



# Article

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## Description of a new species of the genus *Xenophrys* Günther, 1864 (Amphibia: Anura: Megophryidae) from Mount Jinggang, China, based on molecular and morphological data

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### Abstract

A new species, *Xenophrys jinggangensis* **sp. nov.**, is described based on a series of specimens collected from Mount Jinggang, Jiangxi Province, Eastern China. The new species can be easily distinguished from other known congeners by morphology, morphometrics and molecular data of the mitochondrial 16SrRNA gene. The new species is characterized by its small size with adult females measuring 38.4–41.6 mm in snout-vent length and males measuring 35.1–36.7 mm; head length approximately equal to head width; tympanum large and distinct, about 0.8 times of eye diameter; vomerine teeth on two weak ridges; tongue not notched behind; relative finger length  $II < I < IV < III$ ; slight lateral fringes present on digits; toes bases with thick, fleshy web; dorsum with tubercles and swollen dorsolateral folds; large pustules scattered on flanks; and unique color patterns. The new species represents the thirty-first known *Xenophrys* in China.

**Key words:** Megophryidae, *Xenophrys jinggangensis* **sp. nov.**, morphology, mitochondrial DNA, taxonomy

### Introduction

The genus-level classification of frogs in the genera *Megophrys* Kuhl & Van Hasselt, 1822 and *Xenophrys* Günther, 1864, in the family Megophryidae, are poorly understood, and researchers have employed various classification schemes (Rao & Yang 1997; Delorme *et al.* 2006; Li & Wang 2008; Fei *et al.* 2009; Mahony 2011). Pending comprehensive phylogenetic and morphological research, we follow the treatment from Li & Wang (2008) and Pyron *et al.* (2011) that *Xenophrys* is distinguished from *Megophrys* and all previously known *Megophrys* species in China and should be transferred to the genus *Xenophrys*.

Currently, the genus *Xenophrys* contains 42 species and is distributed in Southeast Asia from southern and eastern Himalayan Region to Borneo (Frost 2011). There are 30 species of *Xenophrys* recognized from China; only three *Xenophrys* species are recorded from Eastern China, i.e., *X. boettgeri* (Boulenger, 1899) and *X. kuatunensis* (Pope, 1929) in Mount Wuyi, *X. huangshanensis* (Fei & Ye, 2005) in Mount Huangshan, all having body length shorter than 50 mm. Therefore, the *Xenophrys* diversity is probably underestimated in Eastern China which has extensive mountainous areas and suitable habitats.

During herpetological surveys conducted from 2010 to 2011 on Mount Jinggang (26°13'04"–26°52'30" N; 113°59'12"–114°18'28" E), Jiangxi Province, we found an unknown, relatively small (i.e. body length shorter than 50 mm) species which can be assigned into genus *Xenophrys* on the basis of the following characters: head broad and depressed, tympanum distinct, tubercles on the outer edge of the upper eyelids short, tubercles on the snout absent, no mid-dorsal fold, no black horny spines on dorsum, hindlimbs long, heels overlap (Li & Wang 2008). Herein we describe this new species based on morphological and molecular data.

## Material and methods

**Taxon sampling.** Samples used for molecular analyses including *X. brachykolos* (Inger & Romer, 1961) from Hong Kong, *X. boettgeri* and *X. kuatunensis* from Mount Wuyi, *X. jinggangensis* **sp. nov.** from Mount Jinggangshan, *X. mangshanensis* (Fei & Ye, 1990) from Mount Nanling, *Ophryophryne pachyproctus* Kou, 1985 from Wuhuangling Forest Park (Figure 1). All specimens were fixed in 10 % buffered formalin after preserving muscle tissue in 95 % ethanol, and later transferred to 70 % ethanol.

**Extraction, PCR and sequencing.** DNA was extracted from muscle tissue using a standard phenol-chloroform extraction protocol (Sambrook *et al.* 1989). The mitochondrial 16S rRNA gene from all taxon samples was sequenced. Fragments of the genes were amplified using primer pairs designed for ranid frogs (Simon *et al.* 1994). PCR amplifications were performed in a 60 reaction volume with the following cycling conditions: an initial denaturing step at 94 °C for 1.5 min; 33 cycles of denaturing at 94 °C for 45 s, annealing at 55 °C for 45 s and extending at 72 °C for 90 s, and a final extending step of 72 °C for 10 min. PCR products were purified with spin columns. The purified products were sequenced with both forward and reverse primers using BigDye Terminator Cycle Sequencing Kit according to the guidelines of the manufacturer. The products were sequenced on an ABI Prism 3730 automated DNA sequencer in Beijing Genomics Institute. All sequences have been deposited in GenBank (Table 1).



**FIGURE 1.** Collecting localities in Southern and Eastern China: 1 Mt. Jinggang, Jinggangshan City, Jiangxi Province, specimens collected here refer to *Xenophrys jinggangensis* **sp. nov.** 2 and 3 Mt. Wuyi, Guixi City, Jiangxi Province, specimens collected here refer to *X. boettgeri* and *X. kuatunensis*. 4 Hong Kong, specimens collected here refer to *X. brachykolos*. 5 Mt. Nanling, Ruyuan County, Guangdong Province, specimens collected here refer to *X. mangshanensis*. 6 Wuhuangling Forest Park, Qinzhou City, Guangxi, specimens collected here refer to *Ophryophryne pachyproctus*.

TABLE 1. Localities and voucher data for all specimens used in this study.

ID	Current genus and species name	Locality	Specimen voucher no.	16S rRNA gene
1	<i>Xenophrys boetgeri</i>	China: Mt. Wuyi, Jiangxi	SYS a000378	JX867340
2	<i>Xenophrys brachykollos</i>	China: Hong Kong	SYS a001502	JX867339
3	<i>Xenophrys kuatunensis</i>	China: Mt. Wuyi, Jiangxi	SYS a000241	JX867341
4	<i>Xenophrys major</i>	Vietnam: Tam Dao Hill Station, Vinh Phu,	AMNH A161506	DQ283374.1
5	<i>Xenophrys mangshanensis</i>	China: Mt. Nanling, Guangdong	SYS a000496	JX867335
6	<i>Xenophrys minor</i>	China: Mt. Omei, Sichuan	CIB-ZYC1500	AY561308.1
7	<i>Xenophrys nankiangensis</i>	China: Nanjiang, Sichuan	CIB-XM835	EF397243.1
8	<i>Megophrys nasuta</i>	Malaysia: Tenom Dist, Sabah	FMNH 236525	DQ283342.1
9	<i>Xenophrys omeimontis</i>	China: Mt. Omei, Sichuan	ROM 40462	EF397242.1
10	<i>Xenophrys jinggangensis</i>	China: Mt. Jinggangshan, Jiangxi	SYS a001414	JX867338
11	<i>Xenophrys jinggangensis</i>	China: Mt. Jinggangshan, Jiangxi	SYS a001416	JX867337
12	<i>Xenophrys jinggangensis</i>	China: Mt. Jinggangshan, Jiangxi	SYS a001484 (tadpole)	JX867336
13	<i>Ophryophryne hanshi</i>	Vietnam: Tra My, Tra, Quang Nam	AMNH A163669	DQ283377.1
14	<i>Ophryophryne microstoma</i>	Vietnam: Yen Minh, Ha Giang	AMNH A163859	DQ283391
15	<i>Ophryophryne pachyproctus</i>	China: Wuhuangling Forest Park, Guangxi	SYS a000578	#
16	<i>Pelodytes punctatus</i>	Spain, Barcelona	AMNH A163674	DQ283111
17	<i>Odorrana schmackeri</i>	China: Mt. Omei, Sichuan	CIB-WU37990	DQ359997

# indicates the species of family Megophryidae sequenced in this study.

**Phylogenetic analysis.** Following the classification system established by Frost *et al.* (2011), sequences of nine representative species available from GenBank, including four species of the genus *Xenophrys* and two species of the genus *Ophryophryne* (i.e. *Ophryophryne microstoma* Boulenger, 1903 and *Ophryophryne pachyprocta*, and *Megophrys nasuta* (Schlegel, 1858), *Pelodytes punctatus* (Daudin, 1802) and *Odorrana schmackeri* (Boettger, 1892), were included in the genetic analyses (Zheng *et al.* 2004, Fu *et al.* 2007, Frost *et al.* 2006). The latter two species were used as the out-group. Data of all voucher specimens of above species are available in Table 1. Alignments were first conducted using Clustal X 1.81 (Thompson *et al.* 1997) in MEGA 5.05 (Tamura *et al.* 2011), with default parameters and the alignment being checked and manually revised, if necessary. The GTR model (Posada & Crandall 2001), assuming a gamma-shaped distribution across sites (Felsenstein 2004), was selected as the best-fitting nucleotide substitution model using Akaike's Information Criterion (Akaike 1974) in Modeltest 3.7 (Posada *et al.* 2004). Sequence data were analyzed using maximum parsimony (MP) and maximum likelihood (ML) implemented in PAUP\* 4.0 b10 (Swofford 2003), and Bayesian inference (BI) using MrBayes 3.12 (Ronquist & Huelsenbeck 2003). The phylogenetic tree was constructed using MP, ML and BI methods. For MP analysis, heuristic MP searches were executed in 1000 random addition replicates with all characters unordered and equally weighted, and using tree bisection reconnection (TBR) branch-swapping. Bootstrap branch proportions were calculated with 1000 MP replicates. For ML analysis, the bootstrap consensus tree inferred from 500 replicates was used to represent the evolutionary history of the taxa analyzed. Branches corresponding to partitions reproduced in less than 50 % of bootstrap replicates were collapsed. For BI analysis, two independent runs with four Markov Chain Monte Carlo simulations were performed for one million iterations and sampled every 100<sup>th</sup> iteration. The first 25 % of samples were discarded as burn-in. Convergence of the Markov Chain Monte Carlo simulations was assessed using Tracer v.1.4 (<http://tree.bio.ed.ac.uk/software/tracer/>). Apart from phylogenetic tree-based methods, we also calculated pairwise sequence divergence based on uncorrected p-distance implemented in MEGA 5.05 (Tamura *et al.* 2011).

**Morphometrics.** Measurements were made with digital calipers to the nearest 0.1 mm. Abbreviations used are SVL = snout–vent length; HDL = head length from tip of snout to the articulation of the jaw; HDW = head width, between left and right articulations of the quadratojugal and maxilla; SNT = snout length, from tip of snout to the anterior corner of the eye; EYE = eye diameter, from the anterior corner of the eye to posterior corner of the eye; IND = internasal distance; IOD = interorbital distance; TMP = tympanum diameter; TEY = tympanum–eye distance, from anterior edge of tympanum to posterior corner of the eye; HND = hand length, from distal end of radioulna to tip of distal phalanx of III; RAD = radioulna length; FTL = foot length, from distal end of tibia to tip of distal phalanx of III; TIB = tibial length; TaL = tail length in tadpole, was measured from the tip of the tail fin to the vent.

All studied specimens and materials for DNA analysis are deposited in The Museum of Biology, Sun Yat-sen University (SYS), Guangzhou, Guangdong Province, China.

Collection abbreviations: **CIB**, Chengdu Institute of Biology, the Chinese Academy of Sciences; **AMNH**, American Museum of Natural History; **ROM**, Royal Ontario Museum, Toronto.

Specimens examined are listed in Appendix 1.

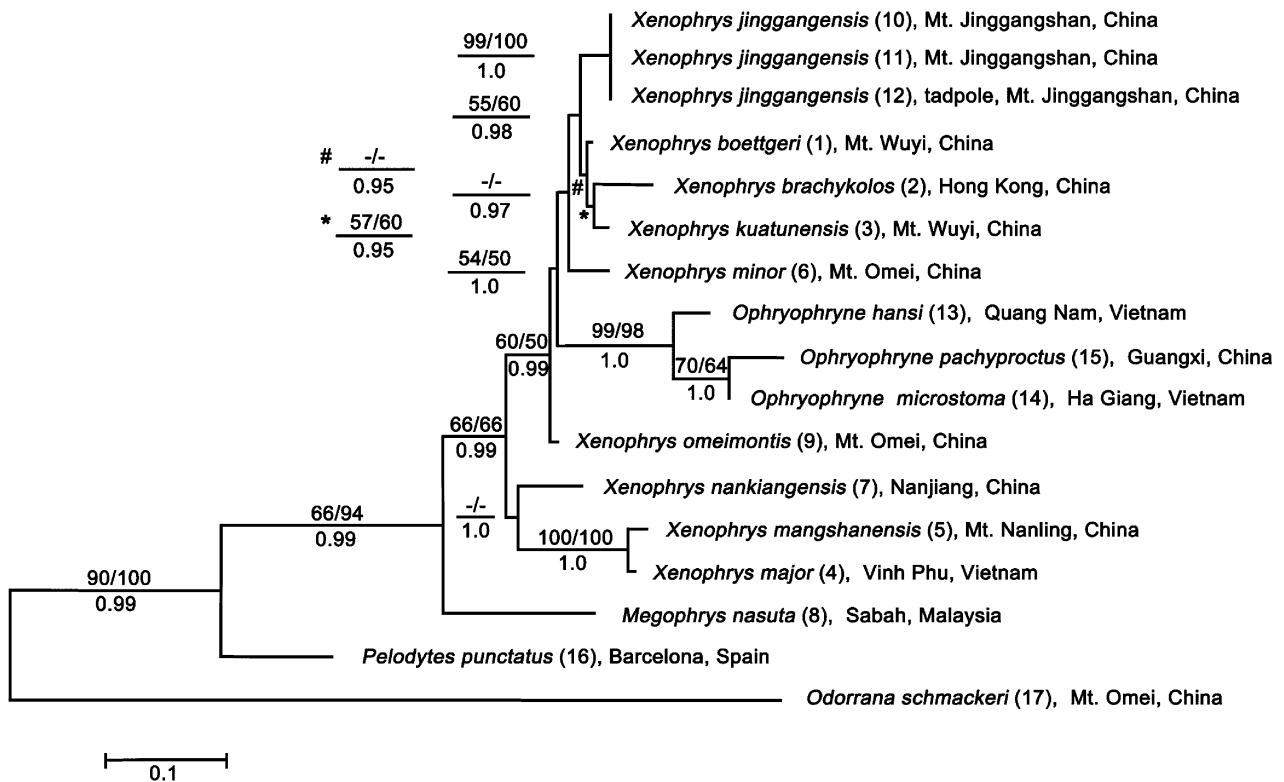
## Results

### Molecular phylogenetic analyses revealed a new species of genus *Xenophrys*

For the 422 bp 16SrRNA gene, a total of eight sequences were obtained from individuals in our study and nine sequences were downloaded from Genbank (Accession No. see Table 1). Collectively 83 out of 137 variable sites were parsimony-informative with 54 singletons. The three phylogenetic approaches resulted in the virtually identical topology indicating that the monophyly of three individuals from Mount Jinggang was strongly supported (60 %, 55 %, and 0.98 for MP, ML bootstrap proportions and Bayesian posterior probability, respectively; Figure 2). In the phylogenetic tree, the individuals from Mount Jinggang were assigned to the subset of small-sized species of genus *Xenophrys*. The pairwise genetic distance between *X. boettgeri* and *X. kuatunensis* was only 0.019 (uncorrected p-distance), whereas the smallest pairwise genetic distance between the individuals from Mount Jinggang and other small-sized species of genus *Xenophrys*, except *X. huangshanensis*, was 0.027 (Table 2).



Combined with further evidence from morphology, our molecular genetic results indicate that the individuals from the Mount Jinggang represent an undescribed species of the genus *Xenophrys*. Herein, we described it as a new species, *Xenophrys jinggangensis* sp. nov..



**FIGURE 2.** Bayesian inference tree derived from partial DNA sequences of the mitochondrial 16S rRNA gene. Numbers above branches are bootstrap support for maximum parsimony (1000 replicates)/maximum likelihood (500 replicates) analyses (>50 retained) and numbers below branches indicate Bayesian posterior probabilities (>90% retained).

### *Xenophrys jinggangensis* Wang sp. nov.

**Holotype.** Adult female, SYS a001430, collected by Jian Zhao and Run-Lin Li on 13 September 2011, from Mount Jinggang (26°33'06.30" N, 114°09'17.60" E; 845 m a.s.l.), Jinggangshan City, Jiangxi Province, China (Figure 3).

**Paratypes.** Two adult females: SYS a001413 (Figure 4A) and a001416; two adult males: SYS a001414–1415. All collected from the same locality as holotype at 700–850 m a.s.l. by Jian Zhao, Zhong Zhang and Run-Lin Li on 13 September 2011.

**Other examined materials.** Six tadpoles: SYS a001484, from the same locality as holotype at 700–850 m a.s.l. by Jian Zhao and Run-Lin Li on 5 December 2011 (Figures 4C, 4D).

**Diagnosis.** *Xenophrys jinggangensis* sp. nov. is characterized by the combination of following characters: (1) a small-sized species with 38.4–41.6 mm SVL in adult females, 35.1–36.7 mm SVL in adult males; (2) head length approximately equal to head width (HDL/HDW ratio 1); (3) snout almost truncate in plan view, strongly projecting, sloping backward to mouth in profile, protruding well beyond margin of lower jaw; (4) tympanum great and distinct, TMP/EYE ratio 0.8 in females and males; (5) vomerine teeth on two weak ridges; (6) margin of tongue smooth, not notched behind; (7) relative finger length II < I < IV < III; (8) lateral fringes on digits minute, toes with a thick, fleshy web at their bases; (9) large subarticular tubercle at base of each digit; (10) dorsal skin granulated with tubercles, forming single swollen dorsolateral folds parallel to contra-lateral fold and discontinuous V-shaped fold from above the tympanum to the shoulder, flanks with larger pustules scattered, ventral surface smooth with granules; (11) several large tubercles on the upper eyelid, one of them horn-like, remarkably prominent at the edge of the eyelid; (12) dorsum light brown, four wide longitudinal dark-brown stripes parallel each other, a dark brown triangle between eyes; dorsal limbs and digits light brown with dark brown transverse bands; ventral surface grayish with black and brown spots.





**FIGURE 3.** 3A: Dorsal view of the adult female holotype SYS a001430 of *Xenophrys jinggangensis* **sp. nov.** in life. 3B: Lateral view of the holotype in life. 3C and 3D: Hand and foot of the holotype in life. 3E and 3F: Dorsal and ventral views of the holotype in preservative. Photo Ying-Yong Wang and Jiang-Mo Zhang.





**FIGURE 4.** 4A: General aspect of the adult female paratype SYS a001413 in life. 4B: *X. jinggangensis* active at night on a rock in a mountain stream on 10 September 2011. 4C: Dorsal view of *X. jinggangensis* tadpole at stage 38 of in life on 5 December 2011. 4D: Ventrolateral view of *X. jinggangensis* tadpole at stage 37 of in preservative. Photo Ying-Yong Wang and Jian Zhao.

**Comparisons.** Comparative data of *Xenophrys jinggangensis* **sp. nov.** with 42 known species of *Xenophrys* were obtained from the literatures (Boulenger 1908; Inger & Romer 1961; Taylor 1962; Fei *et al.* 1992, Tian *et al.* 2000; Ohler *et al.* 2002; Inger & Iskandar 2005; Mathew & Sen 2007; Fei *et al.* 2009; Mo *et al.* 2010) and shown in Table 3. The new species can be steadily distinguished from all known 42 congeners by the combination of following characters: tympanum great and distinct, dorsal skin granulated with tubercles, swollen dorsolateral folds, large pustules scattered on flanks and the unique color pattern. Further, the new species is significantly smaller in body size from the following 20 congeners: *X. aceras* (Boulenger, 1903), *X. auralensis* (Ohler, Swan & Daltry, 2002), *X. baluensis* (Boulenger, 1899), *X. caudoprocta* (Shen, 1994), *X. damrei* (Mahony, 2011), *X. gigantea* (Liu, Hu & Yang, 1960), *X. glandulosa* (Fei, Ye & Huang, 1990), *X. jingdongensis* Fei & Ye, 1983, *X. lekaguli* (Stuart, Chuaynkern, Chan-ard & Inger, 2006), *X. longipes* (Boulenger, 1886), *X. major* (Boulenger,



1908), *X. mangshanensis*, *X. medogensis* (Fei & Ye, 1983), *X. omeimontis* (Liu, 1950), *X. robusta* (Boulenger, 1908), *X. sangzhiensis* (Jiang, Ye & Fei, 2008), *X. shapingensis* (Liu, 1950), *X. shuichengensis* (Tian, Gu & Sun, 2000), *X. spinata* (Liu & Hu, 1973) and *X. takensis* (Mahony, 2011); it has a small body sized (38.4–41.6 mm SVL in adult females, 35.1–36.7 mm SVL in adult males), as opposed to 63.5–118.3 mm SVL in adult females, 47.3–115 mm SVL in adult males in those 20 large body-sized species. The new species differs from the following thirteen small body-sized congeners (characters in parentheses) by the presence of vomerine teeth (vs. absent): *X. baolongensis* (Ye, Fei & Xie, 2007), *X. binchuanensis* (Ye & Fei, 1995), *X. binlingensis* (Jiang, Fei & Ye, 2009), *X. boettgeri*, *X. brachykolos*, *X. huangshanensis*, *X. kuatunensis*, *X. minor*, *X. nankiangensis* (Liu & Hu, 1966), *X. tuberogranulatus* (Shen, Mo & Li, 2010), *X. wawuensis* (Fei, Jiang & Zheng, 2001), *X. wuliangshanensis* (Ye & Fei, 1995) and *X. wushanensis* (Ye & Fei, 1995); The new species differs from the following six small body-size congeners (characters in parentheses) by having distinct subarticular tubercles on toes (vs. lacking): *X. daweimontis* (Rao and Yang, 1997), *X. pachyproctus* (Huang, 1981), *X. palpebralespinosa* (Bourret, 1937), *X. parallela* (Inger and Iskandar, 2005), *X. parva* (Boulenger, 1893) and *X. zhangii* (Ye and Fei, 1992); The new species differs from *X. dringi* (Mahony, 2011) (characters in parentheses) in that in that margin of tongue is not notched (vs. notched); from *X. serchhipii* Mathew & Sen, 2007 (characters in parentheses) by having relative finger length  $II < I < IV < III$  (vs. 2nd and 4th fingers subequal in length in *X. serchhipii*); from *X. zunhebotensis* Mathew & Sen, 2007 (characters in parentheses) in that head length is approximately equal to head width (vs. head length smaller than head width), flank scattered with large tubercles (vs. flank scattered with small tubercles), supratympanic fold not curving on to the anterior region of the tympanum (supratympanic fold curving on to the anterior region of the tympanum to give it a round shape), vomerine ridges relatively separated (vomerine ridges close to each other).

**Description of Holotype.** Adult female, SVL 38.4 mm. Head length approximately equal to head width (HDL/HDW ratio 1.0); snout short (SNT/HDL ratio 0.3, SNT/SVL ratio 0.1), almost truncate in plan view, sloping backward to mouth in profile, strongly protruding well beyond margin of lower jaw; top of head flat; eye large and convex, eye diameter 32% of head length (EYE/HDL ratio 0.3), upper eyelid slightly wider than interorbital distance; pupil vertical; nostril oblique ovoid with low flap of skin laterally; canthus rostralis sharp; loreal region vertical, not concave; internasal distance larger than interorbital distance; tympanum elevated relative to skin of temporal region, distinctly visible, TMP/EYE ratio 0.8; tympanum-eye distance great, TEY 2.5 mm, TEY/TMP ratio 0.9; choanae large, ovoid at the bases of the maxilla; two vomerine ridges weakly, oblique, posteromedial to choanae, each bearing numerous prominent teeth; margin of tongue smooth, not notched behind.

Forelimbs moderately slender; radioulna length 26% SVL, hands without web, moderately longer, 27% of SVL; fingers slender, relative finger length  $II < I < IV < III$ ; tips of digits round, slightly dilated; a large subarticular tubercle at base of each finger, slight lateral fringes from subarticular tubercles to terminal phalanges; metacarpal tubercle two, inner one significantly enlarged. Hindlimbs relatively long and moderately robust; tibia length 48% of SVL; foot length 71% of SVL; relative toe lengths  $I < II < V < III < IV$ ; tips of toes round, slightly dilated; toes with a fleshy web at their bases; a large subarticular tubercle at base of each toe, slight lateral fringes from subarticular tubercles to terminal phalanges; tarsal fold absent; but as outer lateral fringes on toe V from hough to terminal phalanges; inner metatarsal tubercle ovoid; outer metatarsal tubercle absent.

Skin on all upper surfaces granulated with tubercles, forming single swollen dorsolateral folds parallel to contralateral fold and discontinuous V-shaped fold from above the tympanum to the shoulder; several large tubercles at the upper eyelid prominent, one of them horn-like, remarkably prominent at the edge of the eyelid; supratympanic fold distinct, curving posteroventrally from posterior corner of eye to a level above insertion of arm where forming swollen glandular pustule; larger pustules scattered on flanks, ventral surface smooth with granules; pectoral gland large, round, prominently elevated relative to ventral surface, closer to axilla than to min-ventral line; single larger femoral gland on rear of thigh, two larger lip glands on anterior part of lower jaw, also round, prominently elevated relative to periphery skin surface; distinct granules on posterior thighs and around cloaca; cloacal opening unmodified, directed posteriorly, at upper level of thighs.

**Measurements of holotype (in mm).** SVL 38.4, HDL 12.2, HDW 12.2, SNT 4.1, IND 4.0, IOD 3.7, EYE 3.8, TMP 2.9, TEY 2.5, HND 10.4, RAD 10.0, FTL 27.2, TIB 18.6.

**Coloration of holotype in life.** Dorsum light brown, four wide longitudinal dark-brown stripes, outer two along the dorsolateral folds parallel each other, inside two intersect in middle; a dark brown triangle with a light center between the two eyes, apex of triangle over occiput; a dark brown stripe along the body axes on the dorsum of snout, the both sides large dark brown spots; tip of snout dark brown with black spots; upper lip with vertical

dark brown bars, the one under the eye largest and distinct; excepting arm, dorsal limbs and digits light brown with dark brown transverse bands; all dark brown regions bordered by black edge lines; a gray-brown stripe on both flanks from the posterior margin of the forelimb insertion to the anterior margin of the hind limb insertion; ventral surface pale grayish with small black spots and dark blotches; lower lip black with vertical white bars, including two lip glands; three longitudinal black stripes on the throat, large lateral black spots on belly, all bordered by white edges; anterior surface of thighs, knee and part of shank red-orange; ventral surface of limbs with large black blotches; ventral surface of digits black, tip of digits orange; pectoral gland, femoral gland white; pupils black; iris whitish with radiating black stripes.

**Coloration of holotype in preservative.** Dorsum creamy white, with black triangle and four wide stripes; a black stripe respectively on both flanks parallel to the dorsolateral stripes; dorsal limbs and digits with black transverse bands; ventral surface pale grayish with small black spots and blotches; creamy white substituted the red-orange in anterior surface of thighs, knee and part of shank; tip of digits whitish without orange.

**Description of tadpole.** Body slender, oval, flattened above; tail depth slightly larger than body depth, dorsal fin arising behind origin of tail, maximum depth near mid-length, tapering gradually to narrow, pointed tip; tail 2.3–2.8 times body length in 37<sup>th</sup>–39<sup>th</sup> stages, tail depth 19% of tail length in 37<sup>th</sup> stage, 22% in 38<sup>th</sup> stage, 24% in 39<sup>th</sup> stage; maximum body width 33% of body length in 37<sup>th</sup> stage, 43% in 38<sup>th</sup> stage, 48% in 39<sup>th</sup> stage; body depth 33% of body length in 37<sup>th</sup> stage, 43% in 38<sup>th</sup> stage, 44% in 39<sup>th</sup> stage; eyes large, lateral; nostril dorsolateral, slightly closer to umbelliform oral disk than to eyes, rim raised; internasal wider than interorbital; spiracle on left side of the body, closer to eye than to end of body; anal tube extends backward above ventral fin, opening medial; oral disk terminal, lips expanded and directed upwardly into typical *Xenophrys* umbelliform oral disk; transverse width of expanded funnel 41–42% of body length in 37<sup>th</sup>–39<sup>th</sup> stages.

**Color in life.** All upper surfaces brown red with black spots, sides of body pale gray with black marks; ventral surface brown with small black and white marks; sides of tail brown-gray with black and white marks; distal portions of fins orange-red with large black marks; hindlimbs orange-red with gray spots; in preservative, color of body gray-black, tail and handlimbs creamy white with dark spots.

Measurements of tadpole: 37<sup>th</sup> stage: 11.4 mm SVL, 31.8 mm TaL; 38<sup>th</sup> stage: 13.3 mm SVL, 30.1 mm TaL; 39<sup>th</sup> stage: 13.8 mm SVL, 32.6 mm TaL.

**Variation.** Measurements and body proportions of type series given in Table 4.

*X. jinggangensis* **sp. nov.** presents obvious sexual dimorphism in secondary sexual characters: SVL in adult females slightly greater than in males, SVL of females 38.4–41.6 mm, SVL of males 35.1–36.7 mm; snout length larger than eye diameter in females, but opposite in males; single subgular vocal sac in adult males; no nuptial pad and nuptial spines were observed in our male specimens.

All five specimens (two males, three females) were very similar in morphology and color pattern. One exception was an individual, found on 10 September, 2011, which featured horn-like conical tubercles that were remarkably prominent at the edges of the eyelids, and had coal black dorsum. (Figure 4B)

**Distribution and biological ecology.** Currently, *X. jinggangensis* **sp. nov.** is known only from the type locality, Mount Jinggang, located in the middle of the Luoxiao Range, running along the border between Jiangxi and Hunan Provinces, China. All individuals were found in small, slow-moving montane streams surrounded by moist subtropical evergreen broadleaved forests between 700–850 m elevations (Figure 1, 5).

All specimens were collected between 10 and 13 September, 2011, and no males were heard calling during the survey. The male paratype SYS a001415 had mature spermaries in the abdominal cavity, measuring  $4.9 \times 2.4$  mm in major axis and minor axis. Female paratype SYS a001416 had a fully developed oviduct without eggs and the ovary fat was fully grown. Tadpoles at Gosner stage 37–44 were found under rocks in the stream on 5 December 2011. Thus, the breeding season of the new species is likely before September.

**Etymology.** The specific epithet “*jinggangensis*” is in reference to the type locality, Mount Jinggang, Jiangxi Province, China.

**Remarks.** Only two species of *Xenophrys*, *X. boettgeri* and *X. minor* were previously known occurring at Mount Jinggang (Zou, 1985). During our herpetological surveys in Mount Jinggang, three apparently different morphotypes of *Xenophrys* were found, including the new species described herein. Morphologically the other two morphotypes could not be identified as any other *Xenophrys* species that were recorded from Eastern China (Y. Y. Wong *et al.*, unpublished data). This indicates the cryptic diversity of the *Xenophrys* in Mount Jinggang and thus the systematics of the *Xenophrys* in Eastern China needs to be revisited.

**TABLE 3.** Characters that differentiate *Xenophrys jinggangensis* sp. nov. from all known 42 recognized species of *Xenophrys*. The grey shade shows characters of each known *Xenophrys* species that is distinctly different from the new species.

	SVL		Horn-like tubercle at edge of upper eyelid: large (++) , small or indistinct (+), absent (-)	Vomerine teeth: present (+), or absent (-)	Tongue notched (++) , feebly notched (+), or not notched (-)	Vocal sac: present (+) or absent (-)	Toes: at least one-fourth webbed (+++), at most one-fourth webbed (++) , with rudiment of web (+), or without web (-)	Subarticular tubercles on toes: distinct (++) , indistinct (+), or absent (-)	Tympanum: eye ratio
	male	female							
<i>X. jinggangensis</i> sp. nov.	35.1–36.7	38.4–41.6	++	+	-	+	++	++	0.80
<i>X. aceras</i>	55.8–62.4	/	+	+	+ or -	-	+	-	0.5–0.67
<i>X. auraldensis</i>	76.7	/	+	-	-	+	+	+	0.60
<i>X. batusensis</i>	/	65	+	+	-	+	+	-	0.6
<i>X. baolongensis</i>	42–45	/	+	-	+	+	-	-	0.41
<i>X. binchuanensis</i>	32–36	40.2–42.5	-	-	+ or -	+	+	-	0.33–0.50
<i>X. binlingensis</i>	45.1–51	/	-	-	+	+	+	++	0.47–0.52
<i>X. boettgeri</i>	34.5–37.8	39.7–46.8*	+	-	+	+	+	-	0.40–0.67
<i>X. brachykolos</i>	33.7–39.3	33.9–45.9	+	-	-	+	++	+	> 0.5
<i>X. caudoprocta</i>	81.3	/	++	+	-	-	+	-	0.5
<i>X. damrei</i>	57.1	69.1	-	+	++	+	+	-	0.58
<i>X. dawweimontis</i>	34–37	40–46	+	+	/	+	-	-	?
<i>X. dringi</i>	42.8–46.7	55	+	+	++	/	+	+	tympanum small
<i>X. gigantea</i>	80.5–107	110.4–115.4	-	-	++	+	+	-	tympanum hidden
<i>X. glandulosa</i>	76–81	77–100	+	+	+	+	+	-	0.5
<i>X. huangshanensis</i>	36–41.6	44.2	+	-	+	+	-	++	< 0.5
<i>X. jingdongensis</i>	53–56.5	63.5	+	+	+	+	+++	-	/
<i>X. kuatunensis</i>	26.2–29.6	37.4	+	-	+	+	-	-	0.44
<i>X. lekaguli</i>	55.6–66.6	71.8–94	+	+	-	+	+	-	0.59–0.74

continued next page



TABLE 3. (continued)

	SVL		Horn-like tubercle at edge of upper eyelid: large (++) , small or indistinct (+), absent (-)	Vomerine teeth: present (+), or absent (-)	Tongue notched (++) , feebly notched (+), or not notched (-)	Vocal sac: present (+) or absent (-)	Toes: at least one-fourth webbed (+++), at most one-fourth webbed (++) , with rudiment of web (+), or without web (-)	Subarticular tubercles on toes: distinct (++) , indistinct (+), or absent (-)	Tympanum: eye ratio
	male	female							
<i>X. longipes</i>	47	65	+	+	+	+	+	-	0.6-0.67
<i>X. major</i>	77	94	+	+	+ or -	+	+++	-	0.5
<i>X. mangshanensis</i>	62.5	73	+	+	+	+	-	-	/
<i>X. medogensis</i>	57.2-68	/	+	+	+	+	+ or -	-	0.4
<i>X. minor</i>	32.2-40.5	42-48.2	+	-	+	+	+	-	0.68
<i>X. nankiangensis</i>	/	44-52.9	-	-	+	/	+	-	tympanum hidden
<i>X. omeimonitis</i>	56-59.5	68-72.5	+	+	+	+	+	++	/
<i>X. pachyproctus</i>	35.3-36.2	35.8	-	+	+	+	-	-	0.29
<i>X. palpebralespinosa</i>	36.2-38	/	++	+	-	+	+++	-	tympanum small
<i>X. parallela</i>	39.4-47.6	/	++	+	++	/	+	-	tympanum small
<i>X. parva</i>	37-44	45-54	+	+	-	+	+ or -	-	0.4
<i>X. robusta</i>	/	114	/	+	+	/	+	-	0.5
<i>X. sangzhiensis</i>	54.7	/	+	-	+	+	+	++	0.62
<i>X. serchhipii</i>	/	37.05	/	+	/	/	+	+	0.39
<i>X. shapingensis</i>	66-84	77-104	-	-	+	-	+++	-	tympanum hidden
<i>X. shuichengensis</i>	99.8-115.6	102-118.3	++	-	+	-	+++	-	0.67
<i>X. spinata</i>	47.2-54.4	54-55	-	-	+	+	+++	++	0.43
<i>X. takensis</i>	47.3-53	72.9	-	+	-	+	+	-	0.71
<i>X. tuberogranulatus</i>	33.2-39	50.5	+ or -	-	-	+	+	-	0.50
<i>X. wawuensis</i>	34.4-42.8	47-49.8	-	-	+	+	+	-	0.33
<i>X. wuliangshanensis</i>	27.3-31.6	41.3	-	-	+ or -	+	+	-	0.50
<i>X. wushanensis</i>	30.4-35.5	38.4	-	-	-	+	-	++	0.50
<i>X. zhangii</i>	32.5-37.2	/	-	+	+	+	-	-	0.5
<i>X. zunhebotoensis</i>	30	39	/	+	/	/	/	/	0.54-0.69

**TABLE 4.** Measurements (in mm) of the type series of *Xenophrys jinggangensis* **sp. nov.** See Materials and Methods for abbreviations.

	SYS a001415	SYS a001414	SYS a001430	SYS a001413	SYS a001416
	Adult male	Adult male	Adult female	Adult female	Adult female
SVL	36.7	35.1	38.4	39.2	41.6
HDL	12.0	11.4	12.2	13.1	13.4
HDW	11.9	11.8	12.2	12.7	13.8
SNT	3.6	3.4	4.1	4.4	4.6
IND	3.5	3.3	4.0	4.0	4.6
OD	3.4	3.3	3.7	3.6	4.0
EYE	3.7	3.5	3.8	4.2	4.2
TMP	2.8	2.9	2.9	3.1	3.4
TEY	2.4	2.3	2.5	2.5	2.5
HND	8.9	9.9	10.4	11.1	11.5
RAD	8.2	8.8	10.0	9.1	10.1
TIB	17.2	17.6	18.6	18.7	19.8
FTL	23.5	25.0	27.2	26.1	28.1
HDL/SVL	0.3	0.3	0.3	0.3	0.3
HDW/HDL	1.0	1.0	1.0	1.0	1.0
SNT/HDL	0.3	0.3	0.3	0.3	0.3
SNT/SVL	0.1	0.1	0.1	0.1	0.1
IND/HDW	0.3	0.3	0.3	0.3	0.3
IOD/HDW	0.3	0.3	0.3	0.3	0.3
EYE/HDL	0.3	0.3	0.3	0.3	0.3
EYE/SVL	0.1	0.1	0.1	0.1	0.1
TMP/EYE	0.8	0.8	0.8	0.8	0.8
TEY/TMP	0.9	0.8	0.9	0.8	0.7
HND/SVL	0.2	0.3	0.3	0.3	0.3
RAD/SVL	0.2	0.3	0.3	0.2	0.2
TIB/SVL	0.5	0.5	0.5	0.5	0.5
FTL/SVL	0.6	0.7	0.7	0.7	0.7

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**FIGURE 5.** Habitat of *X. jinggangensis* at the type locality. Photo Jian Zhao on 5 December 2011.

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## APPENDIX 1. Specimens examined.

- Xenophrys boettgeri* (7): SYS a000312, 0315, 0328–0330, 0376, 0378, Yangjifeng Nature Reserve, Mount Wuyi, Guixi City, Jiangxi Province, China, 600–900 m above sea level, June–August 2008.
- Xenophrys brachykolos* (2): SYS a001502–1503, Hong Kong, 11 February 2012.
- Xenophrys huangshanensis* (10): SYS a001314–1323, Mount Dazhang, Wuyuan County, Jiangxi Province, China, 28 July 2011.
- Xenophrys kuatunensis* (1): SYSa 000241, Yangjifeng Nature Reserve Mount Wuyi, Guixi City, Jiangxi Province, China, 950 m above sea level, 13 April 2008.
- Xenophrys mangshanensis* (8): SYS a000288, Danxiashan Geology Park, Renhua County, Guangdong Province, China, 300 m above sea level, 18 May 2008; SYS a000493, 0494, 0495, 0496, 0586, Mount Nanling, Ruyuan County, Guangdong Province, 800–1100 m above sea level, 24 May 2009 and 14 August 2009; SYS a000996, 0997, Jiulianshan Nature Reserve, Liannan County, Jiangxi Province, China, 23 July 2010.
- Ophryophryne pachyproctus* (9): SYS a000570–0578, Wuhuangling Forest Park, Qingzhou City, Guangxi Zhuang Autonomous Region, China.