



New Distributional Records of the Baibung Small Treefrog, Theloderma baibungense (Jiang, Fei, and Huang 2009) (Anura: Rhacophoridae) from Mizoram, India, with Comments on Taxonomy, Natural History, and Conservation Status

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The genus *Theloderma* Tschudi 1838 (Bug-eyed Treefrogs) comprises 26 currently recognized species that are distributed in northeastern India, Myanmar, southern China, and throughout southeastern Asia (Frost 2021). Information on these frogs is very limited and species delineation for this group is quite challenging, largely due to morphological similarity but also because many species are poorly represented in museum collections, with some known only from a single or a few sampling sites (Nguyen et al. 2014, 2016). The Baibung Small Treefrog (Theloderma baibungense) is known from the type locality in Beibung, Medog County, Tibet, China, to northeastern India (Arunachal Pradesh, Assam, and Nagaland) and northeastern Bangladesh (Lawachara National Park) (Frost 2021). Members of the T. asperum species complex from southern Asia have been identified as either T.



Fig. 1. Baibung Small Treefrogs (Theloderma baibungensis) from Mizoram, India. Photograph by H.T. Lalremsanga.

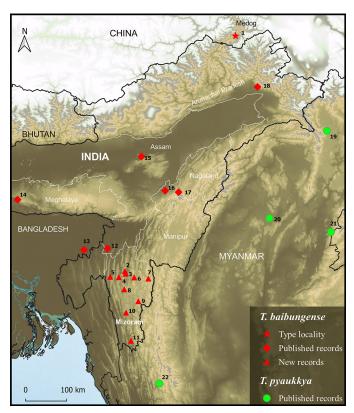


Fig. 2. Map showing distributional records of Baibung Small Treefrogs (Theloderma baibungensis). 1. Type locality in Medog, China (red star); new records from Mizoram, India (red triangles): 2. Sihphir, 3. Muthi, 4. Reiek, 5. Dampa Tiger Reserve, 6. Saitual, 7. Murlen National Park, 8. Samlukhai, 9. North Vanlaiphai, 10. Theiriat, 11. Palak National Wetland; and previously published records (red diamonds): 12. Dosdewa, 13. Lawachara, 14. Tura, 15. Kaziranga National Park, 16. Toulizie, 17. Sechu, 18. Dibang. Published records of the Burmese Camouflaged Frog (Theloderma pyaukkya) (green circles): 19–22.

Table 1. Measurements of Baibung Small Treefrogs (*Theloderma baibungensis*) from Mizoram, India. Abbreviations: SVL = snout-vent length, AG = distance from posterior base of forelimb at its joining with body to anterior base of hindlimb at its joining with body, HL = head length, HW = head width, HD = head depth, FIOD = fore-interorbital distance, HIOD = hind-interorbital distance, ED = eye diameter, UEL = greatest diameter of upper eyelid, SED = greatest depth of upper eyelid, TDH = horizontal diameter of tympanum, TDV = vertical diameter of tympanum, ESL = tip of snout to eye distance, TED = tympanum-eye distance, IND = internarial distance, END = eye to nostril distance, MOP = mandible to posterior orbital distance, MOA = mandible to anterior orbital distance, MN = mandible to nostril distance, FLL = length of forelimb from tip of disc of finger III to axilla, ABL = length of antebrachium from wrist to elbow, PL = length of palm tip of disc of finger III to wrist, FD1 = width of first finger disc, FD2 = width of second finger disc, FD3 = width of third finger disc, FD4 = width of fourth finger disc, FFL1 = first finger length, FFL2 = second finger length, FFL3 = third finger length, TL = tibia length, FOT = length of hindlimb from tip of disc of toe IV to posterior edge of tibia, TD1 = width of first toe disc, TD2 = width of second toe disc, TD3 = width of third toe disc, TD4 = width of fourth toe disc, TD5 = width of first toe disc, FTL1 = first toe length, FTL2 = second toe disc, FTL1 = first toe length, FTL2 = second toe disc, FTL1 = first toe length, FTL2 = second toe length.

Voucher									MZMU			
No.	1291	1846	1966	1292	1633	1826	2108	2319	2023	2594		
Sex	F	F	F	M	M	M	Juvenile	M	M	F		
SVL	30.6	30.8	29.9	31	31.5	30.3	17.2	30.8	31.3	28.3		
AG	13.8	17.2	15.9	15.2	13.8	17	6.4	14.1	14.8	12.4		
HL	10.9	12.7	12.5	12.1	12.8	13	6.5	13.2	13.4	11.9		
HW	10.2	11.2	10.7	11.1	11.1	11.7	5.6	12.4	12.6	10.6		
HD FIOD	5 5.9	4.2 5.5	4.7 5.8	4.6 6.3	6.5 7.5	4.9 6.4	3.5 3.9	6.8 7.9	6.7 8.1	4.4 5.9		
HIOD	8.5	8.4	8.9	8.1	9.4	9.2	5.5	9.8	9.9	7.8		
ED	2.9	2.9	2.8	3.1	3.4	3.2	1.6	3.7	3.8	2.9		
UEL	1.9	1.9	2.0	2	2.1	2.3	1.0	2.6	2.7	1.7		
SED	4.4	3.5	3.7	4	6.1	4.6	2.9	6.5	6.8	3.7		
TDH	2.4	2.7	2.9	2.3	2.3	2.7	1.9	2.6	2.8	2.1		
TDV	2.4	2.3	2.4	2.1	2.1	2.5	1.1	2.9	3	2.1		
ESL	4.9	5.6	5.5	5.3	5.6	5.7	3.3	5.8	6.2	5.1		
TED	1.1	0.9	0.8	0.9	1.1	1.1	0.8	1.3	1.4	0.7		
IND	2.5	2.9	2.3	2.9	2.8	2.9	1.5	3	3.2	2.2		
END	2.9	3.4	3	3.3	3.6	3.5	1.7	3.7	3.9	2.8		
MOP	2.8	4.1	5.1	4.9	4.9	4.3	2.2	5.2	5.4	4.6		
MOA	5.6	7.4	7.8	8.1	7.5	7.3	4.8	7.8	7.9	7.5		
MN	9.5	10.2	11.5	11.3	10.9	10.4	5.7	11.2	11.5	11.2		
FLL	16.8	17.5	16.1	15.9	17.1	16.9	11	17.4	17.6	15.9		
ABL	6.8	6.9	7.2	7.6	7	6.6	3.4	7.7	7.8	7.2		
PL	8.3	7.9	8.8	7.4	9	8.7	4.8	9.4	9.5	8.5		
FD1	1.2	0.7	0.9	0.8	1.3	0.8	0.4	1.4	1.5	0.8		
FD2	1.7	1	1.3	1.4	1.8	1.1	0.5	1.9	2.1	1.2		
FD3	2	2.1	1.2	1.3	2.4	1.5	0.7	2.8	2.9	1.2		
FD4	1.7	1.1	1.4	1.3	2.3	1.3	0.5	2.6	2.7	1.3		
FFL1	2.9	2.6	2.4	2.5	2.3	2.2	1.2	2.8	2.8	2.4		
FFL2	4	3.7	4.3	3.3	3.3	4.1	1.5	3.6	3.8	3.6		
FFL3	5.2	6.9	5.9	5	6	5.7	2.7	6.4	6.5	5.4		
FFL4	4.5	5	4.7	4.4	4.1	4.7	2	4.4	4.6	4.3		
NPL	-	-	-	1.6	2.7	2.6	-	2.8	2.9	-		
HLL	42	42.4	46.4	43.2	46.9	44.7	23.3	44.6	44.9	42.1		
FL	14.3	13.9	15.1	13.3	14.7	13.5	6.3	15.2	15.4	12.9		
TL	15.6	14.4	16.2	14.9	16.3	14.8	7.3	16.6	16.9	15.4		
FOT	18.1	19.6	20.4	18.5	20.3	19.6	9.9	20.5	20.7	0.6		
TD1	0.9	0.7	0.9	0.7	1.1	0.6	0.2	1.3	1.5	0.6		
TD2	1.1	1	1	1	1.5	0.7	0.3	1.7	1.7	1		
TD3	1.1	1.1	0.9	0.9	1.5	0.7	0.4	1.7	1.8	0.9		
TD4	1.2	1.3	1.1	0.9	1.3	0.8	0.5	1.5	1.6	1.1		
TD5	0.94	1	0.9	1.2	1.4	0.9	0.5	1.6	1.8	0.8		
FTL1	2.1	2.6	4.3	2.2	3.7	3.2	1.2	3.8	3.9	2.3		
FTL2	4	3.9	6.1	4.5	5.2	4.8	1.8	5.7	6.1	2.2		
FTL3	6.4	6.3	8.9	7.2	7.1	6.9	2.9	7.4	7.5	6.2		
FTL4	8	8.9	11.7	8.9	8.2	8	4.4	8.8	9	7.9		
FTL5	6.3	6.1	8.3	7.2	6.2	6.1	3.6	6.7	6.9	6.1		

asperum or *T. albopunctatus* (Liu and Hu 1962), but genetic evidence has revealed that frogs from central and northern Myanmar, Bangladesh, and northeastern India are *T. baibungense* (Hou et al. 2017; Poyarkov et al. 2018; Hakim et al. 2020). Moreover, these frogs are morphologically identical to the Burmese Camouflaged Frog (*T. pyaukkya*) (Dever 2017; Hakim et al. 2020) and have been considered conspecific with *T. baibungense* (Poyarkov et al. 2018; Hakim et al. 2020), although Poyarkov et al. (2018) suggested further taxonomic reassessment of the *T. pyaukkya* group because of the high genetic divergence between lineages. Nevertheless, *T. baibungense* is easily distinguished from sympatric rhacophorids by the splattered brown-and-white colored dorsum that resembles a tree fungus or bird droppings (Ahmed et al. 2009) and provides an effective camouflage in its forest habitats (Dever 2017). Herein we present updated distributional records in northeastern India and comment on morphology, conservation status, and phylogenetic placement of the northeastern Indian specimens.

During opportunistic surveys in 2016–2020, we collected 10 specimens of T. baibungense (Fig. 1) from 10 localities in Mizoram, India (Fig. 2). We extracted liver tissues for genetic analysis and fixed specimens in 10% buffered formalin before transferring them to 70% ethanol, depositing them in the Department Museum of Zoology, Mizoram University (MZMU), and measuring them as in Jiang et al. (2009). We amplified partial 16S rRNA genes using primers L02510 (Palumbi 1996) and H03063 (Rassmann 1997), and compared them to 23 congeneric sequences retrieved from the NCBI database. Using MEGA 7 (Kumar et al. 2016), we aligned sequences using the MUSCLE algorithm, estimated the Kimura 2 parameter (K2P) genetic distance, and constructed a maximum-likelihood phylogenetic tree with 1,000 bootstrap replicates using the model GTR+G based on the lowest Bayesian Information Criterion with the Mawblang Toad (Bufoides meghalayanus) as the out-group.

Frogs in this study were relatively large (SVLs = 28.3–31.3 mm) (Table 1), corresponding to the range of 28.3–31.5 mm in Ao et al. (2003), whereas SVLs in the type series were 15.00–16.20 mm (Jiang et al. 2009), which is more similar to the sizes of *T. albopuncatum* (Hou et al. 2017). Morphological data from the original descriptions suggested that *T. asperum*, *T. albopunctatum*, and *T. baibungense* were closely related. However, *T. baibungense* can be easily distinguished from the other two species by various morphological features: (1) Smooth dorsal skin without warts in *T. baibungense* vs. small

warts in *T. albopunctatum*, (2) the absence of a vocal sac in *T. asperum* vs. a pair of inner vocal sacs in *T. albopunctatum* and *T. baibungense*, and (3) the tibiotarsal articulation reaching nearly the tip of the snout in *T. asperum* vs. reaching the eye in *T. albopunctatum* and *T. baibungense* (Fig. 3) (Hou et al. 2017). Consequently, we inferred that the small SVLs of *T. baibungense* in the type series probably was attributable to small sample size, as only two males were included.

The ML phylogenetic reconstruction (Fig. 4) clearly placed *T. baibungense* (OK474164–6) with *T. baibungense* (KU981089) from China by a well-supported node (bootstrap = 100), formed a distinct clade with respect to congeners, and was strongly clustered in a single clade deeply nested in the *Theloderma* clade. The genetic divergence (K2P) between our samples (*T. baibungense*) and type material from Tibet (China) was 1.00%, whereas the average interspecific K2P genetic distance was 10% (Table 2), confirming the presence of *T. baibungense* in Mizoram.



Fig. 3. Tibiotarsal articulation reaching the eye in a Baibung Small Treefrog (*Theloderma baibungensis*).

The taxonomy of the genus *Theloderma* has undergone several revisions and has been subjected to intensive phylogenetic studies (Rowley et al. 2011; Dever 2017; Nguyen et al. 2016; Poyarkov et al. 2015, 2018), but understanding of the diversity of the genus is far from complete (Poyarkov et

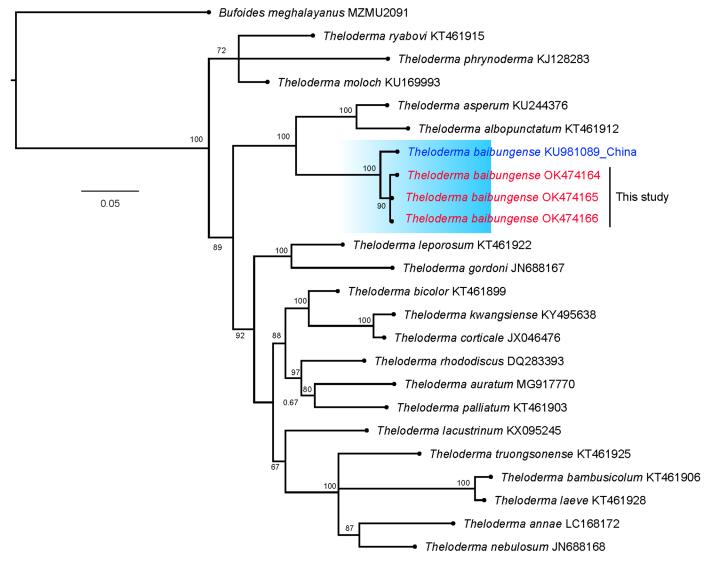


Fig. 4. Maximum-likelihood phylogram (16S rRNA) of the Baibung Small Treefrog (*Theloderma baibungensis*) and related species. Numbers at nodes represent bootstrap support. The Mawblang Toad (*Bufoides meghalayanus*) (MZMU2091) was used as the outgroup.

CNIA	Species											K2	p dista	nce										
<u>SNo</u>		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	T. baibungense OK474164																							
2	T. baibungense OK474165	0.00			1				1													1		
3	T. baibungense OK474166	0.00	0.00										[1						
4	T. baibungense KU981089	0.01	0.01	0.02									[
5	T. albopunctatum KT461912	0.10	0.10	0.10	0.09																			
6	T. annae LC168172	0.13	0.13	0.13	0.12	0.15																		
7	T. asperum KU244376	0.09	0.09	0.09	0.09	0.05	0.14																	
8	T. auratum MG917770	0.13	0.13	0.13	0.13	0.13	0.11	0.12																[
9	T. bambusicolum KT461906	0.13	0.13	0.13	0.13	0.13	0.13	0.12	0.14															
10	T. bicolor KT461899	0.10	0.10	0.11	0.11	0.12	0.10	0.11	0.08	0.13														
11	T. corticale JX046476	0.12	0.12	0.12	0.12	0.14	0.10	0.13	0.09	0.13	0.06													
12	T. gordoni JN688167	0.10	0.10	0.10	0.11	0.14	0.14	0.13	0.13	0.15	0.10	0.11							1					
13	T. kwangsiense KY495638	0.13	0.13	0.13	0.13	0.14	0.10	0.14	0.10	0.14	0.06	0.01	0.12											
14	T. lacustrinum KX095245	0.12	0.12	0.12	0.12	0.13	0.11	0.12	0.10	0.15	0.07	0.10	0.12	0.11										
15	T. laeve KT461928	0.13	0.13	0.14	0.13	0.13	0.12	0.13	0.13	0.02	0.13	0.13	0.15	0.14	0.14									
16	T. leporosum KT461922	0.10	0.10	0.10	0.10	0.12	0.11	0.12	0.10	0.14	0.08	0.09	0.08	0.10	0.10	0.13								
17	T. moloch KU169993	0.10	0.10	0.11	0.11	0.11	0.13	0.11	0.11	0.12	0.09	0.10	0.11	0.11	0.10	0.12	0.09							
18	T. nebulosum JN688168	0.11	0.11	0.12	0.11	0.13	0.08	0.13	0.10	0.10	0.08	0.09	0.12	0.09	0.12	0.10	0.08	0.10						
19	T. palliatum KT461903	0.11	0.11	0.12	0.12	0.13	0.13	0.12	0.08	0.15	0.07	0.09	0.11	0.10	0.09	0.14	0.11	0.12	0.12					
20	T. phrynoderma KJ128283	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.12	0.15	0.13	0.15	0.13	0.13	0.10	0.13	0.14				
21	T. rhododiscus DQ283393	0.10	0.10	0.10	0.10	0.11	0.13	0.10	0.08	0.12	0.06	0.09	0.11	0.10	0.09	0.13	0.09	0.09	0.10	0.07	0.14			
22	T. ryabovi KT461915	0.13	0.13	0.13	0.13	0.14	0.14	0.13	0.13	0.13	0.12	0.12	0.13	0.13	0.13	0.12	0.12	0.06	0.12	0.13	0.12	0.11		
23	T. truongsonense KT461925	0.13	0.13	0.13	0.13	0.13	0.10	0.12	0.11	0.12	0.09	0.12	0.14	0.12	0.10	0.11	0.11	0.10	0.09	0.12	0.13	0.11	0.12	
24	Bufoides meghalayanus	0.17	0.17	0.18	0.17	0.18	0.18	0.18	0.19	0.18	0.19	0.18	0.18	0.18	0.19	0.18	0.19	0.16	0.18	0.17	0.19	0.18	0.18	0.18

Table 2. Estimated Kimura 2 parameter (K2P) genetic distances of the Baibung Small Treefrog (*Theloderma baibungensis*) and related species based on partial 16S rRNA gene sequences.

al. 2018). Nevertheless, the present phylogenetic analysis of the genus clearly demonstrated that the phylogenetic position of specimens from northeastern India (Mizoram) is nested within *T. baibungense* (KU243080; KU981089) with a genetic distance of only 1.6–1.7%. This supports the opinions of Hou et al. (2017) and Poyarkov et al. (2018), who stated that reports of *T. asperum* or *T. albopunctatus* from northeastern India and central and northern Myanmar should be referred to *T. baibungense*. Also, the new records reported herein include the southernmost locality records for the species, which almost bridges the known range of *T. pyaukkya* in Chin State of southern Myanmar.

Our specimens, encountered at elevations of ca. 235– 1,650 m asl, were collected from a road in front of Homestead Flower Garden, at the corner of an empty cement water tank, and along a forest trail on ground covered with leaf litter and twigs, in foliage, and on tree trunks. We found two individuals (MZMU 1291 and another escaped) inside a plastic container with an open lid filled with a small amount of water on 26 June 2018 in an abandoned farm house at the Sihphir locality in Mizoram; seven eggs (diameters = 1.2–1.4 mm) were stuck to the inside wall of the container and in nearby leaf litter.

The conservation status of *T. baibungense* is currently listed as Data Deficient (DD), reflecting uncertainties regarding the species' extent of occurrence, population status, and ecological requirements (IUCN SSC Amphibian Specialist Group 2020). These frogs are rarely encountered and the main threat to the species presumably is the loss of forest habitat (Purkayastha 2021). The species has not been evaluated under the Wildlife Protection Act (1972) of India. Based on

our experiences, we strongly suggest revising the conservation status of this cryptic frog from DD to Near Threatened (NT).

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