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Lectotype designation of *Plestiodon elegans* (Reptilia: Squamata: Scincidae) and the description of a new species of the *Plestiodon elegans* complex from northwestern Yunnan Province, China

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ABSTRACT

The Elegant Skink, *Plestiodon elegans*, was described based on syntype specimens from southeastern China, and it is recorded as widely distributed, expanding across multiple zoogeographic regions. Although previously identified populations have been shown to represent misidentifications of other congeners, many questionable populations remain unexamined, including the ones from Yunnan Province. To clarify the taxonomic status of the Yunnan populations, we designate a lectotype of *Plestiodon elegans* and revise the diagnosis of the species based on its type series. Mitochondrial genealogies recover the population of "*P. elegans*" from northwest Yunnan as paraphyletic to the true *P. elegans*, displaying over 11% of divergences based on the *COI* gene. Morphologically, the population from northwest Yunnan can be diagnosed from *P. elegans* and closely aligned congeners by the absence of enlarged scales posterolateral of cloaca, having a different number of postmental, paravertebral, and midbody scale rows, and a distinct body coloration in adults. Therefore, we describe the northwest Yunnan population as a new species. We discussed the validity of two other members of the *P. elegans* complex, namely *Plestiodon liui* and *Plestiodon popei*, synonymized *P. popei* with *P. elegans*, and updated the diagnostic key to all members of the genus *Plestiodon* in China.

Keywords: Blue-tailed skink; Cryptic species; Synonym; Taxonomy; Yangtze River

Introduction

Skinks of the genus *Plestiodon* comprise of a large radiation of lizards that expand across both North America and Asia (García-Vázquez et al., 2021; Kurita et al., 2017; Okamoto & Hikida, 2012). In China, a total of 10 species have been recorded, including *Plestiodon capito*, *Plestiodon chinensis*, *Plestiodon elegans*, *Plestiodon leucostictus*, *Plestiodon liui*, *Plestiodon popei*, *Plestiodon quadrilineatus*, *Plestiodon tunganus*, *Plestiodon tamdaoensis*, and *Plestiodon takarai* (Wang et al., 2020). Of these species in China, *P. elegans* has the widest distribution, which includes 19 provinces across northern, central, southern, and southwestern China (Zhao & Adler, 1993; Zhao et al., 1999). Several studies have shown that many of the recorded populations of *P. elegans* in northern, central, and even southeastern China represent misidentifications of congeners (Cai et al., 2019; Hikida, 1989; Hikida & Zhao, 1989; Zhang et al., 2022). Despite the ongoing taxonomic changes of the species complex, the true *P. elegans* is still known from a collection of syntypes without detailed morphological data or clear photos. As such, it

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remains difficult to assess the taxonomic status of the remaining questionable populations of *P. elegans* across its range, particularly those that are zoogeographically distinct from the core range of the species.

During the field surveys of northwest Yunnan Province in 2024, we collected a series of specimens that resembles the *P. elegans* superficially, including having five dorsolateral stripes, heterogeneous scales on posterolateral thighs, and blue tails. Through examination of the type series of *P. elegans* in the Natural History Museum in London, we confirm that our newly collected population of *Plestiodon* from northwestern Yunnan is distinct from true *P. elegans* and represents a distinct new species that warrants formal description. To help promote future taxonomic revisions of the *P. elegans* complex, we further designate a lectotype of *Eumeceus elegans* and revised its morphological diagnosis based on the examination of type series. Additionally, we discuss the validity of *P. popei* with respect to *P. elegans*, synonymize the former as a junior synonym of the latter species, and provide an updated diagnostic key to all species of the genus *Plestiodon* in China.

MATERIALS AND METHODS

Sampling

A total of 13 individuals of the genus *Plestiodon* were collected from Lijiang, western Yunnan Province, China. Following euthanasia through overdose injection of MS222, liver tissues were taken from each individual and preserved in 95% ethanol, and all specimens were then fixed in 10% formalin solution and transferred to 75% ethanol after returning from the field. All newly collected specimens were deposited in the Kunming Natural History Museum of Zoology in Kunming Institute of Zoology, Chinese Academy of Sciences (KIZ). Additionally, voucher specimens of recognized congeners were examined (Appendix I) in KIZ, the Natural History Museum (NHMUK), California Academy of Sciences (CAS), and the National Museum of Natural History, Smithsonian Institution (USNM). Morphological data of additional congeners were obtained from literature (Cai et al., 2019; Hikida, 1989; Hikida & Zhao, 1989; Hikida et al., 2001; Kurita et al., 2017; Taylor, 1935; Zhao et al., 1999).

Morphological data and analyses

Morphometric data were measured using a digital caliper to the nearest 0.1 mm. The following morphometric characters were measured: snout–vent length (SVL), from tip of snout to the cloaca; tail length (TAL), measured from the tip of tail to the cloaca; head length to parietal (HLP), from the tip of snout to the posterior tip of parietal scale; head length to jaw (HLJ), from the tip of snout to the axis of jaw; head width (HW), measured at the axis of jaw; head depth (HD), measured perpendicularly at the axis of jaw; internasal distance (IN), measured as the shortest distance between nares; snout–tympanum distance (STD), measured between the tip of snout to the anterior edge of tympanum; snout–eye length (SEL), measured from the tip of snout to the anterior corner of eye; eye–nare distance (END), measured from the nare to the anterior corner of the eye; snout–limb distance (SnL), from the tip of snout to the base of forelimb at the insertion point when forelimb held at the right angle; tympanum diameter (TD), measured as the diameter perpendicularly; eye diameter (ED), diameter of eye measured horizontally; tympanum–eye distance (TED), measured as the shortest distance between the posterior corner of eye to the superoanterior edge of tympanum; interorbital distance at anterior corners of eyes (IODA), measured dorsally between the anterior corners of eyes; interorbital distance at posterior corners of eyes (IODP), measured dorsally between the posterior corners of eyes; trunk length (TRL), measured between the axillary and the groin; midbody width (MBW), measured at the mid-point of SVL; axillary width (AW), measured dorsally at the axillary; pelvis width (PW), measured dorsally at the pelvis; brachium length (BL), measured between the forelimb insertion point at the axillary to the outermost point of the elbow when forearm held at the right angle; forearm and hand length (FHL), measured between the tip of finger IV and elbow when forearm held at the right angle; femur length (FL), measured from the hindlimb insertion point at the groin to the knee joint; and tibia and foot length (TFL), measured from the knee joint to the tip of toe IV when foot is straighten.

Additionally, pholidosis characters and their counting method followed Grismer et al. (2019) and included: supralabials (SL), infralabials (IL), chin shields (CHN), postmental (PM), enlarged nuchal scales (EnLN), supraocular (SupraO), postocular (PostO), postsubocular (PostSubO), postnasal (PostN), temporals (TEM), midbody scale rows around body (MB), paravertebral scale row (PV), ventral scale rows (VS), subdigital lamellae under finger IV (F4S), and subdigital lamellae under toe IV (T4S).

Morphometric measurements were subject to principal component analyses (PCA) using the online statistical platform SRplot (http://www.bioinformatics.com.cn/en; Tang et al., 2023). Furthermore, differential pholidosis characters such as the PVSR and VN were visualized using Violin plot on SRplot as well and subject to Wilcoxon Rank-Sum Test for statistical significance. Description of coloration was standardized following the terms and codes in Köhler (2012).

Molecular analyses

Total genomic DNA was extracted from tissue samples stored in 95% ethanol. Tissue sample was digested using proteinaseK, and subsequently purified using standard phenol-chloroform protocols. A single mitochondrial gene (cytochrome c oxidase subunit 1 [*COI*]) was amplified and sequenced using the published primers and PCR protocols (Che et al., 2012). PCR products were isolated through 1% agarose gel electrophoresis and further purified using Millipore Microcon Kits. Purified PCR products were then sent off for sequencing by the South China Barcoding Center. Homologous sequences of congeners and closely related outgroups were downloaded from GenBank (Table 1). In addition to the newly sequenced *COI* gene, NADH dehydrogenase subunit 1 (*ND1*), which was also commonly used in skink taxonomy, was downloaded for congeners from GenBank.

Phylogenetic analysis was inferred based on both *COI* and *ND1* genes, using both Maximum Likelihood (ML) and Bayesian inference (BI) methods. All genes were aligned by MEGA 11 (Tamura et al., 2021) and then concatenated. Maximum Likelihood analyses were conducted on the IQ-Tree online server (Trifinopoulos et al., 2016), with auto-selected substitution model, 1000 iterations of Ultrafast bootstrap and SH-aLRT branch tests. Bayesian inference was conducted using Mr Bayes v.3.2.7a on CIPRES (Miller et al., 2010), with best substitution model selected using ModelFinder (HKY+I

Table 1 Genbank information for samples used in present study

Species	Locality	COI	ND1
Plestiodon jinjiang **sp. nov.**	Lijiang, Yunnan, China	**PX776071**	**–**
Plestiodon jinjiang **sp. nov.**	Lijiang, Yunnan, China	**PX776070**	**–**
Plestiodon jinjiang **sp. nov.**	Lijiang, Yunnan, China	**PX776072**	**–**
Plestiodon anthracinus	–	KU985925	HM160787
Plestiodon barbouri	Okinawa, Japan	–	HM160788
Plestiodon brevirostris	–	–	MH899842
Plestiodon capito	Nanjiang, Sichuan, China	MK370740	MK370740
Plestiodon cf. elegans	Vietnam	OM420382	–
Plestiodon elegans	Dehua County, Fujian, China	–	HM160812
Plestiodon chinensis	Lishui, Zhejiang, China	KT279358	KT279358
Plestiodon egregius	–	AB016606	HM160809
Plestiodon elegans	Penghu, Taiwan, China		LC150801
Plestiodon elegans	Zhejiang, China	KJ643142	KJ643142
Plestiodon elegans	Zhejiang, China	NC024576	NC024576
Plestiodon fasciatus	Douglas, Kansas, USA	KU985881	HM160813
Plestiodon finitimus	Gifu Prefecture, Japan	JN089940	–
Plestiodon gilberti	–	KU986032	HM160815
Plestiodon japonicus	Nagasaki, Japan	JN089954	HM160820
Plestiodon kuchingoshimensis	Kuchinoshima Island, Japan	–	LC147649
Plestiodon lagunensis	–	–	HM160823
Plestiodon latiscutatus	Miyakejima, Japan	JN089946	HM160826
Plestiodon liui1	Henan, China	MK837970	MT662111
Plestiodon liui2	Henan, China	MK837971	–
Plestiodon liui3	Henan, China	MK837972	–
Plestiodon marginatus	–	–	HM160831
Plestiodon multivirgatus	Nebraska, USA	MH274566	HM160836
Plestiodon obsoletus	Arizona, USA	KU986246	HM160837
Plestiodon oshimensis	Kikaijima, Japan	–	LC147651
Plestiodon quadrilineatus	Hong Kong, China	–	HM160843
Plestiodon reynoldsi	–		HM160845
Plestiodon skiltonianus	–	KU985937	HM160849
Plestiodon stimpsonii	Haterumajima, Japan	–	LC147645
Plestiodon tamdaoensis	Hia Duong, Veitnam	–	LC147652
Plestiodon tetragrammus	Texas, USA	MH274567	HM160855
Plestiodon tunganus	Sichuan, China	MK370739	MK370739
Scincella huanrenensis	Gangwon-do, South Korea	KU507306	KU507306
Sphenomorphus indicus	Tanintharyi, Myanmar	MT608593	NC045408

Newly generated sequences are in bold. "–" indicates missing data.

for *COI*, GTR+I for *ND1*). Two independent Markov Chain Monte Carlo analyses were run, each with four Metropolis-coupled chains, a melting temperature of 0.02, and an exponential distribution with a rate parameter of 25 as the prior on branch lengths. Each run was conducted with 10 million generations and sampled every 1 000 generations, discarding the first 25% of trees as burn-in. Convergence of runs was confirmed with TRACER v.1.7.0 (visual convergence and effective sampling size>200; Rambaut et al., 2018). The uncorrected genetic distance among individuals was calculated using MEGA 11 (Tamura et al., 2021) for each of the two mitochondrial genes used.

RESULTS

The genus *Plestiodon* is recovered as monophyletic (Bayesian posterior probability 1.00/Ultrafast bootstrap 100/SH-aLRT branch test 100, give as such order herein). Although relationships among major groups of the genus remain unresolved, the *P. elegans* as currently recognized is paraphyletic: the populations from Taiwan, Zhejiang, and Fujian Provinces form a well-supported monophyletic group (1.00/99.7/100), which is embedded in the clade containing *Plestiodon kuchinoshimensis, Plestiodon stimpsonii*, *Plestiodon oshimensis*, and *Plestiodon marginatus* with strong supports (1.00/99.1/99), whereas the population from Yunnan forms a clade with *P. tunganus*, *P. capito*, and *P. liui* (0.8/99.4/1.00). Additionally, the sample identified as *P.* cf. *elegans* from Ninh Binh Province, Vietnam (GenBank asscession no. OM 420382, voucher No. USNM 595475) is also paraphyletic with respect to the remaining populations of *P. elegans* (Figure 1).

In addition to the mitochondrial genealogy, the putative new species also showed considerable genetic distance from all recognized congeners from China and nearby countries, ranging from 11.2%–18.2% for the 704bp of *COI* gene (Table 2).

Morphometrically, the population from northwest Yunnan

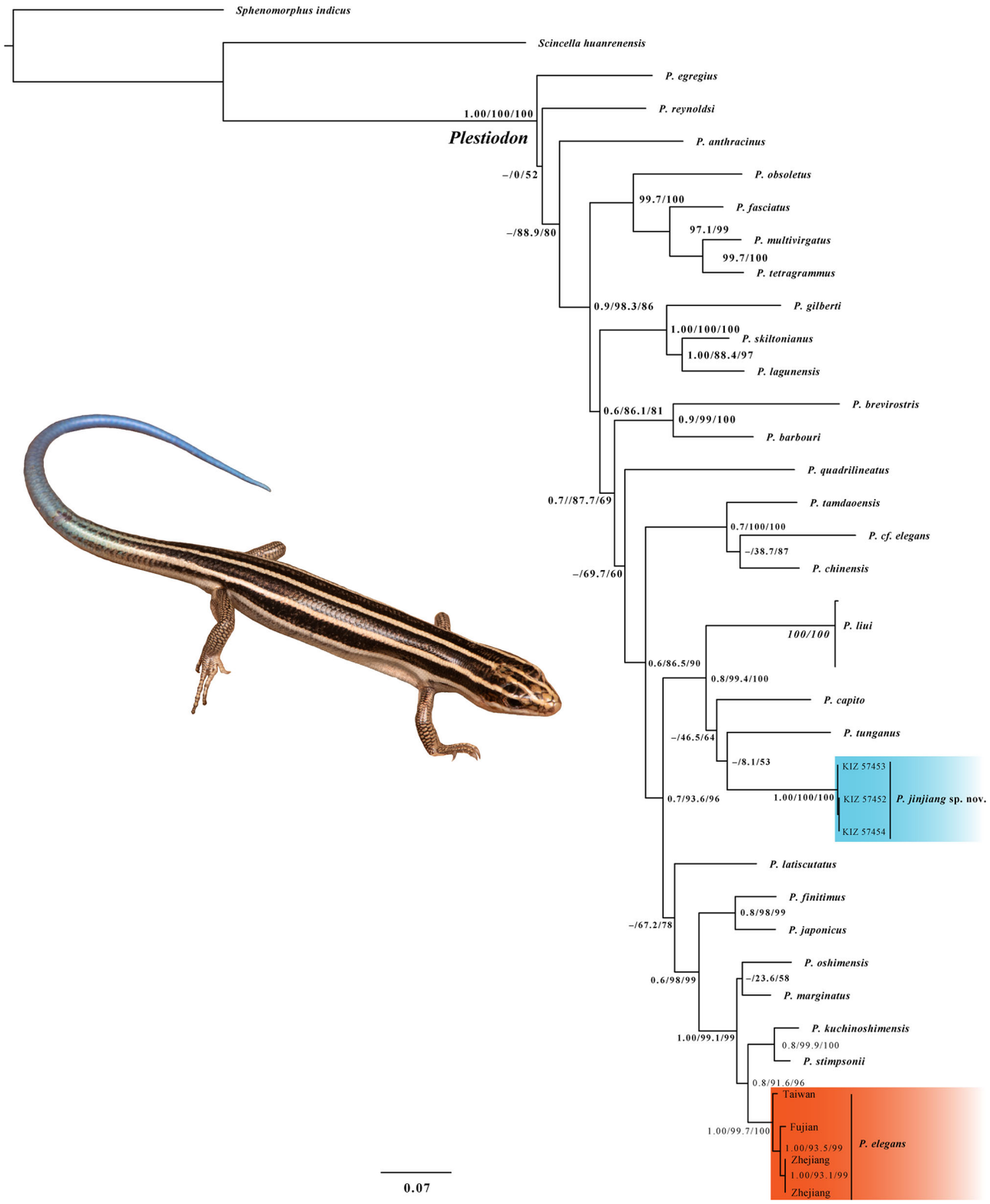

Figure 1 Mitochondrial genealogy of the genus *Plestiodon* inferred from a total of 2 080 bp of concatenated dataset of *COI* and *ND1* genes

Posterior probability of each node from Bayesian analyses was mapped onto the topology of Maximum Likelihood Analyses.

show a clear separation from the true *P. elegans* in morphospace, despite a small degree of overlap (Figure 2). PC1 explains 73.2% of the total morphological variation, which loads most heavily on head length to parietal (HLP) and snout–tympanum distance (STD); and PC2 explains 6.4% of the total variation, which loads most heavily on trunk length (TRL) and pelvis width (PW). Additionally, when considering pholidosis characters, the population from northwest Yunnan shows statistically significant differences on several pholidosis characters, including the number of paravertebral scale rows (61–71 for Yunnan population vs. 51–57 for *P. elegans*, $P<0.01$), ventral scale count (64–73 vs. 57–64, $P<0.01$), and postmental scale count (2, rarely 1 vs. always 1, $P<0.01$; Figure 2). For the population from northeast Yunnan and nearby Sichuan Province, however, its morphological characters align closely with the true *P. elegans* (Table 3).

Table 2 Uncorrected genetic distance among closely related species of the genus *Plestiodon* using 704 bp of *COI* gene

	Plestiodon cf *elegans*	*Plestiodon chinensis*	*Plestiodon tunganus*	*P. jinjiang* **sp. nov.** (KIZ 57453)	*P. jinjiang* **sp. nov.** (KIZ 57452)	*P. jinjiang* **sp. nov.** (KIZ 57454)	*Plestiodon capito*	*Plestiodon egregius*	*Plestiodon liui*	*Plestiodon liui*	*Plestiodon liui*	*Plestiodon elegans* (Zhejiang)	*Plestiodon elegans* (Zhejiang)	*Plestiodon japonicus*
Plestiodon cf. *elegans*														
Plestiodon chinensis	11.4%													
Plestiodon tunganus	17.9%	17.5%												
P. jinjiang **sp. nov.** (KIZ 57453)	18.7%	17.2%	13.9%											
P. jinjiang **sp. nov.** (KIZ 57452)	18.6%	17.4%	13.2%	0.2%										
P. jinjiang **sp. nov.** (KIZ 57454)	18.9%	17.4%	14.0%	0.2%	0.0%									
Plestiodon capito	17.2%	16.1%	12.0%	11.9%	11.7%	12.0%								
Plestiodon egregius	17.5%	16.3%	16.9%	18.0%	18.2%	18.0%	17.5%							
Plestiodon liui	18.1%	17.6%	14.1%	13.5%	13.4%	13.7%	14.3%	17.2%						
Plestiodon liui	17.8%	17.5%	13.8%	13.5%	13.2%	13.7%	14.0%	17.5%	0.3%					
Plestiodon liui	17.8%	17.5%	13.8%	13.5%	13.2%	13.7%	14.0%	17.5%	0.3%	0.0%				
Plestiodon elegans (Zhejiang)	17.2%	14.6%	16.9%	16.6%	16.2%	16.7%	14.9%	17.5%	17.5%	17.5%	17.5%			
Plestiodon elegans (Zhejiang)	17.2%	14.6%	16.9%	16.6%	16.2%	16.7%	14.9%	17.5%	17.5%	17.5%	17.5%	0.0%		
Plestiodon japonicus	16.4%	15.2%	14.6%	14.9%	15.2%	15.1%	14.4%	16.0%	15.2%	15.2%	15.2%	12.8%	12.8%	

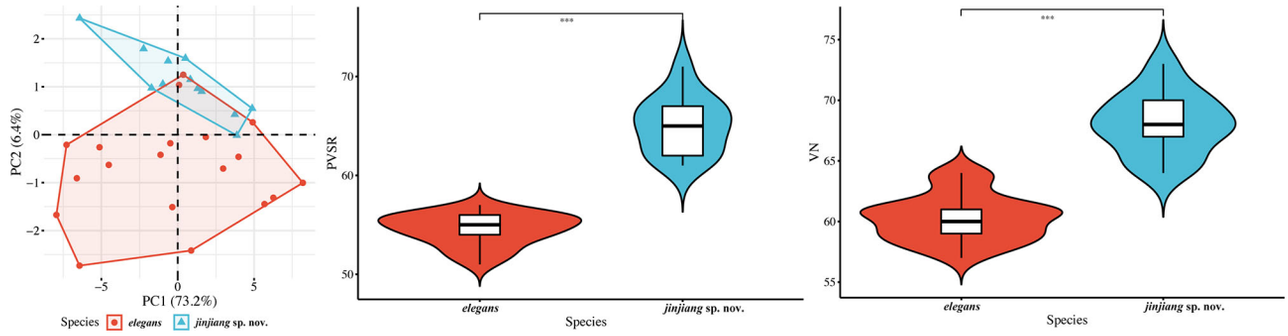

Figure 2 Principle Component Analysis (PCA) and violin plots of morphological data for *Plestiodon jinjiang* sp. nov. and *Plestiodon elegans*

PCA was based on 25 morphometric characters, where the violin plots were based on two pholidosis characters (paravertebral scale rows and ventral scale counts). Asterisk (*) indicates statistically significant differences between groups, with *** indicates a *P* value less than 0.001.

Table 3 Morphological comparison between the type series of *Plestiodon elegans*, the population of *Plestiodon elegans* from northeast Yunnan and Sichuan, and the new species *Plestiodon jinjiang* sp. nov. from northwest Yunnan

	Plestiodon jinjiang **sp. nov.**	*Plestiodon elegans*		*Plestiodon popei*	*Plestiodon liui*	*Plestiodon capito*	*Plestiodon tunganus*
		Type series	Northeast Yunnan and Sichuan population				
Data source	Present study	Present study	Present study	Literature	Present study	Present study	Literature
Sample size	13	9	3	4	1	5	23
SVL (mm)	59.7–86.6	59.61–80.92	45.5–58.1	22.1–26.8	42.6	57.0–66.7	59.0–78.0
TAL/SVL	122.0–161.4%	155.0–179.7%	146.5–174.7%	134.4–154.2%	159.60%	141–182.4%	133.0–168.1%
Nuchal (pair)	1 or 2 (mostly 2)	1	1	2	2	2	1
Postmental	1 or 2 (mostly 2)	1	1	1	1	1 or 2 (mostly 2)	2
Paravertebral	61–71	52–56	56–57	52–54	53	54–57	58–68
Dorsal scale around midbody	26–28	26–28	26 or 27	24	24	22–24	24–28
Ventral	64–73	58–64	58–61	–	54	54–60	–
Posteroinferior temporal	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Paralleogram shaped
Enlarged, keeled scale posterolateral of cloaca	Absent	Present	Present	Absent	Absent	Absent	Absent
Dorsolateral lines on dorsum in adult males	Distinct	Faint or absent	Faint or absent	Unknown	Unknown	Distinct	Absent

Our integrative evidence shows that the population of "*P. elegans*" from northwest Yunnan is not only paraphyletic relative to the true *P. elegans* and possesses considerable mitochondrial genetic divergences from all recognized congeners, but it also displays a suit of diagnostic morphological characters that can diagnose it from recognized species. Therefore, we describe it as a new species. Additionally, we designate specimen NHMUK 1986.12.8.3 as the lectotype of *P. elegans*. This act will allow future revisions to objectively delineate this taxon relative to the new species described here, and other populations of *P. elegans* which might be recognized as separate taxa in the future. All other syntypes mentioned by Boulenger (1887) become paralectotypes.

Taxonomic Account

Plestiodon elegans (Boulenger, 1887) (Figure 3)

Lectotype: NHMUK 1986.12.8.3 (designated herein), adult female from Snowy Valley, Ningpo (=Ningbo), Zhejiang Province, China. Purchased by J. H. Leech from locals.

Examined paralectotypes: NHMUK 1986.12.8.2, adult male, 1986.12.8.4, adult female, 1986.12.8.5, juvenile, share the same collection information as the lectotype; 1954.3.10.1 and 1954.3.10.2, adult males, 1954.10.3, adult female, 1954.10.4, juvenile, all from Ningpo (=Ningbo), Zhejiang Province, China, purchased by H. Cuming; 1980.2.17.6, adult male, from Kiukiang Mts, Jiangxi Province. China, collected by C. Maries; 1974.1.16.72, adult male from Shanghai, collected by R. Swinhoe; 1959.12.20.5, adult female, 1956.12.20.6, from Formosa (=Taiwan), China, collected by R. Swinhoe.

Revised diagnosis: *Plestiodon elegans* can be diagnosed from congeners by a combination of the following characteristics: (1) small sized, SVL 59.6–81.4mm in adults; (2) tail slender, long, TAL 148.6–179.7% SVL; (3) nuchals single pair; (4) postmental single; (5) vertebral scales not much wider than neighboring dorsals; (6) scales on posterolateral thighs distinctively heterogeneous in size and arrangement; (7) posterosuperior temporal triangular shaped, posteroinferior one narrow, parallelogram-shaped; (8) single enlarged, keeled scales posterolateral of cloaca on each side; (9) scale rows around midbody 26–28; (10) paravertebral dorsal scale count 52–57; (11) ventral scale count 58–64; (12) subdigital lamellae under finger IV 11–14, under toe IV 17–20; (13) five light dorsolateral stripes present in juveniles and adult females only, absent or faded in adult males; (14) entire tail of juveniles blue, such color retaining in adult females but fading away in adult males.

Plestiodon jinjiang **sp. nov.** Wang, Xu, Lee, Lu, Che

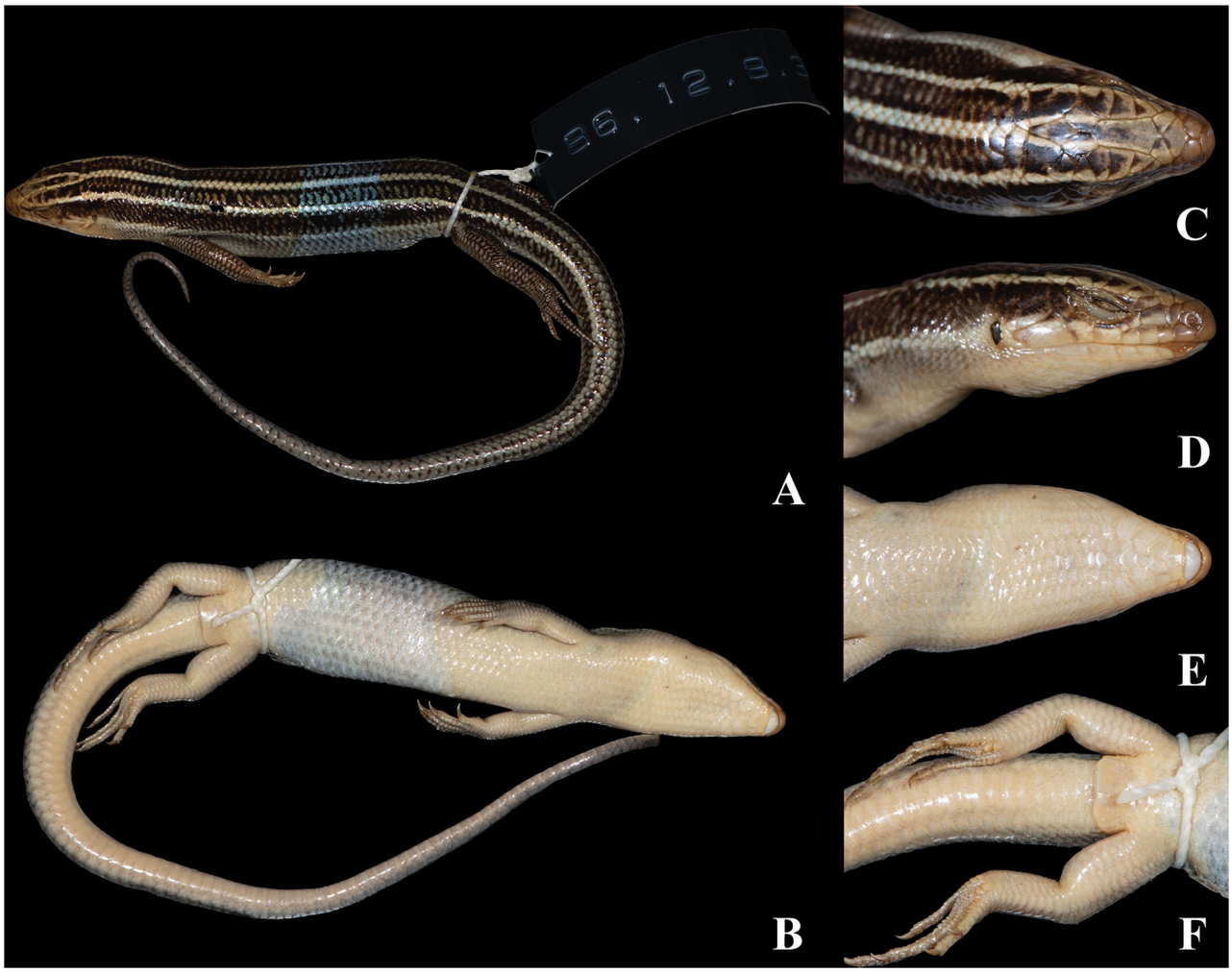

Figure 3 Lectotype of *Plestiodon elegans* (NHMUK 1986.12.8.3)
Dorsolateral overview (A), ventral overview (B), dorsal head (C), lateral head (D), ventral head (E), and cloaca close-up (F). Photos by K.W.

(Figures 4, 5). urn:lsid:zoobank.org:pub:23B16BA8-4633-4353-9C57-3AEC212F6D1D

Holotype: KIZ 57453, adult male, from Jinsha River Valley near Daju Village, Lijiang, Yunnan Province, China (E100.20191º, N27.29122º, elevation 1899 m a.s.l., GCJ02). Collected by Kai Wang, Zhuo-Yu Lu, Xian-Kun Huang, and Xiang-Jin Liu on 21 May, 2024.

Paratypes: KIZ 57454, adult female sharing the same collecting information as the holotype. KIZ 58484–58486, 58492–58494, adult males; KIZ 58483, 58487–58490, adult females, all from the same locality as the holotype, collected by Xiang-Jin Liu on 20 July 2024.

Etymology: The species name, *jinjiang*, is derived from the pronunciation of the Chinese word, 金江, which is the abbreviated Chinese name of the upper Yangtze River and it means “golden-river”. We name the new species using this Chinese name to describe its distribution along the upper Jinsha River in Yunnan and possibly Sichuan Province. This epithet is treated as a noun in apposition.

Diagnosis: The new species can be diagnosed from congeners by a combination of the following characteristics: (1) small sized, SVL 59.7–86.6mm in adults; (2) nuchals mostly two pairs, rarely single or three pairs; (3) postmental mostly two, rarely single; (4) vertebral scales not much wider than neighboring dorsals; (5) scales on posterolateral thighs distinctively heterogeneous in size and arrangement; (6) posterior temporals both triangular shaped; (7) no enlarged, keeled scales posterolateral of cloaca; (8) scale rows around midbody 26–28; (9) paravertebral dorsal scale count 61–71; (10) ventral scale count 64–73; (11) adults blackish brown dorsally, with five offwhite colored dorsolateral stripes; (12) entire tail of juveniles blue, such color retaining in adult males but fading away in adult females.

Comparisons: *Plestiodon jinjiang* **sp. nov.** is most similar to *P. tunganus*, in which both species have two postmental scales and high numbers of scale rows around midbody. However, *P. jinjiang* **sp. nov.** can be diagnosed from *P. tunganus* by having differential shape of the posteroinferior temporal scale (triangular shaped vs. parallelogram shaped).

For species in the same clade, *P. jinjiang* **sp. nov.** differ from *Plestiodon capito* by the absence of keeled, enlarged scales posterolateral of cloaca (vs. presence), more scale rows at mid body (26–28 vs. 22–25), and more paravertebral scale rows (61–71 vs. 50–54); and from *Plestiodon liui* by having more postmental scales (mostly two, rarely one vs. always one), more scale rows at midbody (26–28 vs. 24), and more paravertebral scale rows (61–71 vs. 52–58).

For remaining congeners from southern China and nearby Vietnam, *P. jinjiang* **sp. nov.** differs from *P. elegans* by having more postmental scales (mostly 2, rarely 1 vs. always 1), more nuchal scales (mostly two pairs, rarely single or three vs. always single pair), the absence of keeled, enlarged scales

Figure 4 Holotype male of *Plestiodon jinjiang* sp. nov. (KIZ 57453) in life

Dorsolateral overview (A), lateral head (B), dorsal head (C), dorsal body close-up (D), ventral overview (E), and postlateral thigh (F). Photos by K.W.

Figure 5 Paratype female of *Plestiodon jinjiang* sp. nov. (KIZ 57454) in life

Dorsolateral overview (A), lateral head (B), dorsal head (C), dorsal body close-up (D), ventral overview (E), and postlateral thigh (F). Photos by K.W.

posterolateral of cloaca (vs. presence), and by differential adult coloration in adult males (dark brown or brownish black with distinct five offwhite dorsolateral stripes vs. reddish brown without clear stripes on lateral body); from *P. popei* and *P. liui* by having higher scale rows at midbody (26–28 vs. 24); from *P. quadrilineatus* by having five light-colored stripes on the body (vs. four); from *P. chinensis* by having enlarged, irregularly arranged scales on posterolateral thigh (vs. absence) and a distinct dorsal coloration in adults (distinctively striped with five offwhite dorsolateral stripes vs. not striped); and from *P. tamdaoensis* by having enlarged, irregularly arranged scales on posterolateral thigh (vs. absence), more scale rows at midbody (26–28 vs. 22–24), and more paravertebral scale rows (61–71 vs. 39–46).

Description of holotype: Adult male, SVL 62.3 mm, body slender; trunk cross-section circular, TRL 51.0% SVL, MBW 15.9% SVL; head triangular, longer than width, HW 77.1% HLP, wider than depth, HD 76.7% HW; IN 41.9% IODA, IODA 83.6% IODP; limbs moderately developed, FLL 29.5% SVL, HLL 42.0% SVL, fingers and toes overlapping when adpressed toward each other; fingers and toes slender, forth finger and toe longest, respectively, claws well developed; tail original, full grown, slender, near circular in cross section, TAL 161.4% SVL.

All scales smooth. Rostral pentagonal, large, visible from above; nasal elongated, divided vertically, mostly occupied by nares, much smaller than supranasal; supranasal divided, bordering each other narrowly; postnasal single, small, one third of nasal, enclosed by posterior nasal, frontonasal, anterior loreal, and first and second supralabials; supralabials 7/7, posterior-most three taller than others, last one largest, fifth inferior to eye and entering orbit; loreal two, anterior one

superior to second supralabial, posterior one twice bigger than anterior one, superior to third supralabial; preocular single, small; presuboculars two, larger than preocular, situated between fourth and fifth supralabials; postsuboculars five, smaller than presuboculars; primary temporal somewhat rhomboid shaped; secondary temporals two, both triangular shaped, superior one larger, separated from tympanum by two small scales; tympanum deeply sunk, vertically oriented, narrow laterally, TD 58.6% ED, STL 108.3% HLP. Frontonasal spear-shaped pointing posteriorly, subequal to prefrontals, bordering anterior loreal laterally; prefrontals paired, pentagonal, not in contact medially, bordering posterior loreal inferiorly, anterior-most supraciliary and supraocular posterolaterally; supraciliaries 7/7, anteriormost scale largest, reducing size posteriorly; supraoculars 4/4, second from anterior largest, first two (left) or three (right) contacting frontal; frontal elongated spear shaped, pointing anteriorly, bordering frontoparietals posteriorly; frontopairetals rectangular; interparietal elongated, spear-shaped, enclosed by parietals and nuchals laterally and posteriorly; parietals triangular shaped, largest among all dorsal head scales; nuchals two pairs, anterior pair largest, twice deep as posterior pair.

Dorsals imbricate, homogeneous, larger than ventrals, vertebral scales not distinctively widened; paravertebral scale count 62; scale rows around midbody 65; transverse scale rows between outermost lateral stripes 12 at axillary, 10 at midbody, nine at pelvis. Limb scales mostly imbricate, except those of palms and feet; scales of palm and feet granular, some enlarged and protruding; scales of posterolateral thigh heterogeneous in size, shape, and arrangement; subdigital lamellae bearing single weak keel, 12 on finger IV, 17 on toe IV.

Mental large, arch shaped; postmental two, anterior scale trapezoid bordering first two infralabials laterally, posterior one pentagonal pointed posteriorly, bordering second and third infralabials laterally; four pairs of chin shields larger than gulars. Remining ventrals subequal in size, ventral scale counts 65. Anal plate divided; postanal scales not keeled. Medial subcaudal distinctively widened, remaining caudal homogeneous, similar size as ventrals.

Coloration: The dorsal and lateral background surfaces of the head are Light Orange Yellow (Color 7), with regional Jet Black (Color 300) markings on individual scales: sometimes the black markings covers only the peripheral edges of scales, but in other cases they constitute the centers of scales. Supralabials are Pale Pinkish Buff (Color 3), and such color continues posteriorly and terminates on anterior tympanum. Four Pale Pinkish Buff (Color 3) lateral stripes are present on dorsal head: the two medial ones begin on prefrontals and unify into a single vertebral stripe on interparietal, continuing posteriorly and fading away on the anterior one-third of the tail; and the other two lateral stripes begin on anterior-most supraciliary and continue along the lateral edges of supraoculars posteriorly, also fading on one anterior third of the tail. Another Pale Buff (Color 1) ventrolateral stripe begins on posterior edge of tympanum, continues along ventrolateral body, and terminates on groin on each side of the body. The region between the ventrolateral line and lateral-most line of the head on each side of the dorsum is uniformly Jet Black (Color 300). On the other hand, the dorsal region between the vertebral stripe and the adjacent lateral stripe is also Jet Black (Color 300), but heavily mottled with Pale Tawny Olive (Color 17). The dorsal coloration gradually fades and changes into uniform pale Venetian Blue (Color 170) at about one third of the total tail length. Dorsal surface of the limbs is Tawny Olive (Color 17), but the peripheral edges of each individual scale are Brunt Umber (Color 48).

Ventral surfaces of the head, limbs, and body are uniformly white. The anterior one third of the ventral tail is slightly yellowish, which then gradually changes into pale Venetian Blue (Color 170) posteriorly.

Variation: Detail morphometric and pholidosis variation are in Table 4. Sexual dichromatism and ontogenetic shift are evident in the species: for dichromatism, the tails of females are Pale Tawny Olive (Color 17) mottled with Jet Black (Color 300) instead of the blue color in adult males; and for ontogenetic shift, the background coloration of juveniles are unfirmly Jet Black (Color 300) without brownish patches, and the tails of both sexes in juveniles are Venetian Blue (Color 170).

Distribution, natural history, and conservation: *Plestiodon jinjiang* **sp. nov.** is currently known from its type locality in Lijiang, Yunnan Province, but it is likely to be found in adjacent reaches of the Jinsha River in Diqing, Dali, and Chuxiong of Yunnan Province as well. The habitat consists of shrubs and grasslands in the hot-dry valley, and individuals were found under flat rocks or in burrows (Figure 6). Females were gravid in early May, and individuals were observed guarding eggs inside burrows under rocks. A clutch of five eggs were observed in the field, and these eggs hatched in late August. Hatchlings were found living with the female in the field. *Diploderma yulongense*, *Oreocryptotis porphyraceus*, *Elaphe carinata*, *Elaphe taeniura*, *Lycodon* sp., *Bufo andrewsi*, and *Gekko scabridus* were found sympatric with the new species. Facing the similar threats as to the sympatric, endemic lizard *Diploderma yulongense*, *P. jinjiang* **sp. nov.** is threatened by habitat loss due to the unregulated developments in the low-elevation river valley. With no accurate data on its distribution range, we propose to list *P. jinjiang* **sp. nov.** as Data Deficient (DD) for its conservation assessments, pending on future studies.

DISCUSSION

Previous studies have recorded *P. elegans* from Yunnan Province (He &Zhou, 2002; Wang et al., 2022), specifically from Yunnan Fu (=modern Huize County, Qujing; Pope, 1935) and Kunming (He et al., 2002; Yang & Rao, 2008). Although our examination of voucher specimens confirms the distribution of true *P. elegans* in the very northeast part of Yunnan (i.e. Shuifu County in Zhaotong), however, we were unable to examine the referred specimens from Huize and Kunming by previous studies. As Huize and Kunming are in the middle between the type locality of our new species and the locality of confirmed, true *P. elegans*, without obvious geographic or climatic barriers in between, it is difficult to delimit the distribution range of the two species along the Jinsha River in northern Yunnan. Future surveys are needed to confirm the taxonomic identity of the *P.* cf. *elegans* from Kunming and Qujing and reveal the distribution boundaries of species of *Plestiodon* along the Jinsha River in Yunnan Province.

Our larger sample of *P. jinjiang* and *P. elegans* shows that even some of the key diagnostic traits such as number of postmental scales can vary intraspecifically. Therefore,

Table 4 Morphological measurements and pholidosis characters of the type series of *Plestiodon jinjiang* sp. nov.

Catolog Number	KIZ 57453	KIZ 57454	KIZ 58483	KIZ 58492	KIZ 58484	KIZ 58488	KIZ 58487	KIZ 58486	KIZ 58494	KIZ 58490	KIZ 58493	KIZ 58489	KIZ 58485
Type status	Holotype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype
Sex	M	F	F	M	M	F	F	M	M	F	M	F	M
SVL	62.3	67.4	86.6	73.9	71.8	77.6	73.8	68.9	66.0	73.5	59.7	73.1	64.4
TAL	100.6	81.9 (regerated)	(Incomplete)	115.9	10.4	102.0 (regerated)	99.5 (regerated)	96.6	98.4 (regerated)	89.8	80.8		72.7 (regerated)
TAW	5.3	6.6	10.5	6.3	4.8	9.4	7.7	5.7	6.6	6.2	5.3	7.2	5.5
TAD	4.9	5.4	9.5	6.1	5.6	8.6	7.5	5.6	6.5	6.4	5.7	7.4	5.1
HLP	11.0	11.6	14.7	12.5	12.7	13.2	12.8	12.3	12.6	12.9	11.3	13.1	11.8
HLJ	13.2	14.1	16.8	14.1	15.6	17.1	16.8	15.0	15.2	16.7	14.2	15.8	14.3
HW	8.5	9.8	12.2	10.0	9.8	11.4	10.1	9.7	10.0	10.4	8.4	10.9	9.1
HD	6.5	7.6	8.9	7.8	7.9	8.7	7.8	7.1	8.1	8.0	6.9	8.5	7.2
IN	1.8	2.0	2.7	2.3	2.0	2.3	2.4	2.4	–	2.4	2.3	2.4	2.0
STL	11.9	13.3	16.7	13.7	14.1	14.8	14.4	13.0	13.8	14.7	12.5	15.0	12.4
SEL	4.7	5.6	6.9	5.4	5.8	6.3	5.8	5.6	6.0	6.4	5.4	6.3	5.5
END	3.7	4.4	5.5	4.5	4.7	4.6	4.4	4.0	6.3	4.8	4.0	5.0	4.1
SnL	22.5	24.5	31.3	25.0	26.3	26.7	28.4	24.8	24.9	27.7	23.3	28.8	23.6
TD	1.7	1.6	1.7	1.5	1.5	1.3	1.3	1.5	1.3	1.4	1.7	1.7	1.3
ED	2.9	3.0	3.9	3.0	1.4	3.3	3.4	3.3	3.0	3.9	3.2	4.3	3.4
TED	4.5	5.2	6.5	5.8	5.4	5.9	5.4	4.9	5.3	5.5	4.8	6.0	4.7
IODA	4.4	5.0	5.8	5.0	5.0	5.2	4.8	4.5	4.9	5.1	4.3	5.0	4.4
IODP	5.3	6.4	7.4	6.1	6.2	6.4	6.4	6.0	6.5	6.6	5.4	6.9	5.9
TRL	31.8	35.5	46.6	40.1	38.4	41.4	39.0	35.6	33.1	38.4	30.5	36.1	34.2
MBW	9.9	15.6	15.6	12.6	10.6	13.8	11.1	11.8	11.9	11.2	9.7	14.3	11.1
AW	8.4	9.7	12.2	9.7	9.5	10.6	9.8	9.2	9.6	8.8	7.7	8.9	7.6
PW	7.6	9.0	12.4	9.5	9.7	11.4	10.9	8.4	9.1	9.8	8.4	9.9	8.4
BL	6.3	6.6	8.0	6.7	6.7	7.4	7.1	7.0	6.6	7.0	6.5	7.3	5.2
FHL	12.1	13.3	15.6	12.7	14.8	14.3	14.2	13.6	12.7	14.9	12.0	13.5	12.4
FLL	18.4	19.9	23.6	19.4	21.5	21.7	21.3	20.7	19.3	21.9	18.5	20.8	17.6
FL	9.2	9.4	12.1	11.6	11.0	10.9	9.9	10.0	10.4	10.9	9.0	11.0	8.7
TFL	17.0	19.5	21.9	19.4	19.9	18.8	19.7	20.1	18.6	20.6	17.3	19.2	18.3
HLL	26.1	28.9	34.0	31.0	30.9	29.7	29.6	30.1	29.0	31.4	26.2	30.2	27.0
SL	7-7	7-7	7-7	7-7	8-8	7-7	7-7	7-7	7-7	7-7	7-7	7-7	7-7
IL	6-6	6-6	6-6	6	6-7	6-6	6-7	6-6	6-6	6-6	6-6	7-6	6-6
CHN	3-3	3-3	3-3	3-3	4-4	4-4	3-3	2-3	3-3	2-3	3-3	3-3	3-3
PM	2	2	2	2	1	1	2	2	2	2	2	2	2
EnLN	2	2	2	2	2	2	2	2	2	2	2	2-3	1-1
SupraO	4-4	4-4	4-4	4-4	4-4	4-4	4-4	4-4	4-4	4-4	4-4	4-4	4-4
postnasal	1	1	1	1	0	0	0	0	1	0	0	0	0
TEM	1-2/1-2	1-2/1-2	1-2/1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	2-2	2-2
MBSR	27	26	26	26	27	28	28	26	26	26	26	27	27
PVSR	62	62	61	65	67	67	67	62	65	65	71	68	64
DBRF	12	13	10	13	13	13	–	–	–	–	–	–	–
DBRM	10	10	10	10	10	10	10	10	10	10	10	10	10
DBRH	9	9	9	9	11	9	–	–	–	–	–	–	–
VN	65	64	65	67	70	68	68	67	70	73	69	68	71
F4S	12	12	11	11	12	12	12	13	13	13	11	11	12
T4S	17	16	16	19	15	16	18	17	16	18	15	16	16

"–" indicates missing data.

describing new species relying on a few morphological characters only and a sample size can be problematic. This raises question regarding the validity of a recognized taxon of the genus, *P. popei*. Described from two hatchlings and two embryotic specimens, *P. popei* was diagnosed from its sympatric species, *P. elegans*, by having a different shape of lower temporal (triangular vs. parallelogram shaped), fewer middorsal scale rows (24 vs. 26), and absence of enlarged, keeled pair of scales posterolateral of cloaca (vs. presence) (Hikida, 1989). In the original description, Hikida (1989) noted that the type series display a series of abnormal scalation characters, including number of chin shields, nuchals, supraciliaries, and paravertebrals. In addition to the fact *P. elegans* is sympatric with *P. popei* (Hikida, 1989), and

Figure 6 Macro- (A) and micro-habitats (B) of *Plestiodon jinjiang* sp. nov. at the type locality in Lijiang, Yunnan Province, China (Photos by K.W.)

continuous survey efforts at the type locality only found the former species (Ben-Fu Miao, personal communication), the types of *P. popei* are likely just young *P. elegans* with abnormal morphological characters. As such, we consider *P. popei* as a junior synonym of *P. elegans*.

To facilitate future taxonomic study of the genus in China, we compiled an updated diagnostic key and the provincial distribution to all recognized species of the genus *Plestiodon* in China.

Updated key and provincial distribution to the species of the genus *Plestiodon* in China
(modified from Zhao et al., 1999; "?" indicates questionable records)

1a. Adults and juveniles with four distinct yellowish stripes on dorsum ..... *P. quadrilineatus*
(Guangdong, Guangxi, Hainan, Hong Kong, Macao)
1b. Juveniles with five stripes on dorsum; adults either retain such striped patterns or uniformly colored without stripes 2
2a. Inferior secondary temporal scale parallelogram shaped; postmental scale two ..... *P. tunganus*
(Sichuan)
2b. Inferior secondary temporal scale triangular shaped; post mental scale one or two 3
3a. Scales on posterolateral thighs not distinctively differentiated 4
3b. Scales on posterolateral thighs distinctively enlarged, irregularly arranged 6
4a. Distinct, wide black lateral stripe continued from snout to lateral body in adults; paravertebral scale rows 38–46..... ..... *P. tamdaoensis*
(Guangdong, Hong Kong)
4b. Lateral body speckled with red or orange in adults; paravertebral scale rows ≥48 5
5a. Three supraoculars in contact with frontal; midbody scale row usually 24; juveniles with three distinct stripes and two laterally arranged doted lines ..... *P. chinensis*
(Anhui, Chongqing, Fujian, Guangdong, Guizhou, Hainan, Hebei?, Hubei, Hunan, Hong Kong, Jiangsu, Jiangxi, Liaoning, Macao?, Sichuan, Shandong, Shanghai, Taiwan, Yunnan, Zhejiang)
5b. Two supraoculars in contact with frontal; usually two pairs of nuchals; midbody scale row usually 26; juveniles without any stripes but scattered fine speckles ..... *P. leucostictus*
(Taiwan)
6a. Posterolateral anal scales keeled and differentiated; post-mental one 7
6b. Posterolateral scales not differentiated; post-mental one or two 8
7a. Posterior loreal in contact with two supralabials; juvenile tail completely blue ..... *P. elegans*
(Anhui, Beijing?, Chongqing, Fujian, Guangdong, Guangxi, Guizhou, Henan?, Hubei?, Hunan, Jiangsu, Hong Kong, Jiangxi, Sichuan, Shanxi?, Shaanxi?, Shanghai, Taiwan, Tianjin?, Northeast Yunnan, Zhejiang)
7b. Posterior loreal in contact with mostly three supralabials; juvenile tail blue only at distal end ..... *P. takarai*
(Taiwan)
8a. Paravertebral scale row 62–71; midbody scale row 26–28; post-mental two (rarely one) ..... *P. jinjiang*
(Northwest Yunnan, southern Sichuan?)
8b. Paravertebral scale row under 58; midbody scale row under 26 9
9a. Postmental two; paravertebral scale row 48–52 ... *P. capito*
(Beijing, Gansu, Guizhou, Henan, Hebei, Hubei, Inner Mogolia, Liaoning, Ningxia, Sichuan, Shaanxi, Tianjing)
9b. Postmental single, paravertebral scale row 52–54 . .*P. liui*
(Henan, Hubei, Jiangsu, and Zhejiang)

SCIENTIFIC FIELD SURVEY PERMISSION INFORMATION

Permissions for field surveys in Yunnan Province, China were issued by Yunnan Provincial Forestry & Grassland Department.

DATA AVAILABILITY

Mitochondrial sequences have been deposited in Genbank (Accession No. PX776070–776072), and the COI alignment used have been deposited in Science Data Bank under digital object identifier (DOI) 10.57760/sciencedb.28809.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

K.W. conceived the project, collected morphological data of the lectotype and paralectotypes of *P. elegans*, performed genetic and morphological analyses, wrote the draft with inputs of S.J.X., and revised the draft with inputs from all coauthors; S.J.X. collected morphological data of the new species, assisted in the writing of the draft; J.L. collected morphological data of the key comparative congeners from the US museum; Z.Y.L. collected the type series of the new species, assisted in the collection of morphological data; N.Z. and J.Q.J. collected the genetic data; and J.C. supervised the project and provided funding supports. All authors read and

approved the final version of the manuscript.

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