

Taxonomic revision of genus *Rohanixalus* (Anura: Rhacophoridae) in China with description of one new species

DEAR EDITOR,

Based upon morphological and molecular evidence, the authors revised the genus *Rohanixalus* Biju, Garg, Gokulakrishnan, Chandrakasan, Thammachoti, Ren, Gopika, Bisht, Hamidy and Shouche, 2020 (Anura: Rhacophoridae) in China through describing one new species, adding one species to the fauna (*R. shyamrupus*) and supplementing data on one species (*Rohanixalus hansenae*; Supplementary Materials). *Rohanixalus wuguanfui* sp. nov. can be distinguished by the following combination of characters: (1) habitus small and slender; (2) tympanum indistinct; (3) dorsal skin yellowish-green with light-yellow speckles; (4) pair of light-yellow dorsolateral stripes extending from eyes to over vent before terminating; and (5) toe webbing up to a half below first subarticular tubercle on toe I and one quarter below first subarticular tubercle on toe V. *Rohanixalus shyamrupus* was found in Medog County, Xizang and can be distinguished by the following combination of characters: (1) habitus small and slender; (2) tympanum distinct; (3) dorsal skin dark brown or dark green with reddish tinge; (4) pair of white dorsolateral stripes extending from eyes to over vent before terminating; and (5) toe webbing up to one quarter below first subarticular tubercle on toe I and first subarticular tubercle on toe V. *Rohanixalus hansenae* from China can be distinguished by the following combination of characters: (1) habitus small and slender; (2) tympanum indistinct or weakly developed; (3) dorsal skin dark brown or light-yellow-green with dark spots; (4) lateral surfaces of head and body and dorsal surfaces of limbs with fine light brown speckles clustered in large patches; (5) pair of yellow dorsolateral stripes starting from eyes, extending from eyes to over vent before terminating; and (6) toe webbing up to first subarticular tubercle on toe I and first subarticular tubercle on toe V.

After examining the phylogenetic correlations of three genera: *Chirixalus* Boulenger, 1893, *Chiromantis* Peters, 1854 and *Feihyla* Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan, Raxworthy, Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green, and Wheeler, 2006, Biju et al. (2020) concluded with a necessity of recognizing a fourth genus, *Rohanixalus* Biju, Garg, Gokulakrishnan, Chandrakasan, Thammachoti, Ren, Gopika, Bisht, Hamidy, and Shouche, 2020. They assigned taxa to the genus *Rohanixalus* based upon morphological and molecular

data, as well as reproductive modes (e.g., spawning, nesting behavior and clutch morphology) (Biju et al., 2020). The genus *Rohanixalus* is widely distributed in South and Southeast Asia with a total of eight species recognized to date (Supplementary Table S1). Among these, two species of *R. vittatus* and *R. cf. hansenae* were thought to occur in tropical parts of extreme southern China (Amphibia China, 2023; Biju et al., 2020; Che et al., 2020). Biju et al. (2020) noted that samples of *Rohanixalus* in China were non-monophyletic and that the diversity of *Rohanixalus* species in China was probably underestimated. This is consistent with Che et al. (2020) findings that samples of “*F. vittata*” (currently *R. vittatus*) from Yunnan and Xizang, China were not monophyletic and likely represented a species complex. Further, samples of “*F. vittata*” from Myanmar, Thailand, China, and Vietnam also did not cluster as a monophyletic group. And the relationship of the species to “*F. hansenae*” (currently *R. hansenae*) required further examinations (Che et al., 2020).

During herpetological surveys from 2017 to 2022, a total of 39 specimens identified as *Rohanixalus* species (small to medium-sized adults; vomerine teeth absent; a pair of prominent to faint, continuous or discontinuous, contrasting light-colored dorsolateral stripes starting from tip of snout, extending over upper eyelid margins and ending adjacent to vent unilaterally; foot webbing moderate, not extending beyond the second subarticular tubercle at either side of toe IV) were collected from tropical regions in both extreme southern China (Yunnan, Guangxi and Hainan) and Xizang (Figure 1A).

Specimens were collected opportunistically. Some individuals were subsequently euthanized with 20% ethanol according to standard euthanasia protocols for amphibians while other individuals were toe-clipped for tissue sampling and then released. Liver or muscle tissues were taken from

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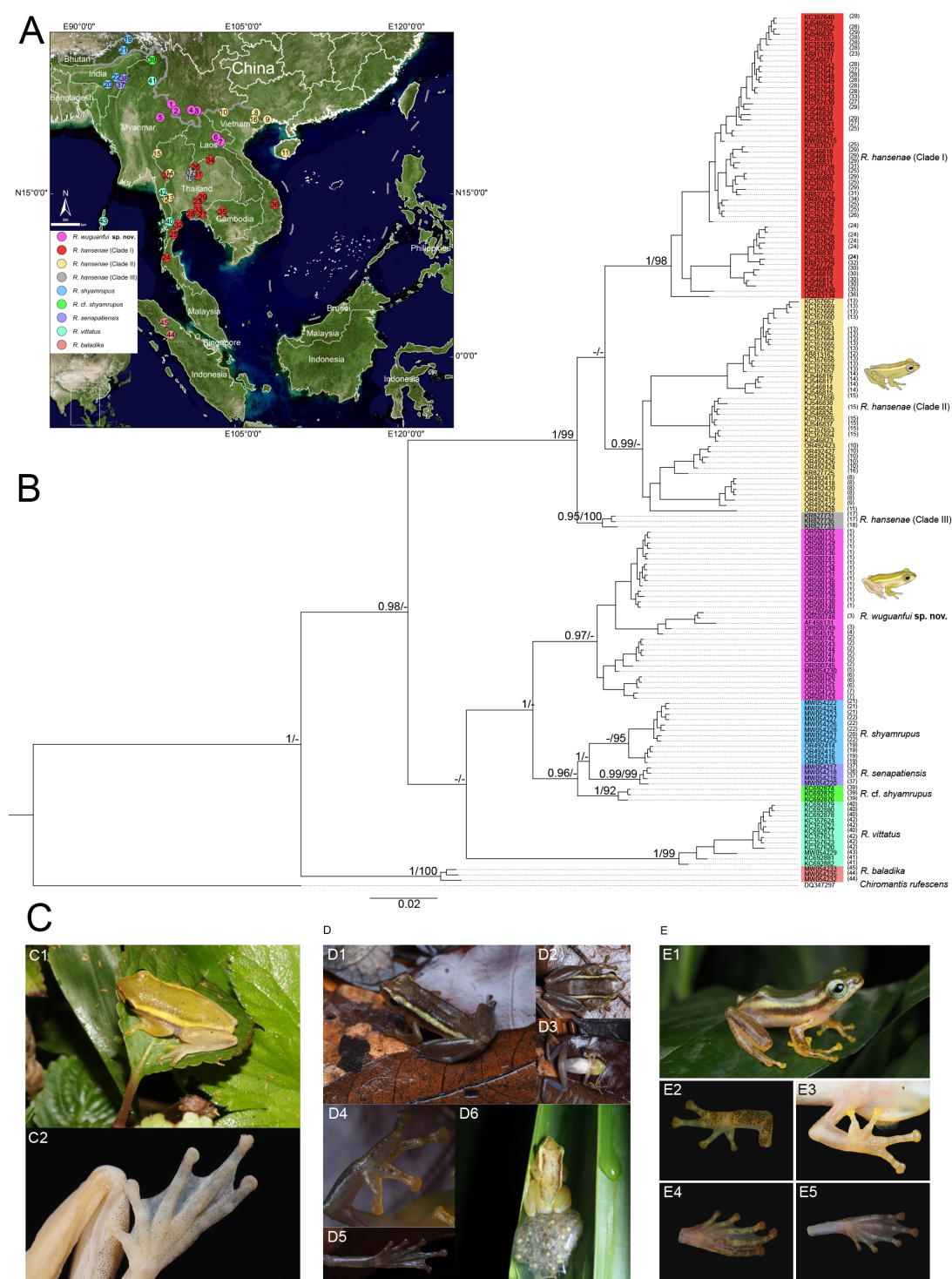


Figure 1 Sampling localities, phylogenetic relationship and morphological characteristics of *Rohanixalus*

A: Sampling localities of *Rohanixalus* used in this study. **B:** Phylogram of *Rohanixalus* resulting from analyses of a fragment of mitochondrial 16S rRNA gene. Nodal support values with Bayesian posterior probabilities (BPP) ≥ 0.95 /bootstrap support (BS) ≥ 70 were shown close to node. “—” denoted BPP < 0.95 and BS < 70 . Scale bar represented 0.1 nucleotide substitutions per site. Tips were labeled with genebank numbers and the localities corresponded to those in Supplementary Table S2 and Figure 1A. **C:** Specimens of *R. wuguanfui* sp. nov. from Nangun River, Cangyuan County, Lincang City, Yunnan, China. Photos by Xiao-Long Liu. **D:** Specimens of *R. hensenei* from Yongzhong Village, Nansheng Township, Wuzhishan City, Hainan, China. Photos by Ren-Da Ai. **E:** Specimens of *R. shyamrupus* from Buqun Lake, Beibeng Township, Medog County, Xizang, China. Photos by Xiao-Long Liu.

the euthanized specimens and preserved in 95% ethanol. Voucher specimens were fixed in 75% ethanol and deposited at Southwest University, Chongqing, China (Supplementary Table S2).

Morphological measurements were taken with digital slide

calipers to the nearest 0.1 mm and all measurement ratios were accurate to 0.01. Morphological terminology and measurement methods were the same as Fei et al. (2009) and Biju et al. (2014) and webbing formula followed Myers & Duellman (1982). Maturity and gender of the specimens were

determined by inspecting gonads through a small lateral or ventral incision (Supplementary Materials and Methods).

Phylogenetic relationships of matrilineal genealogies of *Rohanixalus* species were reconstructed using mitochondrial 16S rRNA gene (Simon et al., 1994). Sequences of *Rohanixalus* and representative outgroup (Biju et al., 2020) were downloaded from GenBank. Additionally, we added sequences from Laos, Vietnam, Cambodia and Myanmar (Supplementary Table S2). Bayesian inference (BI) was performed using MrBayes 3.2 (Ronquist et al., 2012). Maximum likelihood (ML) analysis was performed using RAXML v7.2.6 with the GTRGAMMA model of molecular evolution and the same partitioning scheme as in BI analysis. Mean genetic distances between and within species were calculated in MEGA v6.0.6.

Phylogenetic analysis recovered one new clade distinct from known species of *Rohanixalus*, and *R. hansenae* as three clades (Clades I, II and III; Figure 1B). BI and ML trees had almost identical topologies. However, terminal clades of ML trees had low support values (Figure 1B). The lineage of *R. vittatus* from Myanmar was recovered as sister to some samples from Yunnan and Xizang, with uncorrected pairwise 16S distances between *R. vittatus* and these samples of 11.4%–12.2%. Samples from Xizang and *R. shyamrupus* from India nested into a single clade with maximal uncorrected pairwise 16S distances of merely 0.9%. Uncorrected pairwise 16S distances between *R. hansenae* (Clade I) and another two clades (Clades II and III) ranged from 5.1%–7.2% (Supplementary Table S3).

Based upon congruence in genetic differentiation and diagnostic morphological features, the authors herein described one distinct lineage of *Rohanixalus* as *R. wuguanfui* sp. nov., reported *R. shyamrupus* as a new record for China and supplemented morphological data of *R. hansenae* in China.

Taxonomic accounts

Rohanixalus Biju, Garg, Gokulakrishnan, Chandrakasan, Thammachoti, Ren, Gopika, Bisht, Hamidy, and Shouche, 2020

Type species: *Ixalus vittatus* Boulenger, 1887

Diagnosis: A rhacophorid frog with the combination of (1) small to medium-sized adults (adult SVL=18–29 mm); (2) tympanum indistinct or weakly developed; (3) vomerine teeth absent; (4) entire dorsum and laterodorsal surfaces of limbs dappled with fine dark brown speckles, some speckles clumping together to form dark irregular spots or blotches over dorsum; (5) a pair of prominent to faint, continuous or discontinuous, contrasting light-colored dorsolateral stripes starting from tip of snout, extending over upper eyelid margins and ending adjacent to vent at either side; (6) groin and anterioposterior aspects of thigh without any prominent marking or coloration; (7) webbing between fingers absent, except a rudiment of web at the base between fingers III and IV; (8) foot webbing moderate, not beyond the second subarticular tubercle at either side of toe IV; and (9) eggs laid in terrestrial bubble nests (Biju et al., 2020).

Suggested common name: Rohan's tree frog (in English)/ cè tiáo shù wā (侧条树蛙属 in Chinese).

Distribution: Indian (Northeastern states and Andaman Islands); Myanmar; Thailand; Laos; Cambodia; China (Yunnan, Guangxi, Hainan and Xizang); Vietnam; Malaysia; and Indonesia (Sumatra).

Content: The genus contains nine recognized species: *Rohanixalus baladika* (Riyanto & Kurniati, 2014), *R. hansenae* (Cochran, 1927), *R. marginis* (Chan, Grismer, Anuar, Quah, Grismer, Wood, Muin, and Ahmad, 2011), *R. nauli* (Riyanto & Kurniati, 2014), *R. punctatus* (Wilkinson, Win, Thin, Lwin, Shein, and Tun, 2003), *R. senapatiensis* (Mathew & Sen, 2009), *R. shyamrupus* (Chanda & Ghosh, 1989), *R. vittatus* (Boulenger, 1887) and *R. wuguanfui* sp. nov.

Rohanixalus wuguanfui sp. nov.

(Supplementary Table S4; Figure 1C1, C2)

Chirixalus vittatus — Yang, 1991, Amphibia and Reptilia of Yunnan, 198; Yang and Rao, 2008, Amphibia and Reptilia of Yunnan, 106; Fei, Hu, Ye, Huang, 2009, Fauna Sinica. Amphibia. Volume II. Anura, 734 (in part).

“*Rohanixalus* sp.1” — Biju, Garg, Gokulakrishnan, Sivaperuman, Thammachoti, Ren, Gopika, Bisht, Hamidy, and Shouche, 2020, Zootaxa, 4878, 29.

“*Rohanixalus* sp.2” — Biju, Garg, Gokulakrishnan, Sivaperuman, Thammachoti, Ren, Gopika, Bisht, Hamidy, and Shouche, 2020, Zootaxa, 4878, 29.

Diagnosis: A *Rohanixalus* with the combination of (1) small, narrow adult body size (adult male SVL=20.2–23.1 mm; adult female SVL=23.7 mm); (2) snout sub-elliptical to nearly pointed in dorsal view; (3) tympanum indistinct; (4) horizontal pupil; (5) vomerine teeth absent; (6) skin of limbs is beige; (7) dorsal skin yellowish-green with light-yellow speckles; (8) pair of light-yellow dorsolateral stripes starting from eyes, extending over vent and then terminating; and (9) toe webbing up to a half below first subarticular tubercle on toe I and one quarter below first subarticular tubercle on toe V. Morphological comparisons with other species are listed in Supplementary Materials.

Holotype: SWU 001965, an adult male collected from Nangun River (N23.279522°, E99.212052°, 1934.56 m a.s.l.; Figure 1A), Cangyuan County, Lincang City, Yunnan, China, on 20 June 2018 by Xiao-Long Liu.

Paratypes: Three adult males SWU 001967, SWU 001969 and SWU 001970, one adult female SWU 001968, same data as holotype. One adult male 004605, collected from Yingpanhe Reservoir (E101.506986°, N22.653631°, 1363.75 m a.s.l.; Figure 1A), Kangping Township, Jiangcheng County, Pu'er City, Yunnan, China, on 25 June 2020 by Xiao-Long Liu.

Description of holotype: Adult male; body size small and narrow (SVL=21.6 mm); head length larger than head width (HL=7.5 mm; HW=6.0 mm); top of head relatively flat; snout sub-elliptical to nearly pointed in dorsal view; snout length smaller than interorbital distance (SL=2.8 mm; IOS=3.5 mm); canthus rostralis distinct, loreal region slightly concave; tympanum indistinct (TYD=1.5 mm); interorbital distance wider than maximal width of upper eyelid (INS=2.2 mm; UEW=1.4 mm); nostril slightly closer to tip of snout than to anterior ocular corner; tongue pyriform, with deep notch at posterior tip; vomerine teeth absent; pineal ocellus absent; eyes moderately large (EL=2.9 mm) and protruding, pupil horizontal; supratympanic fold indistinct; external single subgular vocal sac.

Forelimbs robust (FAHL=10.0 mm); relative finger length: I<II<IV<III; tips of all four fingers expanded into discs; all fingers with lateral dermal fringes bilaterally; subarticular tubercles distinct and spherical; supernumerary tubercles below the base of finger indistinct; inner and outer metacarpal tubercle indistinct and small warts on palm; nuptial pad

invisible; finger webbing rudimentary.

Hindlimbs slender and long; tibiotarsal articulation reaching eye when hindlimb stretched alongside of body; heels overlapping when thighs flexed vertical to axis of body; relative toe length: $I < II < III \approx V < IV$; toe discs smaller than finger discs; inner metatarsal tubercle small, outer metatarsal tubercle absent; toe webbing formula $I1^{1/2}-2II1^{1/4}-2III1^{1/4}-2IV2-1^{1/4}V$ (Supplementary Table S4).

Dorsal skin smooth and ventral skin covered with dense flat warts.

Coloration of holotype in life: Skin of limbs beige; dorsal skin yellowish-green with light-yellow speckles; lateral surfaces of head and body (including tympanic region) and dorsal surfaces of limbs with fine light brown speckles forming larger patches; pair of light-yellow dorsolateral stripes starting from eyes, extending over vent and then terminating.

Coloration of holotype in preservative: Similar to that in life except dorsal color faded to light grey and skin of limbs faded to milky white packed with fine light brown speckles.

Variation: Spots on some individuals less obvious than in holotype. Both SWU 004605 and SWU 004606 have darker body coloration, without spots on back.

Etymology: The new species name is a patronym for the late Chinese herpetologist Prof. Guanfu Wu from Chengdu Institute of Biology, Chinese Academy of Sciences. The new species was named after Prof. Wu in recognition of his lifetime contributions to herpetological research in China and his great guidance to younger generations. We suggest the Chinese formal name as “wú shì cè tiáo shù wā” (吴氏侧条树蛙).

Sexual dimorphism: Mature males have external single subgular vocal sac and nuptial pad invisible while mature females have well-developed ovaries and body size slightly larger than males.

Distribution: This species is distributed in Cangyuan County, Lincang City, Jiangcheng County, Pu'er City and Ximeng County in southern Yunnan. Based upon phylogenetic relationships (Figure 1B), it is also found in western Myanmar and northern Laos.

Ecology: This species is usually found on secondary shrubs adjacent to ponds at an altitude of up to 2 000 m. Two sympatric amphibian species, i.e. *Tylototriton shanjing* and *Gracixalus yunnanensis*, were also found at the type locality.

***Rohanixalus shyamrupus* (Chanda & Ghosh, 1989) — New Record for China**

(Supplementary Table S4; Figure 1E1–E5)

Philautus shyamrupus — Chanda & Ghosh, 1989, Journal of the Bombay Natural History Society, 86, 215. Type locality: Hornbill, Namdapha Tiger Reserve and proposed Biosphere Reserve, India; holotype: ZSIC A 7944 (formerly ZSI-KZ 313).

Chirixalus shyamrupus — Bossuyt and Dubois, 2001, Zeylanica, 6, 58.

Chirixalus shyamrupus — Chen, Prendini, Wu, Zhang, Suwannapoom, Chen, Jin, Lemmon, Lemmon, Stuart, Raxworthy, Murphy, Yuan, and Che, 2020, Molecular Phylogenetics and Evolution, 145 (106724), 5.

Chirromantis shyamrupus — Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan, Raxworthy, Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green, and Wheeler, 2006, Bulletin of the American Museum of Natural History, 297, 367.

“*Feihyla vittatus*” — Che, Jiang, Yan, Zhang, 2020, Amphibians and Reptiles in Xizang Diversity and Evolution,

327.

“*Rohanixalus* cf. *shyamrupus*” — Biju, Garg, Gokulakrishnan, Sivaperuman, Thammachoti, Ren, Gopika, Bisht, Hamidy, and Shouche, 2020, Zootaxa, 4878, 29.

Rohanixalus shyamrupus — Biju, Garg, Gokulakrishnan, Sivaperuman, Thammachoti, Ren, Gopika, Bisht, Hamidy, and Shouche, 2020, Zootaxa, 4878, 29.

English name: Hornbill bubble-nest frog. Shyamrup's bush frog (Dinesh et al., 2009). Shyamrup's bubble-nest frog (Biju et al., 2020).

Chinese name: This species has been found in China only in Medog County, Xizang so that its Chinese formal name is recommended as “xǐ shān cè tiáo shù wā” (喜山侧条树蛙).

Chinese specimens: Two adult males (SWU 0001135, SWU 0001137) and two adult females (SWU0001136, SWU0001138) were collected from Buqun Lake, Beibeng Township, Medog County, Xizang, China (E95.224565°, N29.252888°, 1424 m a.s.l.; Figure 1A).

Diagnosis of Chinese specimens: A *Rohanixalus* with an unique combination of (1) small and narrow adult size (adult male SVL=23.0 mm; adult female SVL=23.3–24.0 mm); (2) snout sub-elliptical to nearly pointed in dorsal view; (3) tympanum distinct; (4) horizontal pupil; (5) vomerine teeth absent; (6) skin of limbs brown; (7) dorsal skin dark brown or dark green and with reddish tinge; (8) lateral surfaces of head and body (including tympanic region) and dorsal surfaces of limbs dense with fine light brown speckles forming larger patches; (9) pair of white dorsolateral stripes starting from eyes, extending over vent and then terminating; (10) toe webbing up to one quarter below first subarticular tubercle on toe I and first subarticular tubercle on toe V. Morphological comparisons with other species were listed in Supplementary Materials.

Diagnosis of Chinese specimens: A *Rohanixalus* with an unique combination of (1) small and narrow adult size (adult male SVL=23.0 mm; adult female SVL=23.3–24.0 mm); (2) snout sub-elliptical to nearly pointed in dorsal view; (3) tympanum distinct; (4) horizontal pupil; (5) vomerine teeth absent; (6) skin of limbs brown; (7) dorsal skin dark brown or dark green and with reddish tinge; (8) lateral surfaces of head and body (including tympanic region) and dorsal surfaces of limbs dense with fine light brown speckles forming larger patches; (9) pair of white dorsolateral stripes starting from eyes, extending over vent and then terminating; (10) toe webbing up to one quarter below first subarticular tubercle on toe I and first subarticular tubercle on toe V. Morphological comparisons with other species were listed in Supplementary Materials.

Description of Chinese specimens: Small, narrow adult body size (adult male SVL=23.0 mm; adult female SVL=23.3–24.0 mm); snout length larger than or equal to interorbital distance; canthus rostralis distinct, loreal region slightly concave; tympanum indistinct; interorbital distance wider than maximum width of upper eyelid; nostril slightly closer to tip of snout than to anterior ocular corner; tongue pyriform, with deep notch at posterior tip; vomerine teeth absent; pineal ocellus absent; eyes moderately large; pupil horizontal; supratympanic fold indistinct.

Forelimbs robust; relative finger length: $I < II < IV < III$; tips of all four fingers expanded into discs; all fingers with lateral dermal fringes bilaterally; subarticular tubercles are distinct and spherical; supernumerary tubercles below the base of finger are indistinct; inner and outer metacarpal tubercle indistinct

and small warts on palm; finger webbing rudimentary.

Hindlimbs slender and long; tibiotarsal articulation reaching eyes when hindlimb stretched alongside of body, heels overlapping when thighs flexed vertical to axis of body; relative toe length: $I < II < III \approx V < IV$; toe discs smaller than finger discs; inner metatarsal tubercle small, outer metatarsal tubercle absent; toe webbing formula $I 1^{1/4} - 2 II 1 - 2 III 1 - 1^{3/4} IV 1^{3/4} - 1 V$ (Supplementary Table S4).

Dorsal skin smooth and ventral skin covered with dense flat warts.

Coloration in life: Skin of limbs brown, dorsal skin dark brown or dark green and with reddish tinge; lateral surfaces of head and body (including tympanic region) and dorsal surfaces of limbs dense with fine light brown speckles forming larger patches; and pair of yellow dorsolateral stripes starting from eyes, extending over vent and then terminating.

Coloration in preservative: Similar to that in life except dorsal coloration faded to light grey and skin of limbs faded to milky white dense with brown spines.

Variation of Chinese specimens: SWU 0001136 has shorter hand length and snout length than other specimens. Reddish coloration on dorsal skin not apparent in some individuals.

Sexual dimorphism: Mature males have external single subgular vocal sac and nuptial pad invisible while mature females have well-developed ovaries, body size slightly larger than males.

Distribution: This species is known to be distributed in northeastern India and southern Xizang, China.

Ecology: This species is found in China at an altitude of 1 500 m. Five sympatric amphibian species, i.e. *Duttaphrynus stuarti*, *Liurana medogensis*, *Rhacophorus translineatus*, *Kurixalus naso* and *Polypedates braueri*, co-existed with this species in Medog County.

Comment

Diversification of *Rohanixalus* in China: A phylogeographic assessment of *Rohanixalus* in China would require additional sampling of intermediate localities and the determination of distributional ranges of *R. wuguanfui*, *R. hansenae* and *R. shyamrupus*. *Rohanixalus vittatus* is widely distributed and its type locality is in Bhamò, Myanmar (Biju et al., 2020), adjacent to southwestern region of Yunnan. *Rohanixalus vittatus* may occur in China close to Yunnan border. However, no sample for verification is currently available. Samples previously identified as *R. vittatus* in China were updated as *R. wuguanfui* and *R. hansenae* in the present study. This region consists of north-south oriented mountains and highlands and several species of amphibians and reptiles are endemic to this region (Bernstein et al., 2020; Chen et al., 2021; Zaw et al., 2019). More sampling and further analysis are required for determining whether or not high-elevation areas in northern Myanmar and tropical regions in extreme southern China have led to the diversification of *Rohanixalus* species. In this study and Biju et al. (2020), phylogenetic analyses indicated that *R. hansenae* contains three mitochondrial clades corresponding to *R. hansenae* (= *R. hansenae* Clade I), *R. cf. hansenae* 1 (= *R. hansenae* Clade II) and *R. cf. hansenae* 2 (= *R. hansenae* Clade III). Due to insufficient morphological data, we still consider these three clades as belonging to the single species “*R. hansenae*”. Further taxonomic studies on this group require more sampling of intermediate localities and more integrative evidence, such as bioacoustics, osteology, larval

morphology and nuclear DNA, to better understand cryptic diversity within *R. hansenae*.

Taxonomy of *Rohanixalus shyamrupus*: *Rohanixalus shyamrupus* was described from Namdapha Biosphere Reserve from northeastern India, adjacent to southern Tibetan region of China. Che et al. (2020) referred the *Rohanixalus* species from Medog County, Xizang, China as *R. vittatus* due to its nestling within a clade of “*R. vittatus*” from Kachin, Myanmar. Biju et al. (2020) referred to *Rohanixalus* species from Kachin as *R. cf. shyamrupus*. In the present study, phylogenetic analysis revealed that the sample from Medog County, Xizang, China is nested within the clade of *R. shyamrupus* from other localities, with uncorrected pairwise 16S distances between *R. shyamrupus* and the sample from Medog County of merely 0.9%. These data suggest that the above Medog samples should be named as *R. shyamrupus*. However, some differences existed in morphological measurements of our Medog County sample to other *R. shyamrupus*. These differences are primarily reflected in ratios of SL/EL, EL/HL and TYD/EL. And these phenotypic changes may just be geographic-based intraspecific variations. *Rohanixalus senapatiensis* is also nested within the clade of *R. shyamrupus*. More sampling in intermediate areas, as well as more loci in molecular data, are required for defining species boundaries within this clade.

NOMENCLATURAL ACTS REGISTRATION

The electronic version of this article in portable document format will represent a published work according to the International Commission on Zoological Nomenclature (ICZN), and hence the new names contained in the electronic version are effectively published under that Code from the electronic edition alone (see Articles 8.5–8.6 of the Code). This published work and the nomenclatural acts it contains have been registered in ZooBank, the online registration system for the ICZN. The ZooBank LSIDs (Life Science Identifiers) can be resolved and the associated information can be viewed through any standard web browser by appending the LSID to the prefix <http://zoobank.org/>.

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SCIENTIFIC FIELD SURVEY PERMISSION INFORMATION

Permission for field surveys was granted by the Science and Technology Department of Xizang in the Second Tibetan Plateau Scientific Expedition and Research Program (permit No. [2021]157-1).

SUPPLEMENTARY DATA

Supplementary data to this article can be found online.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

Z.Y.Y. and J.C. conceived and designed the study. R.D.A. and X.L.L. conducted the surveys. B.L.S., J.M.B., C.S. and S.C. prepared the data. X.L.L. and J.K.H. analyzed the data. X.L.L. and J.K.H. wrote the paper. All authors read and approved the final version of the manuscript.

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