keogh, 2000).

Asian coral snakes are small to medium-sized elapids ranging from tropical to subtropical areas of eastern Asia. Formerly, they belonged to two genera: *Calliophis* and *Maticora*. However, Slowinski *et al.* (2001) designated a new (monotypic) genus *Sinomicrurus* for a portion of the

genus *Calliophis* based on morphological and *cytochrome b* sequence characters. Nowadays, the genus *Sinomicrurus* contains 5 species: *S. maccllellandi* (Reinhardt, 1844), *S. japonicus* (Günther, 1868), *S. sauteri* (Steindachner, 1913), *S. kelloggi* (Pope, 1928), *S. hatori* (Takahashi, 1930). *S. kelloggi* is the only species of the genus *Sinomicrurus* which has 15 dorsal scale rows, the other four species have 13 dorsal scale rows.

In China, *S. kelloggi* was recorded from the Municipality and Provinces of Yunnan, Chongqing, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hunan, Jiangxi, Zhejiang and Anhui (Chen *et al.*, 2013; Ji and Wen, 2002; Sun *et al.*, 2015; Wang *et al.*, 2015; Zhao and Adler, 1993; Zhao, 1998, 2006). But only few records were known in Hainan Province (Chu and Huang, 1990; Shi *et al.*, 2011; Wang, 2014; Zhao, 1990, 2004). The first record of this species on Hainan was on 10 May 1964 from Wuzhishan National Nature Reserve (NNR) (Zhao, 2004) where a single specimen was collected. Later, Chu and Huang (1990) recorded this species from Jianfengling NNR. Based on our study, all specimens that were recorded as *S. kelloggi* in Hainan Province belong to a new taxon, that we describe as a new species below.

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From 2010 to 2016, four coral snakes were sampled from Hainan Province. They have 15 dorsal scale rows, and are morphologically similar to *S. kelloggi*. However, they are distinct from *S. kelloggi* in some external morphological characters, for instance the striped pattern on the head. Based on morphological analyses, these four specimens, while clearly belonging to the genus *Sinomicrurus*, differ from the other five known species and should be considered as a new species of this genus.

2. Materials and Methods

We examined 26 characters in these 4 new coral snakes and 12 *S. kelloggi*. Specimens are preserved in formalin and deposited in the Museum of Huangshan University (see Table 1). Fourteen count characters were taken, for

the numbers of preoculars (PreOc), postoculars (PostOc), temporals (Tem), supralabials (SL), infralabials (IL), loreal (Lor) at left and right; the numbers of dorsal scale rows (DSR) (DSR counting at one head length behind the head, at midbody, and at one head length before the vent), ventral plates (VEN), subcaudal plates (SC, the terminal scute excluded from the number of subcaudals), nasals, bands on body (Bands) and tail (Tail Bands), and the number of blotches and spots on the ventral and subcaudal part. Twelve mensural characters were taken as: snout-vent length (SVL), total length (TL), tail length (TaL), head width at broadest point (HW), head length from anterior edge of rostral to posterior end of mandible (HL), head height (HH), rostral width (RW), eye length, eye width, perimeter at neck (PN), perimeter at midbody (PM) and perimeter before vent (PV).

Table 1 Morphometric (mm) and meristic characters for the holotype and paratypes of *Sinomicrurus houei* sp. nov. and *S. kelloggi*.

Characters/No./Sex	HUM20170001	Re5410	CIB108251	HUM20170004	<i>S. houei</i> sp. nov.	<i>S. kelloggi</i>
	holotype	paratype	paratype	paratype	<i>n</i> = 4	<i>n</i> = 12
	Male	Male	Female	Female	Range	Range
Snout-vent length	556	476	500	499	476–556	412–557
Tail length	73	60	57	71	57–73	43–73
Total length	629	536	557	570	536–629	473–630
Tail length/total length	0.1172	0.1119	0.1023	0.1161	0.1023–0.1172	0.0801–0.1309
Head length	22.0	21.2	18.2	22.0	18.2–22.0	13.0–16.0
Head width	10.9	10.2	9.0	10.5	9.0–10.9	9.0–11.0
Head height	7.4	7.2	6.3	7.3	6.3–7.4	5.0–7.0
Head length/width	2.02	2.08	2.02	2.10	2.02–2.10	1.35–1.45
Perimeter at neck	34.0	29.0	25.6	23.0	23.0–34.0	22.0–29.0
Perimeter at midbody	45.0	36.0	32.0	32.0	32.0–45.0	24.0–36.0
Perimeter before vent	28.0	24.5	24.1	24.0	24.0–28.0	20.0–25.0
Perimeter at midbody/ total length	0.0715	0.0672	0.0575	0.0561	0.0561–0.0715	0.0447–0.0634
Eye lengthwise	2.2	3.2	2.0	2.1	2.0–3.2	1.8–2.5
Eye widthwise	2.2	3.2	2.0	2.1	2.0–3.2	2.0–2.2
Rostral width	4.0	3.8	3.5	3.2	3.2–4.0	3.5–4.5
Dorsal scale rows	15–15–15	15–15–15	15–15–15	15–15–15	15–15–15	15–15–15
Ventrals	173	175	178	183	173–183	177–197
Subcaudals	35	28	32	34	28–35	27–36
Anal plate	divided	divided	divided	divided	divided	divided
Preoculars	1/1	1/1	1/1	1/1	1/1	1/1
Postoculars	2/2	2/2	2/2	2/2	2/2	2/2
Temporals	1 + 2	1 + 2	1 + 2	1 + 2	1 + 2	1 + 2
Supralabials	7/7	7/7	7/7	7/7	7/7	7/7
Infralabials	7/7	7/7	7/7	7/7	7/7	6/6
Number of dorsal bands on body	16	16	19	18	16–19	19–24
Number of dorsal bands on tail	4	2	3	3	2–4	3–5
Number of blotches on ventral	34 + 7	29 + 5	36 + 6	36 + 6	29–36 + 5–7	37–48 + 5–9

Body and tail lengths were measured using a ruler to the closest 1 mm; other measurements were measured with an electronic caliper to 0.1 mm. Terminology for scale counts follows standard colubrid terminology (e.g., Smith and Campbell, 1994; Smith *et al.*, 2008; Vogel and David, 2010; Vogel and Luo, 2011). Symmetric mensural head characters were measured only on the right side, while asymmetric characters were recorded on both sides.

3. Results

Sinomicrurus houi sp. nov. Wang, Peng and Huang (Figures 1, 2, 3)

Calliophis kelloggi — Zhao, 1990, From water onto land: 359.

Calliophis kelloggi — Chu and Huang, 1990, Col. Pap. Herp.: 152.

Calliophis kelloggi — Zhao and Adler, 1993, Herpetology of China: 265.

Calliophis kelloggi — Zhao, 1998, Fau. Sin.Rep. Vol. 3, Squa. Serp.: 342–344.

Calliophis kelloggi — Shi and Meng, 2001, A guide to Hainan terrestrial vertebrate: 83.

Calliophis kelloggi — Ji and Wen, 2002, Atlas of reptiles of China: 236.

Calliophis kelloggi — Zhao, 2004, Sich. Jour. Zool.: 329.

Sinomicrurus kelloggi — Zhao, 2006, The snakes of China: 297.

Sinomicrurus kelloggi — Shi, Zhao and Wang, 2011, Herpetofauna of Hainan: 259, Plates XXIV-128.

Sinomicrurus kelloggi — Wang, 2014, Wild vertebrate in Diaoluoshan, Hainan, China: 119.

Suggest English name: Hou's coral snake.

Suggest Chinese name: 海南华珊瑚蛇 (Hǎi Nán Huá Shān Hú Shé).

Holotype HUM20170001 (Figures 1, 2), adult male, was found at the forest edge on a path near a gutterway at the side of Tianchi Lake, Jianfengling NNR, Hainan island, Hainan, China (108°46' E, 18°39' N; 805 m a.s.l.; Figure 4), collected by Lijun WANG and Mian HOU on 17 Jun 2010, and deposited in the Museum of Huangshan University.

Paratypes Re5410, adult male, and CIB108251, adult female, from the same locality as the holotype, collected on 25 Mar 2011 by Lijun WANG and Mian HOU. The former deposited in the Shanghai Natural History Museum, the latter deposited in the Herpetological Museum of Chengdu Institute of Biology, Chinese Academy of Sciences. HUM20170004, adult female, collected in the Diaoluoshan NNR, Hainan Island, Hainan, China (109°54' E, 18°41' N; 726 m a.s.l.) on 9 Jul 2012 by Yiwu ZHU. The specimen is deposited in the Museum of Huangshan University.

Etymology The species name is a patronym honoring Mian HOU (Sichuan Normal University, China), a modern herpetological enthusiast and naturalist. He has been contributing substantially to the taxonomy and life history of amphibians and reptiles for 20 years. He collected 3 of the 4 type specimens.

Diagnosis *Sinomicrurus houi* sp. nov. differs from the known five congeners by a combination of the following characters: 1) dorsal scale rows (DSC) 15: 15: 15, smooth



Figure 1 Body of Holotype (HUM20170001, adult male). A: Dorsal; B: Ventral. Photos by Lifang PENG.



Figure 2 Head of holotype (HUM20170001, adult male). A: Dorsal; B: Right; C: Ventral; D: Left. If: Infralabial. Photos by Lifang PENG and Song HUANG.

throughout; 2) ventrals (VL) 173–183; 3) subcaudals (SC) 27–38; 4) head relatively elongated, head length (HL) 2.0–2.1 times as long as head width (HW); 5) no loreal; 6) supralabials (SL) 7/7, infralabials (IL) 7/7; 7) dorsal surface scarlet, with 16–19 edged yellowish black bands on trunk of body, 2–4 on tail; 8) numbers of ventral spots 34–42; 9) dorsum of head having a narrow white broadwise band in the forefront of head (covering almost all the 3rd, 4th, 5th, 6th supralabials, preoculars, and continuing through forefront prefrontals) and two symmetric white stripes appearing a Chinese symbol for the figure eight (“八”, from both sides of frontal to neck sides and gradually widening); 10) maxillary teeth behind the fangs present.

Description of holotype An adult male with SVL 556 mm, Tal 73 mm, TL 629 mm, TaL/TL 0.117; HL 22.0 mm; HW 10.9 mm; HL/HW 2.02; HH 7.4 mm, head distinct from neck; eye length 2.2 mm; eye width 2.2 mm, eye length/width 1.0, pupil round; rostral width 4.0 mm; internasals 2.0 times wider than long, contacting only the nasals laterally; length of internasal suture slightly less than half diameter of eye; prefrontals as wide as long, in

contact laterally with nasal, preocular, and supraocular; prefrontal suture 1.8 times diameter of eye; frontal 1.7 times longer than wide; supraoculars 2.2 times longer than wide; parietals 2.3 times longer than wide; parietal suture 0.5 times length of parietals; single preocular, as long as wide, pentagon; 2 postoculars, upper slightly wider than lower, reaching beyond upper and lower borders of eye, respectively; 1 + 2 temporals; 7/7 supralabials, the 3rd and 4th bordering the eye, sixth largest and longest; 7/7 infralabials, first pair in contact behind mental, second small, from first to fourth touching anterior chin-shields, 4th largest and contacting anterior and posterior chin-shields; no loreal; preocular and nasal in contact; 15–15–15 forebody-midbody-hindbody transverse dorsal scale rows, dorsal scales well smooth; apical pits absent; PN 34.0 mm, PM 45.0 mm, PV 28.0 mm; PM/TL 0.072; ventrals 173; anal plate divided; 35 subcaudals, paired; tail complete, tip round.

Coloration of the holotype in life Dorsum of head black, with a narrow white broadwise band in the forefront of head (covering almost all the 3rd, 4th, 5th, 6th supralabials, preoculars, and continuing through forefront prefrontals)

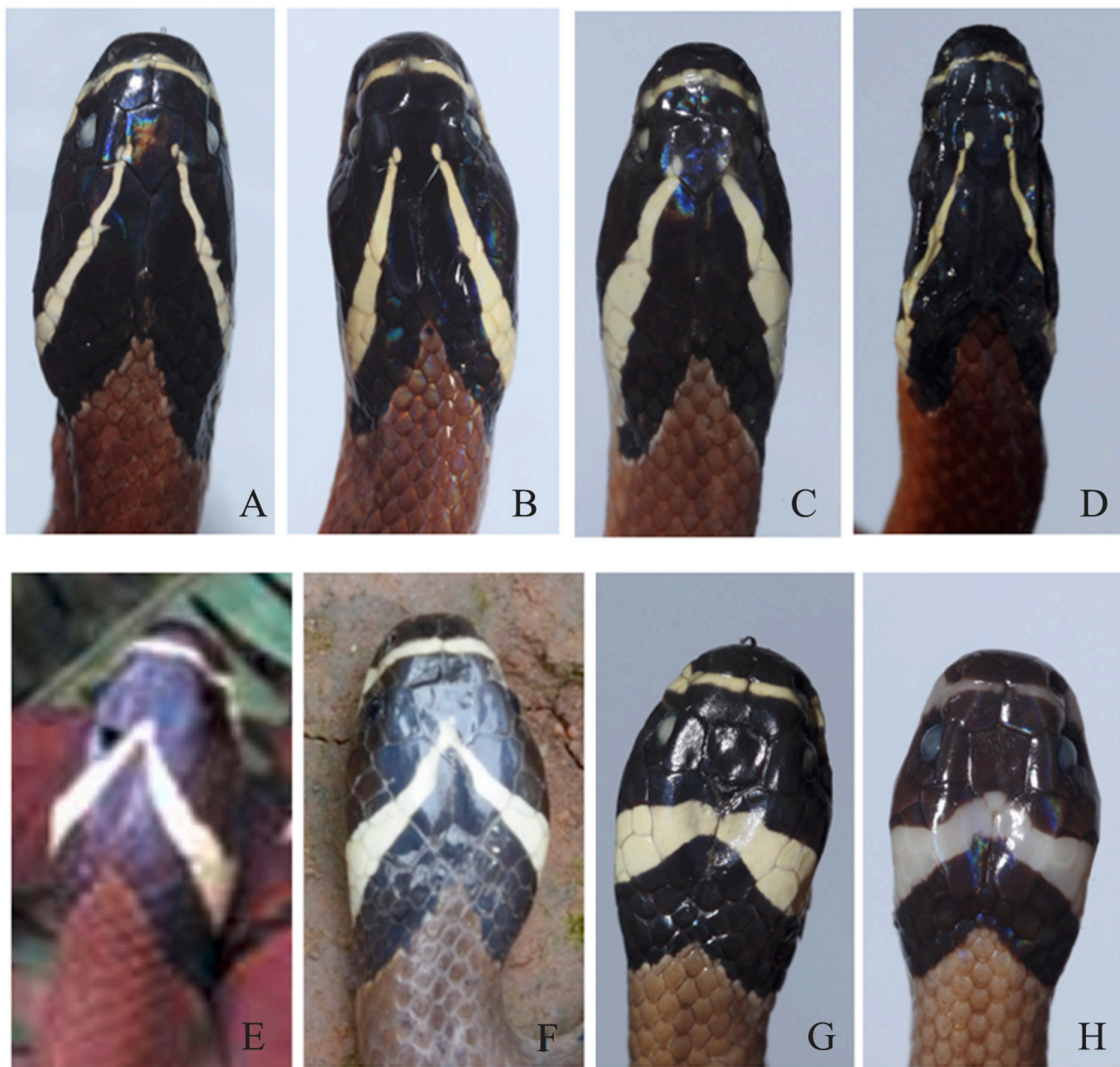


Figure 3 Dorsal head views of *Sinomicrurus houi* sp. nov.: holotype HUM20170001 (A), paratypes Re5410, CIB108251, HUM20170004 (B, C, D), morphological transition type from Vietnam (Orlov *et al.*, 2003) and Yunnan (Sun *et al.*, 2016) (E, F) and typical *S. kelloggi* from Yunnan Province (Wang *et al.*, 2015) and Anhui (Chen *et al.*, 2013). (G, H). Photos by Lifang PENG and Diancheng YANG (A, B, C, D).

and two symmetric white stripes appearing a Chinese symbol for the figure eight (“八”, from both sides of frontal to neck sides and gradually widening); ventral of head creamy yellow; dorsum of body scarlet, turning tangerine towards venter; black dorsal bands finely edged with pale pinkish buff; eye surrounded by dark pigment; 16 inerratic dorsal bands on body (all crossing midline), about 1 scales wide; the first dorsal band meets the 14th ventral; 4 dorsal bands on tail; 34 black blotches on ventral scales; 7 spots on subcaudal with black.

Variation The variation in measurement is given in Table

1. The holotype and the paratypes are similar in general aspects.

Comparisons Based from morphology analysis, the genus *Sinomicrurus* have three species groups, the *S. maclellandi*, *S. kelloggi* and *S. japonicus* groups.

The *S. maclellandi* group species differs from the *S. kelloggi* group species by having 13 scale rows on the body, ventrals 195–241, subcaudals 25–46, 1 + 1 temporals, 6/6 infralabials, with (*S. m. maclellandi*, *S. m. iwasaki*, *S. m. swinhoei*) or without (*S. m. gorei*, *S. m. univirgatus*) black rings, the broader band on the

head shaped in curve (*S. m. maccllelandi*, *S. m. iwasakii*, *S. m. univirgatus*) or straight with irregular border (*S. m. gorei*, *S. m. swinhoei*), with a black vertebral stripe and the transverse bars restricted to the sides of the body or totally absent (*S. m. univirgatus*), having a pair black spots or one irregular spot between the black rings (Günther, 1858, 1964, 1968; Mell, 1929; Nakamura and Ueno, 1963; Orlov *et al.*, 2003; Reinhardt, 1844; Shang *et al.*, 2009; Shi *et al.*, 2011; Smith, 1943; Stejneger, 1907; Wall, 1910, 1913, 1923; Zhao, 1998, 2004, 2006).

The above characters refer to *S. kelloggi* which has 15 scale rows on the body, ventrals 154–202, subcaudals 27–38, 1 + 2 temporals, 6/6 (*S. kelloggi*) or 7/7 (*S. houi* sp. nov.) infralabials, with black rings, the broader band on head shaped like “V” (*S. kelloggi*) or “八” (*S. houi* sp. nov.), without any black vertebral stripe or any spots which between the black rings (Günther, 1858, 1964, 1968; Mell, 1929; Orlov *et al.*, 2003; Pope, 1928; Shi *et al.*, 2011; Smith, 1943; Zhao, 1998, 2004, 2006).

The *S. japonicus* species group can be distinguished from the *S. maccllelandi* group and *S. kelloggi* by a combination of characters: 13 (*S. hatori*, *S. japonicus*) or 15 (*S. sauteri*) scale rows on body, ventrals 196–269, subcaudals 28–31, 1 + 1 temporals, 6/6 (*S. hatori*, *S. sauteri*) or 7/7 (*S. japonicus*) infralabials. On the body they do not have rings (*S. sauteri*, *S. j. takarai*), have short whitish lateral band (*S. hatori*), only have black rings (*S. j. japonicus*) or have black rings with fresh white borders (*S. j. boettger*), the broader band on head is absent (*S. japonicus*) or there is a straight whitish band with irregular anterior border, with three (*S. hatori*, *S. sauteri*), five (*S. j. japonicus* [intermittently on lateral], *S. j. boettgeri* [completely]) or seven (*S. j. takarai*) black longitudinal stripes on the body (Nakamura and Ueno, 1963; Orlov *et al.*, 2003; Shang *et al.*, 2009; Steindachner, 1913; Stejneger, 1907; Takahashi, 1930; Zhao, 1998, 2004, 2006).

Sinomicrurus houi sp. nov. differs from *S. kelloggi* by the following characters: 1. dorsum of head with a narrow white broadwise band in the forefront of the head (covering almost all the 3rd, 4th, 5th, 6th supralabials, preoculars, and continuing through forefront prefrontals) and two symmetric white stripes appearing a Chinese symbol for the figure eight (“八”, from both sides of frontal to neck sides and gradually widening); 2. a longer head (HL/HW is 2.02–2.10 vs. 1.35–1.45); 3. a higher number of infralabials (7/7 vs. 6/6); 4. the fourth infralabial distinct larger than the fifth as opposed to almost equal; 5. a smaller number of bands on dorsal (16–19 vs. 19–24); 6. a smaller number of spots on ventral

side (34–42 vs. 43–55); 7. the ground color is scarlet as opposed to brownish red (Günther, 1858, 1964, 1968; Mell, 1929; Orlov *et al.*, 2003; Pope, 1928; Shi *et al.*, 2011; Smith, 1943; Zhao, 1998, 2004, 2006).

Distribution The new species is currently known from the NNRs of Diaoluoshan, Jianfengling and Wuzhishan (Chu and Huang, 1990; Zhao, 2004; Wang, 2014), Hainan Province, China.

Natural History *Sinomicrurus houi* sp. nov. is a nocturnal terrestrial snake, living in the forest floor of montane rain forest, usually hidden in deciduous or humic layers very close to streams or ditches. It feeds primarily on snakes, consuming small snakes and the juveniles of snakes which live in the same habitats, such as *Indotyphlops braminus*, *Argyrophis diardii*, *Hebius popei* and *H. boulengeri* etc., presumably they also prey on grass lizards and skinks, and may also feed on the sleeping juveniles of *Acanthosaura lepidogaster* and *Pseudocalotes microlepis* resting on the roots of bushwoods. In captivity, they catch actively and feed on juveniles of *Dinodon rufozonatum* (Figure 5), *Xenochrophis flavipunctatus*, *Pantherophis guttatus* and skinks).

4. Discussion

Those species with large body size in Elapinae have evoked more attentions in academia and the general public, due to their unique behavioral characteristics, large population size, high economic importance and aesthetic appeal. There are few specimens and molecular data for small body sized snakes of the genus *Sinomicrurus* due to their rare encounters in the wild.

In this study, the discovery of *S. houi* sp. nov. represents the first description of a new species of *Sinomicrurus* in 87 years, the last being *S. hatori* (Takahashi, 1930). Presently, this genus comprises six species. *S. hatori* and *S. sauteri* are endemic to Taiwan Province, China, *S. japonicus* only occurs at Japan, *S. kelloggi* and *S. maccllelandi* are found in southern China and adjacent Southeast Asian countries, and *S. houi* sp. nov. is found only in Hainan Province, China.

During our long term study on the genus *Sinomicrurus*, we recorded *S. kelloggi* from Anhui (Chen *et al.*, 2013) and Yunnan Province (Wang *et al.*, 2015) for the first time. Morphologically, they were typical *S. kelloggi*. Orlov *et al.* (2003) and Sun *et al.* (2015) reported a morphological transition type from Vietnam and Yunnan. Morphologically, their specimens are between *S. kelloggi*

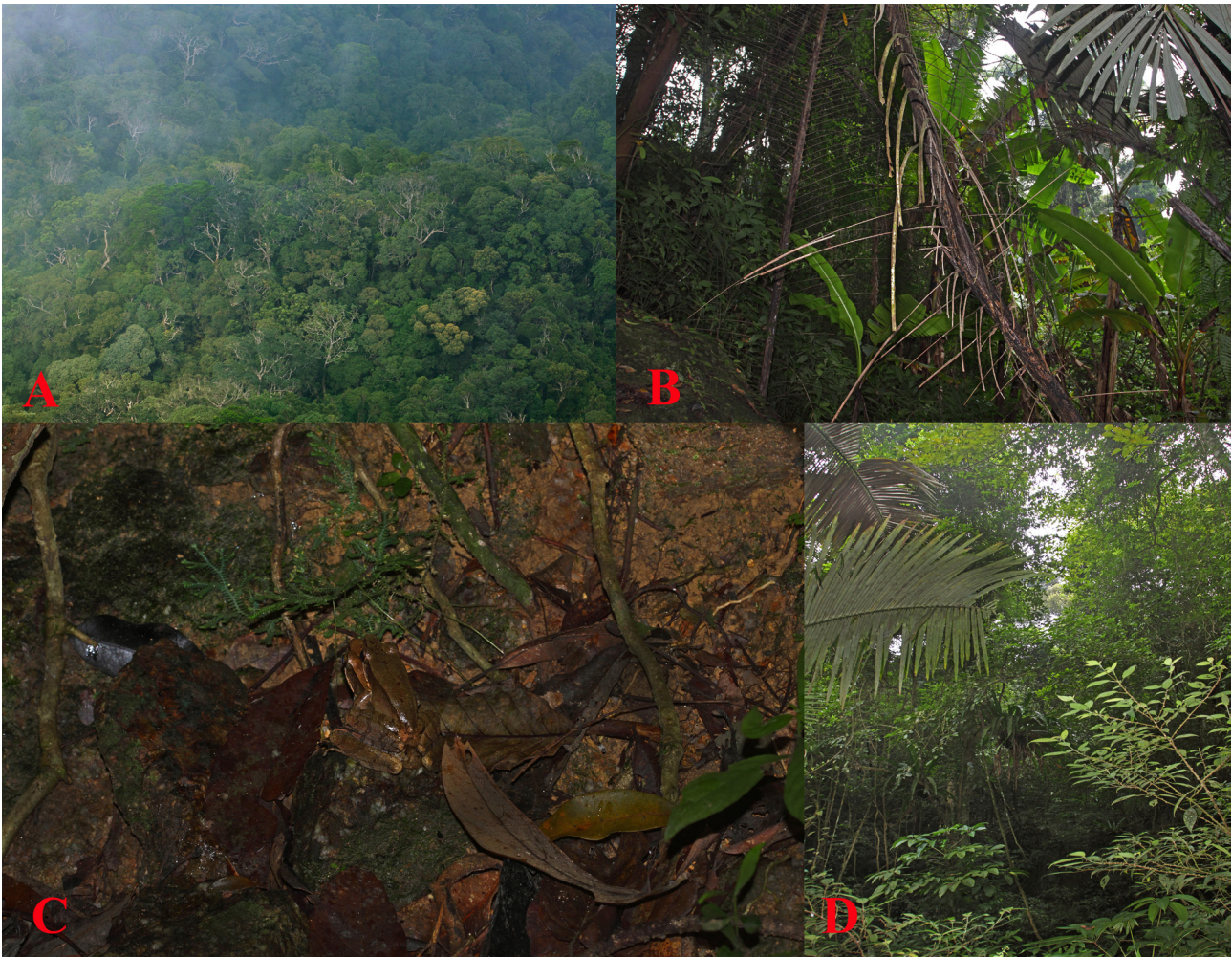


Figure 4 The habitat of *Sinomicrurus houi* sp. nov. on Tianchi, Jianfengling National Nature Reserve, Ledong County: A: The holistic habitat; B and D: the microhabitat; C: The microhabitat on the side of a stream where *S. houi* sp. nov. was found hunting. Photos by Mian HOU.

and *S. houi* sp. nov. Their taxonomic status may need further study. The species diversity of genus *Sinomicrurus* is obviously underestimated.

The new species is currently known from the NNRs of Diaoluoshan, Jianfengling and Wuzhishan, these three localities are situated on the east and west slopes of Qiongzong Mountain ranges respectively. Probably this species occurs in the entire Qiongzong Mountains range at levels of about 500–900 m elevation and is endemic for Hainan Province, China.

The three NNRs from which *S. houi* sp. nov. is known harbour more than 95% species of the fauna of Hainan, especially many endemic species are ranged there, such as *Nomascus hainanus*, *Petaurista hainana*, *Neohylomys hainanensis*, *Polyplectron katsumatae*, *Arborophila ardens*, *Phylloscopus hainanus*, *Cuora galbinifrons hainanensis*, *Achalinus hainanus*, *Dinodon rosozonatum*,



Figure 5 *Sinomicrurus houi* sp. nov. preyed on juveniles of *Dinodon rufozonatum* in captivity. Photo by Hang YANG and Wei LI.

Xenopeltis hainanensis hainanensis, *Goniurosaurus hainanensis*, *Goniurosaurus bawanglingensis*, *Gekko similignum*, *Tylototriton hainanensis*, *Hylarana spinulosa*, *Nidirana hainanensis*, *Odorrana hainanensis*, *Limnonectes fragilis*, *Amolops torrentis*, *Amolops hainanensis*, *Kurixalus hainanus*, *Liuxalus hainanus*, *Liuxalus ocellatus* etc. (Frost, 2017; Gong *et al.*, 2006; Shi *et al.*, 2011; Shi and Meng, 2001; Uetz *et al.*, 2017; Wu *et al.*, 2003).

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