



New Record of the Leopard Gecko *Goniurosaurus araneus* (Squamata: Eublepharidae) for China and Habitat Partitioning between Geographically and Phylogenetically Close Leopard Geckos

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Abstract.—Two specimens of the Leopard Gecko *Goniurosaurus araneus* (Squamata: Eublepharidae) were collected from Nonggang National Nature Reserve, Chongzuo Prefecture, Guangxi Zhuang Ethnicity Autonomous Region, China, in October 2011. This species is a new record for China and this report is a range extension for the species from northern Vietnam to southern Guangxi. A phylogenetic study demonstrated that *Goniurosaurus araneus* and *G. luyi* are a species pair. We show for the first time that they coexist broadly but are narrowly allopatric in a small area in southern Guangxi, separated only by a river, similar to what had been reported previously for *G. yingdeensis* and *Goniurosaurus* indet. from northwestern Guangdong. A river as a geographical barrier, elevation, and aspect may have contributed to habitat partitioning between *G. araneus* and *G. luyi*.

Key words: *Goniurosaurus luyi*, distribution, separation by river, geographic barrier, elevation, aspect, karst, Nonggang

Introduction

Leopard Geckos of the genus *Goniurosaurus* are distributed exclusively in karst and igneous substrate forests in eastern and southeastern Asia. Areas include the Ryukyu Archipelago, South China (Hainan, Guangdong, Guangxi, and Guizhou Provinces), and northern Vietnam. Nonggang National Nature Reserve (NNR) in southern Guangxi (Fig. 1), a province designated as the Autonomous Region for the Zhuang minority people in China, covers an area of more than 100 km², including 73 km² of primary tropical rainforest, all on karst landform. Elevation ranges from 100 to 600 m above sea level, with a mean annual temperature of 22 °C and mean annual rainfall of 1,350 mm (Qi 1980). Eighty-eight species of amphibians and reptiles, including *G. luyi*, have been recorded (Yang et al. 2011). During a field trip in October 2011, we collected two individual *Goniurosaurus*, which

we herein assign to *G. araneus* Grismer, Viets, and Boyle, 1999, and, for the first time, report a range extension of this Leopard Gecko from northern Vietnam to southern China as a new record for China. We also confirm the presence of *G. luyi* in Nonggang.

The distributions of *G. araneus* and *G. luyi* are intertwined with *G. hainanensis* and *G. lichtenfelderi* and rather perplexing, prompting a review of the history of *Goniurosaurus*. Mocquard (1897) described the first species, *Eublepharis lichtenfelderi*, from two specimens from Grande Norway Island (Xuy Nong Chao) in the Tonkin Gulf, northern Vietnam (Fig. 1). Barbour (1908) first established the genus *Goniurosaurus*, based on a new species, *G. hainanensis*, from a single specimen collected from Mt. Wuchi (Wuzhishan, Five Finger Mountain), central Hainan Island, China. Namiye (1912) described *Gymnodactylus albofasciatus kuroiwae* from the Ryukyu Archipelago; Wermuth (1965) separated them and moved the subspecies to *Goniurosaurus* as *G. kuroiwae*; the former is now *Geckoella albofasciatus*

(Boulenger, 1885). Maki (1931) described *Eublepharis orientalis* from Tonakishima and Tokashiki Islands; Okada (1936) described *Gymnodactylus yamashinae* from Kumejima

Island; Nakamura et al. (1959) described *Eublepharis splendens* from Tokunoshima Island; all three also occur on the Ryukyu Archipelago. Börner (1981) created a new genus

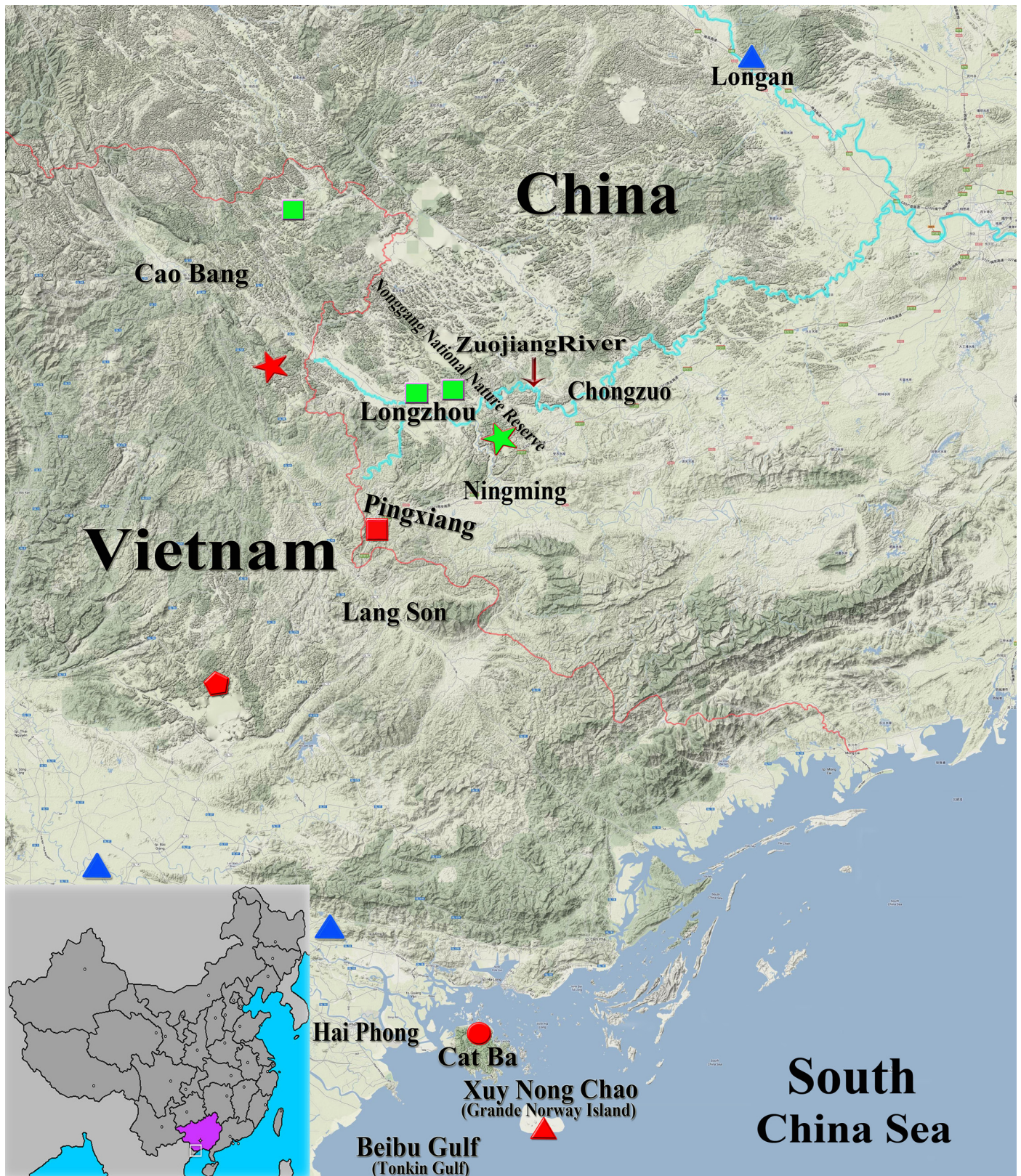


Fig. 1. Distribution map of *Goniurosaurus* species between northern Vietnam and southern Guangxi, with stars for *G. araneus*, circles for *G. catbaensis*, pentagons for *G. huiliensis*, triangles for *G. lichtenfelderi*, rectangles for *G. luii* (all type localities in red), and the courses of rivers in sky blue.

Amamisauros to include all these four species. Grismer (1987) corrected this move and placed all Leopard Geckos from the Ryukyu Archipelago, southern China, and northern Vietnam in *Goniurosaurus*.

The last 20 years have been the most active period in the discovery of additional species of *Goniurosaurus*. Grismer et al. (1994) described *G. kuroiwae toyamai* from Iheyajima Island; Dickhoff (2004) elevated that taxon to a species as *G. toyamai*, resulting in a total of five species known from the Ryukyu Archipelago thus far. Grismer et al. (1999) described two species, *G. araneus* and *G. luyi*, from near the border between Vietnam and China in Cao Bang and Guangxi Provinces, respectively (Fig. 1). Grismer et al. (2002) described *G. bawanglingensis* from Bawangling NNR on Hainan Island, China. Orlov et al. (2008) described *G. huuliensis* from Lang Son Province, northern Vietnam (Fig. 1). Ziegler et al. (2008) described *G. catbaensis* from Cat Ba Island in the Tonkin Gulf, northern Vietnam (Fig. 1). Wang et al. (2010) described *G. yingdeensis* from Shimentai NNR in Yingde County, Guangdong Province, China; at the same time, Yi et al. (2010) reported another form, *Goniurosaurus* indet., from nearby Qingxin County. Wang et al. (2013) described *G. liboensis* from Maolan NNR in Libo County, Guizhou Province, China. The genus currently contains 15 known species.

No one paid attention to *G. hainanensis* since its original description in 1908 until Smith (1935) regarded it as a synonym of *G. lichtenfelderi*. Huang (1964) then reported an Indian species, *Eublepharis macularius* (Blyth 1855), based on two specimens from Dongfang County, Hainan Island. Grismer (1988) regarded this report near the type locality of *G. hainanensis* as a mistake for a species close to *G. lichtenfelderi*, and further provided evidence that *G. hainanensis* and *G. lichtenfelderi* were geographic subspecies. In that same year, Hu and Zhao (1987) regarded *G. hainanensis* as *G. lichtenfelderi* by listing *G. lichtenfelderi* from Hainan as the only Leopard Gecko for China. Their work provided the first Hainan appearance for *G. lichtenfelderi*. Adding to the confusion, Li et al. (1986) reported *G. lichtenfelderi* from Guizhou; this different species was then treated as such in the literature until Wang et al. (2013) found more specimens and identified them as *G. liboensis*, thus excluding *G. lichtenfelderi* from Guizhou. Orlov and Darevsky (1999) described *G. murphyi* from a village between Bac Ninh and Bac Giang Provinces (Fig. 1), but Grismer (2000) regarded it as a junior synonym of *G. lichtenfelderi*, making it the first continental record from northern Vietnam after more than 100 years since its first description from an island. At the same time, *G. hainanensis* was elevated to a species and its distribution was defined as restricted to Hainan Island (Grismer 2000, Blair et al. 2009). A historical report of *G. lichtenfelderi* by Wen (1983) from Longan County, near Nanning, southern Guangxi (Fig. 1)

is the likely source of the record for *G. lichtenfelderi* from Guangxi in Zhao and Adler (1993). Because of the close proximity of the Vietnamese continental locality to Guangxi, we have included this single record of *G. lichtenfelderi* for China until the specific locality is revisited. However, we herein disregard the record of *G. lichtenfelderi* from Guangdong in Li et al. (2011) because it was based on *Goniurosaurus* indet. (Yi et al. 2010), which definitely is a distinct species that is similar to *G. yingdeensis* in at least the number of body bands. Consequently, the distribution of *G. lichtenfelderi* is from a mainland locality in southern Guangxi, the holotypic island in the Tonkin Gulf, and a mainland locality in northern Vietnam (Fig. 1). Grismer et al. (1999) mentioned *G. luyi* from Hainan based on two specimens from pet markets but dismissed this record in Seuffer et al. (2005), resulting in the distribution of *G. luyi* being only from Guangxi. However, Thanh et al. (2006) reported *G. luyi* from northern Vietnam (Fig. 1), creating a broad distribution of the species across the international border. Although Grismer et al. (1999) referred to Hu and Zhao (1987) for the distribution of *G. araneus*, thus implying its presence in China, that work contains no mention of *G. araneus*. Perhaps they treated the listing of *G. lichtenfelderi* in Vietnam by Hu and Zhao (1987) as *G. araneus* or it might have been a mistranslation of the listing or the citation.

In summary, only seven species of *Goniurosaurus* were recorded from China: *G. bawanglingensis* (Hainan), *G. hainanensis* (Hainan), *G. liboensis* (Guizhou), *G. lichtenfelderi* (Guangxi), *G. luyi* (Guangxi), *G. yingdeensis* (Guangdong), and *Goniurosaurus* indet. (Guangdong). This report of *G. araneus* increases the number of species or forms in *Goniurosaurus* from seven to eight in China.

Coexistence of *G. araneus* and *G. luyi* within a small area like Nonggang caught our attention. A similar phenomenon was first observed for *G. yingdeensis* and *Goniurosaurus* indet. in northwestern Guangdong, with only a river separating the pair (Zhang et al. 2014). We herein provide preliminary data on habitat partitioning between *G. araneus* and *G. luyi* from Nonggang, morphological variation, and comparisons among species of Leopard Geckos. This paper also provides specific locality records of *G. luyi* in order to define its distribution beyond the type locality in China.

Materials and Methods

Tian-Bo Chen collected two adult specimens of *G. araneus* (KIZ-012729 and KIZ-012730) from Nonggang NNR (22°29'38"N, 106°47'06"E), Longzhou County, Chongzuo Prefecture, Guangxi Zhuang Ethnicity Autonomous Region, China, at night in October 2011. A total of four specimens of *G. luyi* also were collected from the same reserve and time frame but in different localities (NG-11101503, 11101508, 11102125, 11102202). These specimens were compared

with Chinese and Vietnamese congeners and other currently undescribed Chinese species from the wild, pet markets, and/or photos and descriptions in literature. They were fixed in 75% ethanol (after preserving liver tissues in 95% ethanol for DNA analysis) and deposited in the Kunming Institute of Zoology (KIZ), Chinese Academy of Sciences, Kunming, Yunnan Province, China. We subsequently examined habitat parameters for these localities, including elevation, plant composition, and aspect.

All measurements were made with an electronic vernier caliper to the nearest millimeter. Measurable and meristic abbreviations are as follows: snout-vent length (SVL), tail length from posterior edge of the vent to the tip of the tail (TAL), snout to eye length from the tip of the snout to the anterior-most point of the eye (SEL), maximum inter-orbital distance (IOD), eye to ear distance from the posterior margin of the eye to the posterior margin of the ear (EE), maximum head width (HW), head length from the tip of the snout to the posterior margin of the ear (HL), maximum head height (HH), forelimb length from the axilla to the tip of the fourth finger (FLL), hindlimb length from the groin to the tip of the fourth toe (HLL), number of supralabials (SL), number of infralabials (IL), number of nasal scales surrounding the nares (N), number of internasals (IN), number of cilia (CIL), number of postmentals (PM), number of gular scales bordering the postmentals (GP), number of dorsal tubercle rows at midbody (DTR), number of granular scales surrounding the dorsal tubercles (GST), number of paravertebral tubercles between limb insertions (TL), number of scales around midbody (MB), number of subdigital lamellae on the forelimb under the first to fifth fingers (LD1, LD2, LD3, LD4, LD5), number of subdigital lamellae on the hindlimb under the first to fifth toes (LT1, LT2, LT3, LT4, LT5), number of preanal pores (PP), number of postcloacal tubercles (PAT), and number of dorsal tubercles in the first, fourth, and eighth caudal whorls (DT1, DT4, DT8). Bilateral scale counts are given as right/left.

Results

Habitat partitioning.—*Goniurosaurus araneus* is currently known only from the type locality in Vietnam and Nonggang NNR, Guangxi, China. It is nocturnally active in karst brae covered with thick tropical rainforest (Fig. 2). The two specimens were collected in the Longshan area at elevations of 150–170 m. The four individuals of *G. luyi* in Nonggang NNR also were nocturnally active in karst brae and collected at elevations of 180–260 m. The habitat of the two species was separated by the Zuojiang River (western river in Fig. 1), running approximately northwest to southeast from Vietnam to Nonggang, then from west to east to meet with the Youjiang River (eastern river) after Nonggang (Fig. 1); these two rivers join to form the Yongjiang River, a major tributary in the Pearl River drainage system. Extensive sur-



Fig. 2. Habitats of *Goniurosaurus araneus* and *G. luyi* at Nonggang National Nature Reserve, southern Guangxi, China. Photographs by Tian-Bo Chen.

veys since 2009 confirmed that the species were allopatric and that their ranges were separated by the river. The area northeast of the Zuojiang River was occupied by *G. luyi* and that to the southwest by *G. araneus*. Both species were active at night mostly on rock surfaces and occasionally on the forest floor. The principal vegetation at the respective elevations did not appear to differ in canopy height or plant composition; however, the aspects where two species were found differed, *G. araneus* frequently on north-facing slopes, *G. luyi* on south-facing slopes. The two individuals of *G. araneus* were fed crickets, scalewings (Lepidoptera), spiders, small beetles (Tenebrionidae), and waxworms (Pyralidae) in captivity near the site of collection.

Morphological variation.—The diagnostic characters of *G. araneus* from Nonggang are: Nuchal loop and four body bands between the forelimb insertion and the caudal constriction are broad, pale to bright orange; five caudal bands are white; body and limbs are nearly immaculate dorsally and laterally with only a few spots; males have 23–29 preanal pores. In life, the dorsal ground color of head and body was rusty brown

with a bluish gray tint (Fig. 3A), that of limbs more purplish; a few individuals from pet markets had more or larger speck-

les (Fig. 3B–D), calvaria mottled with some large dark spots or irregular blotches, and an orange-brown iris. The nuchal



Fig. 3. Variation among live *Goniurosaurus araneus* in head marking, body bands, dorsal and lateral mottling, and tail (A, female KIZ-012730 with regenerated tail and few dark spots on head; B, pet market female with original tail, unusual body bands, and numerous dark spots on head; C, pet market male with original tail and few dark spots on head; D, male with regenerated tail and large dark blotches on head). Photographs by Tian-Bo Chen (A), Hang Yang (B, C), and Nikolai L. Orlov (D).

loop and body bands were edged anteriorly and posteriorly with black; all orange bands were immaculate. The ground color of the tail was black to dark brown; white caudal bands were immaculate and complete ventrally. Ventral surfaces of

the head, body, and limbs were dull white. In ethanol (Fig. 4), the ground color of the dorsum became gray; the nuchal loop and body bands turned pale white, but spots and edges of body bands remained darker than the interspaces; the

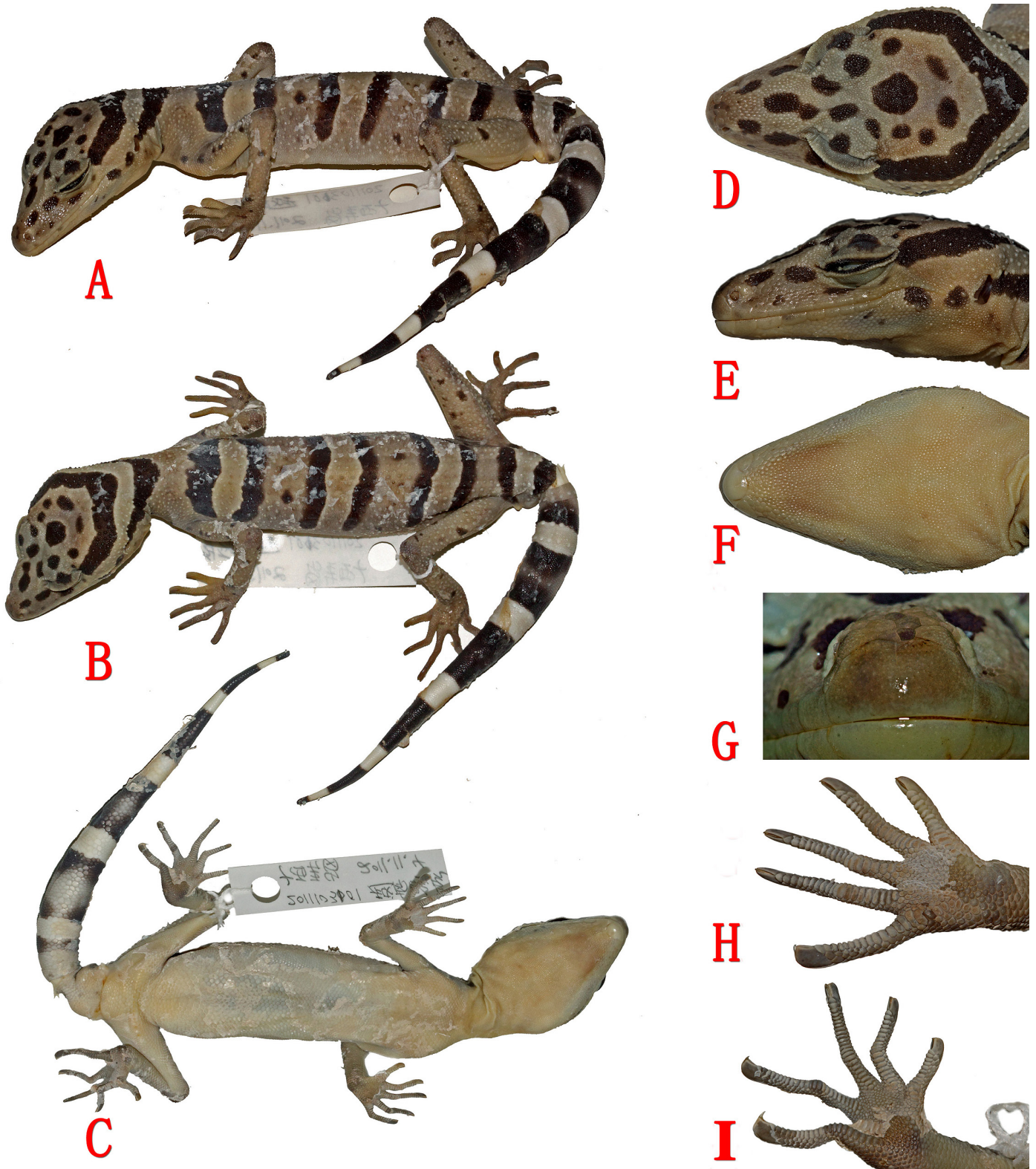


Fig. 4. *Goniurosaurus araneus* (KIZ-012729 in ethanol) in lateral, dorsal, and ventral full views (A, B, C, respectively), its head in dorsal, lateral, and ventral views (D, E, F, respectively), rostral and mental scales (G), and ventral pes and manus (H, I). Photographs by Mian Hou.

white caudal bands lost the bluish tint. Morphological measurements are detailed in Table 1.

Of the two individuals from the Nonggang NNR, the male has a pair of internasal scales between the first supranasals, but the female has only one (Fig. 5A–B). We also checked specimens from pet markets and literature records; most individuals have only one internasal contacting the midline behind the rostral. The transverse series of caudal tubercles on the original tail is absent on the regenerated tail (Fig. 5C–D). In the male, a distinct enlarged globular region was evident between the posterior edge of the cloaca and the base of the tail (Fig. 6A), as opposed to the lack thereof in the female (Fig. 6B). Preanal pores were distinctly present only in males (Fig. 6C) and absent in females (Fig. 6D).

Grismer et al. (1999) noted the absence of a row of enlarged supraorbital tubercles in *G. araneus*, but rows were present in both specimens (Fig. 7). The counts of eyelid fringe scales were lower than those given by Grismer et al. (1999; 52–54 versus 61–67) and the body scales of *G. araneus* from Nonggang were more granular than elongate as described by Grismer et al. (1999).

Species comparisons.—*Goniurosaurus araneus* (Fig. 8A–B) differs mainly from *G. hainanensis* (Fig. 8L) and *G. lichtenfelderi* (Fig. 8K) in the number of body bands between the forelimb insertion and caudal constriction, as well as in the number of preanal pores. *Goniurosaurus araneus* has four body bands and 23–29 (erroneously reported as 18–22 in Wang et al. 2013) preanal pores, whereas the latter two species both have only three body bands. *Goniurosaurus hainanensis* (24–32; Grismer et al. 2002,



Fig. 5. Variation in internasal scales and caudal bands of *Goniurosaurus araneus* (KIZ-012729: A, two scales in male; C, original tail. KIZ-012730: B, one scale in female; D, regenerated tail). Photographs by Mian Hou.

Table 1. Measurements (mm, if applicable) of *Goniurosaurus araneus* specimens from Nonggang National Nature Reserve, southern Guangxi Province, China. See the text for abbreviations of characters.

Character	KIZ-012729 male	KIZ-012730 female
SVL	114.89	108.99
TAL	94.87 (original)	67.52 (regenerated)
SEL	12.34	11.18
IOD	8.76	8.02
EE	9.73	9.55
HW	21.73	20.96
HH	15.34	14.94
HL	35.96	35.05
FLL	50.32	48.89
HLL	64.65	55.52
SVL:TAL	1.21	1.61
SVL:HL	3.19	3.11
HL:HW	1.65	1.67
HL:HH	2.34	2.35
SEL:EE	1.27	1.17
SL	8/9	9/10
IL	9/9	9/9
N	7/6	7/8
IN	2	1
CIL	53/54	52/54
PM	5	5
GP	9	7
DTR	22	21
GST	11	11
TL	31	29
LD1	9/10	11/12
LD2	15/17	16/17
LD3	19/18	18/19
LD4	19/20	20/21
LD5	11/16	16/16
LT1	9/11	14/13
LT2	18/18	18/18
LT3	24/23	24/23
LT4	25/24	23/23
LT5	21/21	22/21
PP	23	0
PAT	3/3	4/6
DT1	7	regenerated
DT4	5	regenerated
DT8	4	regenerated

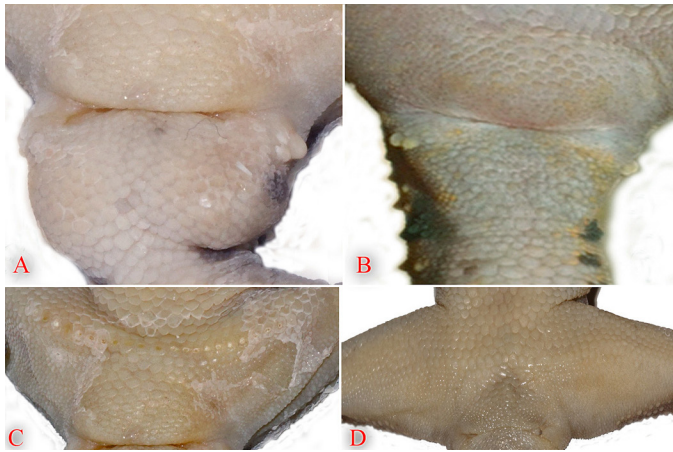


Fig. 6. Sexual dimorphism of *Goniurosaurus araneus* in tail base and preanal pores (male, A, C; female, B, D). Photographs by Mian Hou (KIZ-012729: A, C; KIZ-012730: D) and Yi-Wu Zhu (B, pet market).

Blair et al. 2009) and *G. araneus* have similar counts of preanal pores, but *G. lichtenfelderi* has a larger count variation of 17–32 preanal pores (Orlov and Darevsky 1999, Grismer 2000).

With our data and those of Grismer et al. (1999, 2002) combined, the remaining known species from China and Vietnam all have 4–5 body bands between the forelimb insertion and caudal constriction, but *G. araneus* is the most immaculate dorsally and laterally, has the widest bright orange immaculate body bands, 5–6 white caudal bands, 6–7 nasal scales surrounding the naris, a row of enlarged supraorbital tubercles on each side, 4–6 postmentals, 52–67 eyelid fringe scales, 129–149 scales around midbody, and 23–25 subdigital lamellae under the fourth toe, its upper eyelid scales are one-half the size of those on calvaria, and, in contrast to adults, juveniles in life are black with white body and caudal bands.

Goniurosaurus bawanglingensis (Fig. 8C) has narrower bright orange but spotted body bands, many more dark blotches on the body, a series of enlarged flat imbricate scales on the mediolateral portions of the front digital wrist, more preanal pores (37–46), but lower counts of 2–3 postmentals and 18–22 subdigital lamellae under the fourth toe, and upper eyelid scales similar in size to those on the calvaria (Grismer et al. 2002). Because of the four body bands between the forelimb insertion and caudal constriction in the photograph in Huang (1964), we could identify his specimen as close to *G. bawanglingensis* instead of a species close to *G. lichtenfelderi*, as indicated by Grismer (1988).

Goniurosaurus catbaensis (Fig. 8D) uniquely has 4–5 body bands that are narrow, orange, and immaculate, many more dark blotches on the body, fewer preanal pores (16–21), lower counts of 2–3 postmentals and 112–127 scales around midbody, and upper eyelid scales similar in size to those on the calvaria (Ziegler et al. 2008).

Goniurosaurus huuliensis (Fig. 8E) has narrower, orange, immaculate body bands, many more dark blotches on the

body, particularly under the head, and lower counts of 2–3 postmentals, 41–44 eyelid fringe scales, 118–129 scales around midbody, and 18–20 subdigital lamellae under the fourth toe (Orlov et al. 2008). Although the following characters were not mentioned in Orlov et al. (2008), photographs showed that a row of enlarged supraorbital tubercles is present on each side of the orbits and the upper eyelid scales are similar in size to those on the calvaria.

Goniurosaurus liboensis (Fig. 8F) has narrower, orange, immaculate body bands, many more dark blotches on the body, a consistent number of preanal pores (23) near the lowest count for *G. araneus*, and upper eyelid scales similar in size to those on the calvaria (Wang et al. 2013).

Goniurosaurus luyi (Figs. 8G–H) has narrower, bright orange, immaculate body bands, many more dark spots on the body, fewer preanal pores (18–22), and juveniles have bright orange body bands (Grismer et al. 1999, 2002). A few discrepancies exist among described characters in our observations and those of Grismer et al. (1999, 2002) and Wang et al. (2013). First, the row of enlarged supraorbital tubercles was supposedly absent in *G. araneus*; we found this character in both *G. araneus* and *G. luyi* from Nonggang (Fig. 7). Second, Grismer et al. (1999) listed 61–67 eyelid fringe scales (ciliaria) in *G. araneus* and Wang et al. (2013; Table 4) listed 57–61 or 52–63 for *G. luyi*; our specimens of *G. araneus* have only 52–54 and our specimens of *G. luyi* only 52–58 cili-



Fig. 7. A row of enlarged supraorbital tubercles in *Goniurosaurus araneus* (A) and *G. luyi* (B) from Nonggang National Nature Reserve, southern Guangxi, China. Photographs by Mian Hou.

aria, indicating that the two species overlap in this character. Among the specimens from Nonggang, we observed no obvious differences in the shapes of body scales in *G. araneus* and *G. luii*, whereas Grismer et al. (1999) indicated that they were more granular than elongate in *G. araneus*.

Goniurosaurus yingdeensis (Fig. 8I) has narrower, dull yellow, immaculate body bands; both males and females have relatively few preanal pores (10–13), many more dark blotches on the body, 7–10 white caudal bands, lower counts of three postmentals, 49–57 eyelid fringe scales, 107–124

scales around midbody, and 19–24 subdigital lamellae under the fourth toe, and juveniles have orange body color and yellow body bands (Wang et al. 2010, 2013). However, note that the immaculate light ring of ground body color immediately after the fourth body band on the caudal constriction was mistaken for an extra body band. That light ring is not edged by black bands anteriorly and posteriorly like the nuchal loop and body bands, and it is not present on the juvenile (Wang et al. 2010: Fig. 1B). That confirms our contention that this species has only four body bands between



Fig. 8. Known species of *Goniurosaurus* from Vietnam and China in groups of >3 and 3 body bands between forelimb insertion and caudal constriction. A–B. *G. araneus* from Nonggang, Guangxi Province, China (KIZ-012730), and pet market; C. *G. bawanglingensis* from Bawangling National Nature Reserve (type locality), Hainan Island, China; D. *G. catbaensis* from Cat Ba Island (type locality), Hai Phong Province, Vietnam; E. *G. huuliensis* from Huu Lien Nature Reserve (type locality), Lang Son Province, Vietnam; F. *G. liboensis* from Libo Co. (type locality), Guizhou Province, China.

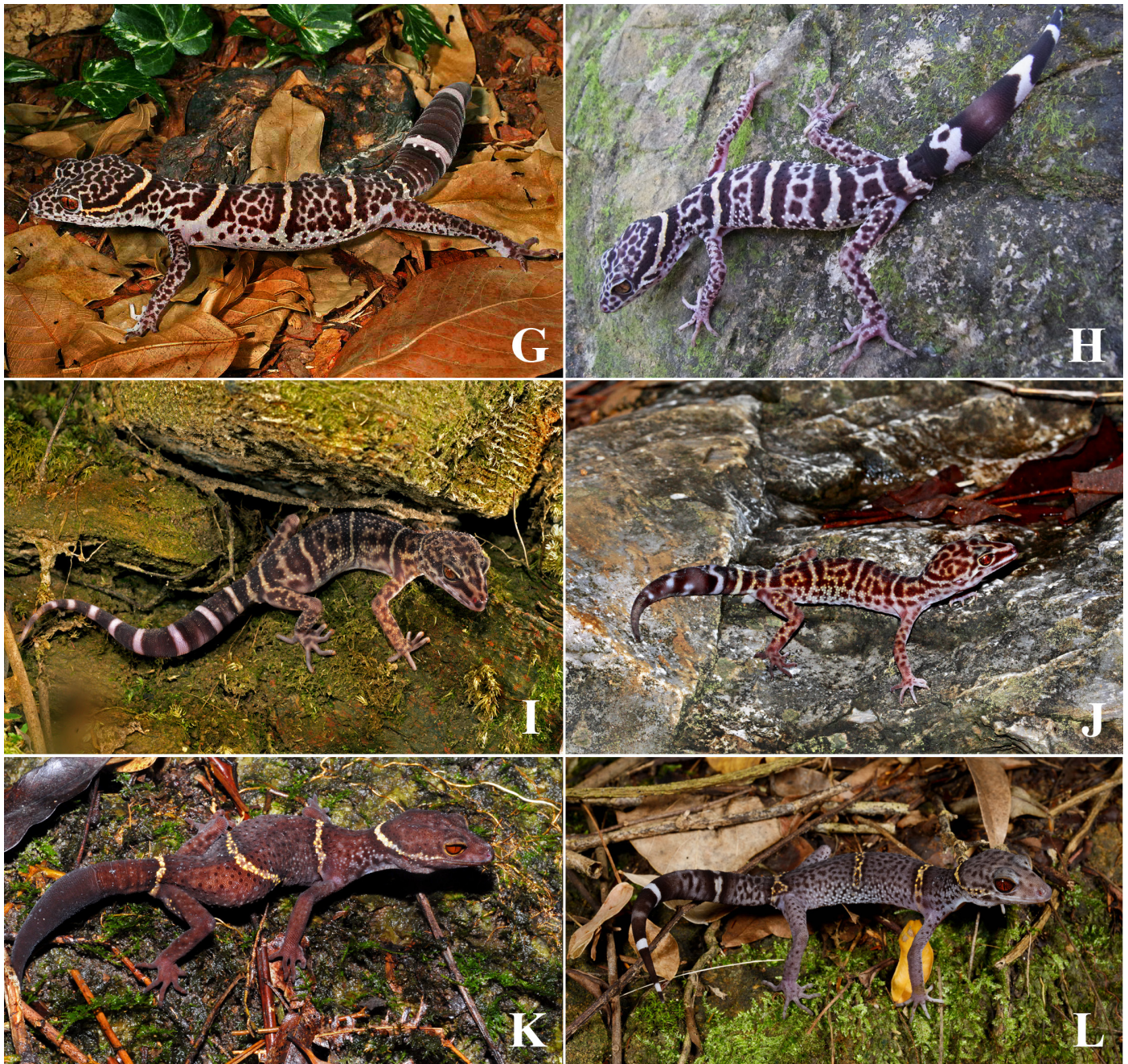


Fig. 8 (cont.). Known species of *Goniurosaurus* from Vietnam and China in groups of >3 and 3 body bands between forelimb insertion and caudal constriction. **G–H.** *G. luii* from Pingxiang Co. (type locality) and Nonggang, Guangxi Province, China; **I.** *G. yingdeensis* from Yingde Co. (type locality), Guangdong Province, China; **J.** *Goniurosaurus* indet., Qingxin Co., Guangdong Province, China; **K.** *G. lichtenfelderi* from Yen Tu Nature Reserve, Quang Ninh Province, Vietnam; **L.** *G. bainanensis* from Diaoluo Mountain, Hainan, China. Photographs by Tian-Bo Chen (A, H), Sheng Zheng (F, I, L), Nikolai L. Orlov (E, G, K), Hai-Tao Shi (C), and Mian Hou (B, J).

the forelimb insertion and the caudal constriction, not five as described by Wang et al. (2010, 2013).

Goniurosaurus indet. (Fig. 8J) has narrower, dull yellow, immaculate body bands, many more large dark blotches on the body, fewer preanal pores (12), lower counts of 2–4 postmentals, 106–107 scales around midbody, 50–55 eyelid fringe scales, and 17–21 subdigital lamellae under the fourth toe, and juveniles have bright orange body color and yellow

body bands (Yi et al. 2010). A re-examination of specimens indicated that this species has a row of enlarged supraorbital tubercles on each side and upper eyelid scales that are one-half the size of those on the calvaria; the number of caudal bands remains unknown.

Discussion

The karst area between Vietnam and Guangxi is relatively homogeneous (Ziegler et al. 2008); not only is it continuous

but more karst species previously recorded only from northern Vietnam have been discovered in Guangxi. Currently, five species have been recorded from the karst tropical rainforest between northern Vietnam and Guangxi: *G. catbaensis* and *G. huuliensis* are recorded only from Vietnam and *G. lichtenfelderi*, *G. luyi*, and herein *G. araneus* occur in both countries. High species diversity within a small area is common in *Goniurosaurus*, and is clearly evident, for example, in the Ryukyu Archipelago.

Of particular interest is the apparent habitat partitioning between species pairs that are closely related both geographically and phylogenetically, such as *G. araneus* and *G. luyi* in southern Guangxi (Grismer et al. 1999, Kratochvil and Frynta 2002, Jonniaux and Kumazawa 2008) or *G. yingdeensis* and *Goniurosaurus* indet. from northwestern Guangdong (Zhang et al. 2014). Both pairs are separated only by a river. Seawater or rivers seem to be effective isolating barriers for geographically close populations and appear to have facilitated speciation in these Leopard Geckos. Additional cryptic species of *Goniurosaurus* may exist in the massive karst areas of China, particularly those farther upland that were unlikely to have been affected by historical rises and falls of sea levels. The report of *G. lichtenfelderi* by Wen (1983) from southern Guangxi likely represents such a cryptic species, the isolation of which probably resulted from habitat partitioning.

Although Lang Son Province in Vietnam (the location of the type locality of *G. huuliensis*) shares a common border with Guangxi, the rivers of that region do not drain into Guangxi. However, the lowland coastal area could have been contiguous into Guangxi at the foothills of Shiwandashan (which means one hundred thousand big mountains) at glacial maxima (Fig. 1). Therefore, we expect to find *G. huuliensis* or close relatives from neighboring Guangxi. In a similar scenario, we suspect that *G. lichtenfelderi* and *G. hainanensis* (both with three body bands between the forelimb insertion and caudal constriction) or *G. catbaensis* and *G. huuliensis* (4–5 body bands between the forelimb insertion and caudal constriction) are forms stranded on islands not long ago and represent closely related pairs.

The type locality of *G. araneus* is 40 km southeast of the capital of the Cao Bang Province in Vietnam (Fig. 1), which shares a common border with Guangxi Province. Nonggang NNR is on this border and thus the discovery of *G. araneus* there is not surprising. Since the species' original description (Grismer et al. 1999), no precise locality data for *G. araneus* have been published; all are listed vaguely as from Cao Bang Province, perhaps with the intent of protecting the species. The known distribution of *G. araneus* is so far limited to a small area between the Nonggang and Cao Bang border and appears to be limited to the upper tributaries that drain into the Zuojiang River (Fig. 1). We caution that the type locality of *G. araneus* might not be accurate. Subsequent efforts at

that site (Orlov et al. 2008, Ziegler et al. 2008, Nguyen et al. 2009) failed to find the species, and pet market collectors tend to misstate collecting sites.

Our confirmation of the previous record of *G. luyi* in Nonggang not only connects the holotypic and the northern Vietnamese populations (Fig. 1), but also supports previous evidence that *G. araneus* and *G. luyi* are closely related species. However, the new records have muddied the water regarding the distribution of *G. luyi*. Localities of the Nonggang (Yang et al. 2011) and northern Vietnamese (Thanh et al. 2006) populations are more or less within a drainage system where tributaries eventually drain into the Zuojiang River running approximately from northwest to southeast from Vietnam to Nonggang. *Goniurosaurus luyi* and *G. araneus* are not sympatric, their ranges clearly separated by the Zuojiang River. Some paratypes of *G. luyi* were from Longzhou (Grismer et al. 1999), which is also within the Nonggang NNR and in the same drainage system (these also are marked in Fig. 1). However, the holotypic locality of *G. luyi* in Pingxiang County is in a separate drainage system. These two drainages do not meet, suggesting that the holotype was actually collected in neighboring Longzhou County instead of Pingxiang County. No one has found *G. luyi* in Pingxiang since the species was described, although its absence there is attributed to zealous pet trade collectors (Stuart et al. 2006). The type specimens were collected for the pet trade, and localities are frequently misidentified to augment prices because customers often imagine that each locality would be represented by a different species. We cannot rule out, however, that these two drainage systems are connected underground through the porous limestone system.

Leopard Geckos are extremely popular pets. Based on our observations in China, *G. araneus* and *G. luyi* have been illegally collected and extensively smuggled for some time since the original species description was published. Although only *G. kuroiwae* from Japan has been formally assessed as Endangered on the IUCN Red List (Ota 2010), essentially all known species of *Goniurosaurus* are threatened with extinction, largely due to overcollection for the international trade in live animals. Consequently, official and international efforts to protect habitat, prohibit illegal collection, and monitor the pet trade are essential.

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