TAPROBANICA, ISSN 1800–427X. Vol. 14, No. 02 (2025): pp. 188–194, pl. 19.
Published by Research Center for Climate Change & Faculty of Mathematics & Natural Sciences, Universitas Indonesia, Depok 16424, INDONESIA.

http://www.taprobanica.org
https://doi.org/10.47605/tapro.v14i2.371

OPEN ACCESS

COMPARATIVE MORPHOLOGY AND ADVERTISEMENT CALL OF *Microhyla fissipes* BOULENGER, 1884 AND *M. heymonsi* VOGT, 1911 (AMPHIBIA: MICROHYLIDAE) FROM TAIWAN

Submitted: 15 October 2024, *Accepted*: 22 September 2025, *Published*: 16 October 2025
Subject Editor: Vladislav Gorin

Mahmudul Hasan[1,4]*, Chun-Fu Lin[2], Ha-Cheol Sung[3], Jiyoung Yun[3] & Masayuki Sumida[4]

[1] *Jamalpur Science and Technology University, Jamalpur-2012, Bangladesh*
[2] *Taiwan Biodiversity Research Institute, Jiji 552, Nantou, Taiwan*
[3] *Institute of Sustainable Ecological Environment, Chonnam National University, 61186 Gwangju, South Korea*
[4] *Amphibian Research Center, Hiroshima University, 1-3-1 Kagamiayam, Higashihiroshima, 739-8526, Japan*
**Corresponding authors.E-mail: E-mail: mhasan@jstu.ac.bd*

Abstract
We evaluated differences in morphology and advertisement calls of *Microhyla fissipes* and *M. heymonsi* from Nantou County, Taiwan, to better delineate the species and to improve our ability to identify them in the field. *M. heymonsi* in the tadpole stage is easily recognized due to the presence of an upturned funnel-like oral disc in the mouth, which has not been noted in other microhylids so far. While the two species exhibit similar call structures in temporal attributes with a series of calls each with rapidly repeating pulses, they were distinguishable with different pulse numbers per call and pulse rate. Mean call duration for *M. fissipes* and *M. heymonsi* was 0.31 ± 0.03 s (n = 97) and 0.36 ± 0.09 s (n = 153), respectively, with the calls comprising 14.3 ± 0.9 and 10.27 ± 2.09 repeating pulses with a pulse rate of 46.66 ± 2.65/s and 28.95 ± 2.91/s, respectively.

***Keywords*:** Bioacoustics, conservation, ecology, morphology, SE Asia, tadpole

Introduction

The genus *Microhyla* Tschudi, 1838 (rice or narrow-mouthed frogs) comprises one of the largest genera within the Microhylidae Günther, 1858. New species are continually being described in this genus using multiple data sets, including morphology, life history, and molecular data (e.g., Matsui *et al*. 2011, Hasan *et al*. 2014, Howlader *et al*. 2015, Gorin *et al*. 2020). Generally, species within the genus are diminutive (<30 mm snout-to-vent length), and many present challenges in identification because they are often phenotypically similar and cryptic, sharing external morphological attributes (Matsui *et al*. 2011, Hasan *et al*. 2014, Poyarkov *et al*. 2014, Garg *et al*. 2019, Atmaja *et al*. 2024). Currently, there are about 55 recognized species within this large genus (Garg *et al*. 2019, Frost 2024, Trofimets *et al*. 2024, Hoang *et al*. 2025). Due to recent advances in molecular methods,

including DNA sequencing of mitochondrial genes and proposed threshold values for species delimitation (>3% of 16S rRNA gene) proposed by Fouquet *et al*. (2007), many cryptic lineages may be present within the nominal *M. fissipes* Boulenger, 1884 (type locality "Formosa", Taiwan). Furthermore, the *M. heymonsi* Vogt, 1911 (originally described from "Formosa", Taiwan) species complex, previously assumed to be a single species (Garg *et al*. 2019, Gorin *et al*.2020).

The ornate chorus frog *M. fissipes,* and the dark-sided chorus frog *M. heymonsi* were first described by Boulenger (1884) and Vogt (1911), respectively, from Taiwan. One apparent nature of anuran reproductive behavior is to communicate through advertisement calls. Calling is a primary means of communication among anurans, but it also poses risks by attracting predators. Many researchers use advertisement call analyses to identify species. These qualitative characteristics are frequently employed in the taxonomic assessment of anuran species with wide geographical distributions, helping to corroborate their current taxonomic status. Bioacoustics calls are considered a crucial precursor to anuran reproductive activity (Toledo *et al*. 2015). Calls, typically produced by males, serve to attract conspecific females and act as passive signals to perform sexual activity during the breeding season (Toledo *et al*. 2015, Köhler *et al*. 2017). They also play an important role in prezygotic isolation, making them useful for resolving species boundaries (Köhler *et al*. 2017; Carvalho *et al*. 2020). Other call types can be emitted in different social contexts, for example, those produced by both males and non-receptive females when grabbed by another male (Duellman & Trueb 1994, Toledo *et al*. 2015).

Microhyla fissipes and *M. heymonsi* are common and widely distributed species. *Microhyla fissipes* lives in southern mainland China and Taiwan (type locality: Taiwan) (Matsui *et al*. 2005). According to Yuan *et al*. (2016), in Taiwan, *M. fissipes* is only found in the northeastern part of the Red River Valley and northward. In contrast, the closely related *M. mukhlesuri* (Mukhlesur's narrow-mouthed frog) is found in the southeastern part of that same river and throughout large parts of Southeast Asia, including the northern Malay Peninsula (Frost 2024). Additionally, Atmaja *et al*. (2024) renamed '*Microhyla* sp. aff. *fissipes*' from Sumatra to *M. mukhlesuri*, utilizing both molecular and morphological analysis. *Microhyla heymonsi* is distributed in Taiwan and mainland southern China, spanning from Zhejiang to Yunnan, including Hainan. Other populations consist of various named and unnamed species from Taiwan, mainland Myanmar (Bago, Kachin, Kayah, Shan, Yangon), and southern peninsular Myanmar (Mon, Tanintharyi), extending southward to peninsular Thailand (Frost 2024). *Microhyla butleri* is also present in Taiwan (Frost 2024), but is not included in our study as we do not have specimens. Recent molecular and morphological studies revealed some confusion among several lineages of *Microhyla* species, which require acoustic and additional external morphological data for clarification (Hasan *et al*. 2014, Kuramoto & Joshy 2006). Therefore, we present here the morphology for tadpoles and acoustic calls data for adults, which contribute to identifying these two species accurately in their early stages.

Materials and methods

Specimen collection. Specimens of *M. fissipes and M. heymonsi* were collected from two localities in Taiwan: Jiji and Yuchi Townships, Nantou County, Taiwan (see Fig. 1). We noted the wetland type and habitat type for each captured individual.

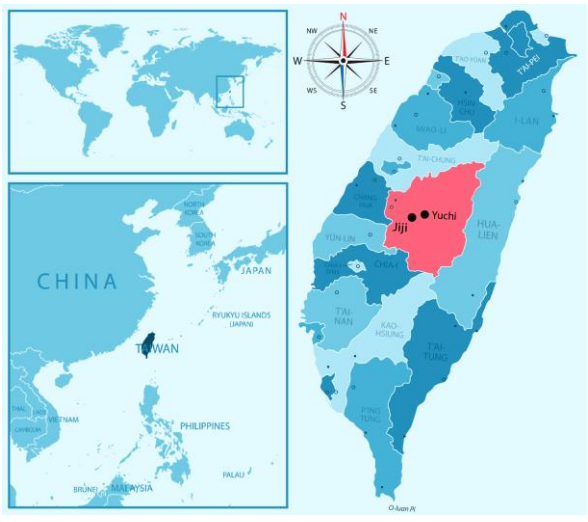

Figure 1. Sampling sites (black dots) in Jiji and Yuchi Townships, Taiwan

Identification of *M. heymonsi* and *M. fissipes* used diagnostic morphological characteristics described in Gaoshi & Pengxiang (2000), Chanda (2002), and Kabir *et al*. (2009). Identification was confirmed by local Taiwanese and Japanese herpetologists (Prof. Kuang-Yang Lue, Taiwan, and Prof. M. Kuramoto, Japan).

We followed the naming conventions of Frost (2024). While our focus was on morphology and advertisement calls of these two species, we included *M. nilphamariensis* data (Hasan *et al*. 2015) to enrich our analyses. We did not collect any *M. nilpamariensis* specimen from Taiwan; rather, it was previously sampled from Nilphamari, Bangladesh, with data from Hasan *et al*. 2015. Identity confirmed using mtDNA 16S data (Voucher number IABHU 4212, GenBank accession number LC090055). *Microhyla fissipes* from Taiwan was evaluated based on morphological data from our previous publications (Hasan *et al*. 2015).

Advertisement calls and bioacoustic analyses. The advertisement calls of *M. fissipes* and *M. heymonsi* were recorded daily, both in the morning and night, from July 30 to August 02, 2014, in Jiji and Yuchi Townships, Nantou County, Taiwan. We recorded and analyzed 97 calls (range 6- 24 calls per individual) from six individuals of *M. fissipes*, 153 calls (range 2 – 14 calls per individual) from 22 individuals of *M. heymonsi,* and 8 calls from a single individual of *M. nilphamariensis*. Spectrograms were generated using Raven Pro 1.6 (Cornell Laboratory of Ornithology, USA) with a 512-sample Fast Fourier Transform and a Hann smoothing window, resulting in a temporal resolution of 2 ms and a frequency resolution of 15 Hz. Sound oscillograms were produced after filtering around 300 – 6000 Hz to analyze the pulse pattern. For each advertisement call, we measured call duration (CD; sec.), number of pulses per call (NP), number of pulses per second (pulse rate, PR), and peak amplitude frequency within a call (peak frequency, PF; Hz), and intercall duration (ID; sec.) (Table 1, Fig. 2).

We tested for differences for each call attribute between *M. fissipes* and *M. heymonsi* using a t-test (average values from two species in SPSS version 21 statistical software [IBM Corporation, Armonk, New York. We tested for deviations from normality using the One-Sample Kolmogorov-Smirnov Test ($p < 0.05$), with no noted departures from normality. We generated box plots for each call characteristic, including the call data from the lone *M. nilphamariensis* for comparison. To evaluate patterns of differentiation among advertisement calls, we also performed principal component analysis (PCA) with Varimax rotation.

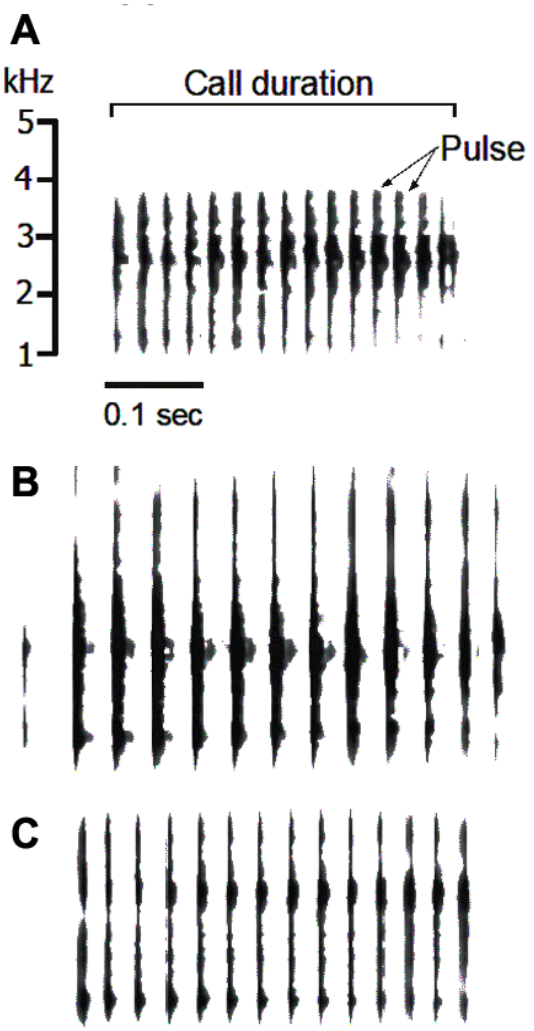

Figure 2. Parts of advertisement calls of **(A)** *Microhyla fissipes*, **(B)** *M. heymonsi,* and **(C)** *M. nilphamariensis*, where measurements of call duration (sec..), no of pulses per call, pulse rate per second, and max frequency of the calls (Hz) were used.

Table 1. Results of call measurements of *Microhyla fissipes, M. heymonsi,* and *M. nilphamariensis*. *n* = no. of individuals; N = no. of calls; CD = call duration (sec.); PF = peak frequency (Hz); NP = No. of pulses / call; PR = Pulse rate; ID = intercall duration (sec.)

Variable	*M. heymonsi* (*n* = 22)			*M. fissipes* (*n* = 6)			*M. nilphamariensis* (*n* = 1)		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
CD	0.36	0.09	153	0.31	0.03	97	0.42	0.01	8
PF	2734.0	431.8	153	2805.9	56.7	97	2713.1	1058.9	8
NP	10.27	2.09	153	14.28	0.89	97	15.00	0.00	8
PR	28.95	2.91	153	46.66	2.65	97	35.38	0.83	8
ID	0.90	0.35	132	0.41	0.11	96	0.69	0.12	8

Plate 19

Figure 3. Adult individuals (in life) of **(A, B)** *Microhyla fissipes*, **(C)** *M. heymonsi*, and **(D)** *M. heymonsi* laying eggs in water; tadpoles (in life) of **(E)** *M. fissipes* and **(F)** *M. heymonsi*; © Photo: M. Hasan and C-F. Lin

Results

Morphology. The live specimens (Fig.3) and their tadpoles (Figs. 3, 4) were distinguishable based on their physical characteristics, with mature *M. fissipes* (SVL 23–30 mm) significantly larger than both *M. heymonsi* (SVL 17–21 mm) and *M. nilphamariensis* (SVL 15–18 mm). Additionally, *M. fissipes* has a more robust body compared to the other two species. *Microhyla fissipes* exhibits variable dorsal coloration, typically ranging from brown and gray to having a greenish or brownish cast, often with scattered darker patterns. Sampled *M. heymonsi* displayed greenish or brownish dorsal coloration, occasionally adorned with minute black dots or blotches. Our observations also aligned with our previous *Microhyla* studies (Hasan *et al*. 2014, 2015). *Microhyla nilphamariensis* typically exhibits a brownish or reddish tint on its back, accompanied by irregular darker patterns. It does not possess the noticeable vertebral line evident in *M. heymonsi* (see Hasan *et al*. 2015). The toe pads of *M. fissipes* are also proportionately larger than those of *M. heymonsi* and *M. nilphamariensis* (Fig.3).

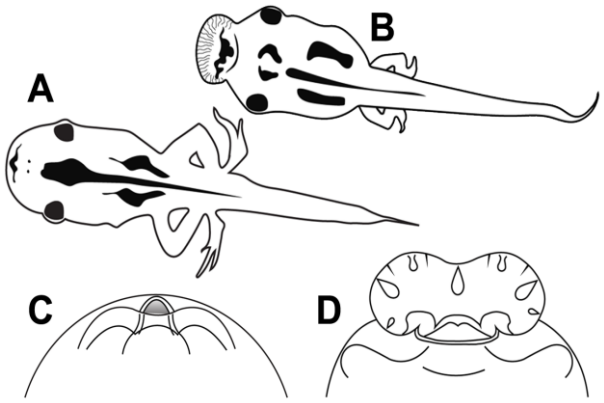

Figure 4. The dorsal aspects of the tadpoles of **(A)** *Microhyla fissipes* and **(B)** *M. heymonsi;* Oral morphology of **(C)** *M. fissipes* and **(D)** *M. heymonsi* tadpoles

Although the *M. fissipes*, *M. heymonsi*, and *M. butleri* can be sympatric in Taiwan, we did not find *M. butleri* at any of the study sites. Therefore, only the tadpole morphology of the former two species is described and compared in this study. The morphology of the tadpoles of *M. fissipes* and *M. heymonsi* is distinct. The tadpole of *M. fissipes* has a rounded or oval-shaped head and body, with slightly transparent lateral sides. In contrast, the tadpole of *M. heymonsi* has an elongated oval body, with two distinctive silvery-white spots visible on the dorsal view at the mid-body and mid-tail muscles (Figs. 3E–F, 4A–B). Both species have a tail tip extending into a flagellum, which moves in a wave-like motion to maintain static balance in still water. The mouth of the *M. fissipes* tadpole is positioned at the anterior end of the head with an inverted U-shaped infralabial flange and an upper lip, which together constitute the buccal cavity (Fig. 4C). The tadpole of *M. heymonsi* can be easily identified by its unique upturned, funnel-shaped oral disc located at the front of its mouth (Fig. 4D, Sup. Fig. 1).

Habitat. Both species appear to be habitat generalists occurring in various habitats, including lowland scrub forests, grassland, agricultural land, pastures and urban areas, breeding in temporary rain pools and other still water bodies. *Microhyla fissipes* is typically found in areas with loose substrate with grass, while *M. heymonsi* inhabits areas around tree barks in the forest. As semi-fossorial species, when not in wetlands, they can also be found in forest floor leaf-litter. They are mostly nocturnal, but their activity can extend into daylight hours during the rainy season. They appear to be tolerant of habitat modification and can also be found in non-intensively farmed agricultural areas.

Bioacoustics. The three species produce a similar series of calls, each containing approximately 10-15 rapidly repeated pulses lasting 0.3-0.4 sec (Fig. 2). However, all measurements except for PF differed significantly (Sup. Table 1), where post hoc pair-wise comparisons among the three species showed that PR differed significantly in all three species, CD differed only between *M. fissipes* and *M. nilphamariensis*, and NP and ID did not differ between *M. fissipes* and *M. nilphamariensis*.

Two principal components (PCs) with eigenvalues were extracted based on the five call variables (Sup. Table 2; Fig. 5). PC1 explained 44.03% of total variance with high positive loadings for NP and PR and high negative loadings for ID, where scores significantly differed among the three species ($F_{2, 31}$=90.39, $p<0.001$). Post-hoc comparisons revealed a significant pair-wise difference between scores for all species (Tukey test, $p<0.05$). PC2 explained 30.65% of total variance with a high positive loading for CD and moderate positive loadings for NP, and scores significantly differed among the three species ($F_{2,31}$=6.365, p=0.005). Post-hoc comparisons detected significant

differences between a) *M. nilphamariensis* and *M. fissipes*, and b) *M. nilphamariensis* and *M. heymonsi* (Tukey test, $p<0.05$).

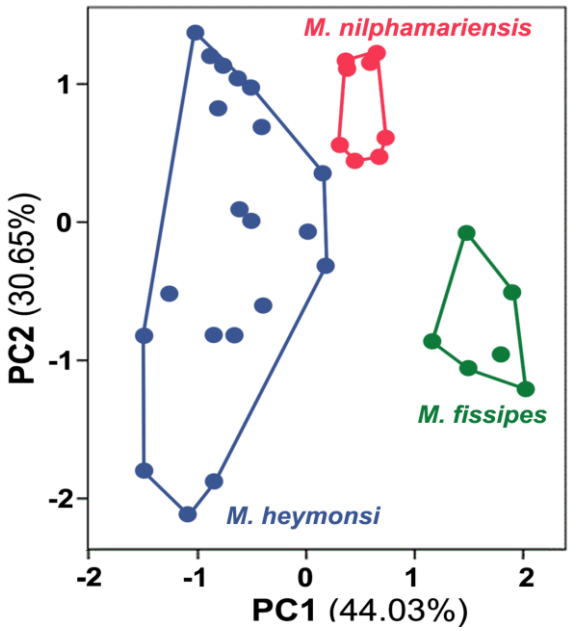

Figure 5. Distribution of Principal component (PC) 1 and PC2 scores derived from five call variables of 29 individuals of three species, *M. fissipes*, *M. heymonsi,* and *M. nilphamariensis*.

Discussion

The accurate delineation of *Microhyla* species has been challenging due to their diminutive size, morphological conservatism, and high level of homoplasy (Zweifel 1986). Miniaturization in anurans is common, often associated with ossification and reduction in the number of digits (Inger & Frogner 1980, Alberch & Gale 1985). For example, in the genus *Microhyla*, there is a tendency for the contraction or loss of the 1st finger, and some species possess only three functional fingers (Inger & Frogner 1980).

The herpetofauna of Taiwan, particularly members of the *Microhyla* genus, is poorly known (Chou & Lin 1998), and identification of the morphologically cryptic *Microhyla* species is challenging (Mahony *et al*. 2009, Hasan *et al*. 2012, Garg *et al.* 2019, Trofimets *et al.* 2024). *Microhyla fissipes* and *M. heymonsi* are emblematic of these challenges. Adults of the *M. heymonsi* group can be differentiated from all other groups by the combination of the following characters (from Garg *et al*. 2019): the absence of webbing between toes; finger and toe discs with prominent dorsal terminal grooves, bifurcate distally; the presence of a small ( )-shaped dark marking in the center of its dorsum; a narrow light mid-dorsal line, extending from the tip of the snout to the vent; and a prominent blackish brown lateral band, marking or skin fold, starting from the tip of the snout to the groin. To this we add characteristics of tadpoles with upturned, funnel-shaped oral discs at their anterior end (Sup. Fig. 1), corroborating the observations of other researchers.

All three species have similar patterns of call structure in temporal acoustic properties over a series of calls with rapidly repeating pulses. However, pulse number per call and pulse rate differed significantly among the three species, while there was a difference only between *M. nilphamariensis* and *M. fissipes* in call duration. Chen *et al*. (2020) indicated that pulse number and rate played a role in call differences between *M. heymonsi* and *M. fissipes* but not in call duration. *Microhyla heymonsi* and *M. fissipes* show that the averages of the variables are all within the range, except pulse number and rate of *M. heymonsi* calls, where our average values (pulse number, 10.27±2.09; pulse rate 28.95±2.91) were higher than those in Chen *et al*. (2020) (pulse number, 6.3±0.8; pulse rate 20.1±1.5). Intra- and inter-individual variation in pulse number and rate is as large as that of call duration or call interval, so it is unlikely to play an important role in species recognition (Chen *et al*. 2020). This might reflect geographical differences between populations in Taiwan and mainland East China. Further research is needed to assess geographic variation in advertisement calls for *Microhyla* species in Southeast and South Asia.

In particular, the scores of PC2 with high positive loadings for call duration and moderate positive loadings for pulse number showed a high degree of differentiation in males of *M. heymonsi*, which may reflect individual differences. This result supports the comments on *Microhyla* species from India (Kuramoto & Joshy 2006). Similarly, high temporal differences and fewer spectral differences appeared in a study of a population of *Dendropsophus microps* males (Forti *et al*. 2015). In contrast to temporal properties, spectral properties (e.g., peak frequency, frequency range) may play a role in the mate recognition system of some frog species (Matsui 1997, Gerhardt & Davis 1988). Here, peak frequency showed little difference among the three species, and frequency range may be a potential difference, as judged from the sonogram (Fig. 2), where the calls of *M. heymonsi* were associated with lower pulse number and rate, and may have expanded their

frequency range to compensate. However, we could not measure the frequency range of *M. nilphamariensis* calls due to the peak energy of the recorded calls. Our analyses imply that the temporal acoustic properties of frog advertisement calls are species-specific and provide reliable characteristics for species recognition.

Author contributions

All the authors contributed equally.

Acknowledgements

We thank K.-Y. Lue and Late. J.-S. Lai, National Taiwan Normal University, for the kind help and logistic support of the fieldwork; Prof. S.C. Lougheed (Queen's University, Canada) for assistance with editing an earlier draft; O. Khan for finalizing the figures; Vladislav Gorin and Alexey Trofimets (Lomonosov Moscow State University, Russia), and Vestidhia Yunisya Atmaja (University of Bengkulu, Indonesia) for reviewing the manuscript.

Research permits

This research collaborated with the Taiwan Biodiversity Research Institute and Hiroshima University, Japan, under the direction of Prof. K.-Y. Lue. No prior permit was required for the execution of the experiment/fieldwork in 2014.

Funding information

This work was supported by Grants-in-Aid for Scientific Research (B&C) (Nos. 17570082 and 20510216) to Masayuki Sumida from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

Supplemental data

https://doi.org/10.47605/tapro.v14i2.371

Literature cited

Alberch, P. & E.A. Gale (1985). A developmental analysis of an evolutionary trend: digital reduction in amphibians. *Evolution*, 39(1): 8–23.

Atmaja, V.Y., R. Eprilurahman, M. Munir *et al.* (2024). Unveiling misidentification of formerly reported *Microhyla fissipes* boulenger, 1884 (Anura: Microhylidae) with notes on two *Microhyla* species from Sumatra. *Taprobanica*, 13(2): 88–100.

Boulenger, G.A. (1884). Descriptions of new species of reptiles and batrachians in the British Museum. Part II. *Annals & Magazine of Natural History*, Series 5, 13(77): 396–398.

Carvalho, T.R., L.J. Moraes, A. Angulo *et al.* (2020). New acoustic and molecular data shed light on the poorly known Amazonian frog *Adenomera simonstuarti* (Leptodactylidae): implications for distribution and conservation. *European Journal of Taxonomy*, 682: 1–18.

Chanda, S.K. (2002). *Hand book – Indian amphibians*. Zoological Survey of India, Kolkata: 335pp.

Chen, Z.Q., Y.F. Lin, Y. Tang *et al.* (2020). Acoustic divergence in advertisement calls among three sympatric *Microhyla* species from East China. *PeerJ*, 8(3): e8708.

Chou, W-H. & J-Y. Lin (1998). *Tadpoles of Taiwan*. Special Publication of the National Museum of Natural Science, No. 7. National Museum of Natural Science, Taichung: 98pp.

Duellman, W.E. & L. Trueb (1994). *Biology of amphibians*. Johns Hopkins University Press, Baltimore: 696pp.

Forti, L.R., R. Marquez & J. Bertoluci (2015). Advertisement call of *Dendropsophus microps* (Anura: Hylidae) from two populations from southeastern Brazil. *Zoologia*, 32(2): 187–194.

Fouquet, A., A. Gilles, M. Vences *et al.* (2007). Underestimation of species richness in Neotropical frogs revealed by mtDNA analyses. *PLoS ONE*, 2(11): e1109.

Frost, D.R. (2024). Amphibian species of the world: an online reference. Version 6.2. American Museum of Natural History, New York <amphibiansoftheworld.amnh.org> Accessed on 15 February 2024.

Garg, S., R. Suyesh, A. Das *et al.* (2019). Systematic revision of *Microhyla* (Microhylidae) frogs of South Asia: a molecular, morphological & acoustic assessment. *Vertebrate Zoology*, 69(1): 1–71.

Gerhardt, H.C. & M.S. Davis (1988). Variation in the coding of species identity in the advertisement calls of *Litoria verreauxi* (Anura: Hylidae). *Evolution*, 42(3): 556–565.

Gaoshi, X. & L. Pengxiang (2000). *Colored illustrations of amphibians & reptiles of Taiwan* (Chinese edition). Science Press, Beijing: 336pp.

Gorin, V.A., E.N. Solovyeva, M. Hasan *et al.* (2020). A little frog leaps a long way: compounded colonizations of the Indian Subcontinent discovered in the tiny Oriental frog genus *Microhyla* (Amphibia: Microhylidae). *PeerJ*, 8(7): e9411.

Günther, A.C.L.G. (1858). On the systematic arrangement of the tailless batrachians and the structure of *Rhinophrynus dorsalis*. *Proceedings of the Zoological Society of London*, 1858: 339–352.

Hasan, M., M.M. Islam, M.M.R. Khan *et al.* (2012). Cryptic anuran biodiversity in Bangladesh revealed by mitochondrial 16S rRNA gene sequences. *Zoological Science*, 29(3): 162–172.

Hasan, M., M.M. Islam, M. Kuaramoto *et al.* (2014). Description of two new species of *Microhyla* (Anura: Microhylidae) from Bangladesh. *Zootaxa*, 3755(5): 401–418.

Hasan, M., M.A.R. Sarker, A. Kurabayashi *et al.* (2015). Genetic variation, advertisement call, and morphometry of *Microhyla nilphamariensis* from Bangladesh. *Philippine Journal of Systematic Biology*, 9(1): 63–80.

Hoang, C.V., C.T. Pham, T.Q. Nguyen *et al.* (2025). A new species of *Microhyla* (Amphibia: Anura: Microhylidae), with an extended description of *Microhyla nanapollexa* from Vietnam. *Zootaxa*, 5566(2): 347–369.

Howlader, M.S.A., A. Nair, S.V. Gopalan *et al.* (2015). A new species of *Microhyla* (Anura: Microhylidae) from Nilphamari, Bangladesh. *PLoS ONE*, 10(3): e0119825.

Inger, R.J. & K.J. Frogner (1980). New species of narrow-mouth frogs (genus *Microhyla*) from Borneo. *Sarawak Museum Journal*, 27(48): 311–324.

Kabir, S.M.H., M. Ahmad, A.T.A. Ahmed *et al.* (2009). *Encyclopedia of flora and fauna of Bangladesh. Volume 25. Amphibians & reptiles*. Asiatic Society of Bangladesh, Dhaka: 204pp.

Köhler, J., M. Jansen, A. Rodriguez *et al.* (2017). The use of bioacoustics in anuran taxonomy: Theory, terminology, methods and recommendations for best practice. *Zootaxa*, 4251(1): 1–124.

Kuramoto, M. & S.H. Joshy (2006). Morphological and acoustic comparisons of *Microhyla ornata*, *M. fissipes*, and *M. okinavensis* (Anura: Microhylidae). *Current Herpetology*, 25(1): 15–27.

Mahony, S., M.M. Hasan, M.M. Kabir *et al.* (2009). A catalogue of amphibians and reptiles in the collection of Jahangirnagar University, Dhaka, Bangladesh. *Hamadryad*, 34(1): 80–94.

Matsui, M. (1997). Call characteristics of Malaysian *Leptolalax* with a description of two new species (Anura: Pelobatidae). *Copeia*, 1997(1): 158–165.

Matsui, M., H. Ito, T. Shimada *et al.* (2005). Taxonomic relationships within the Pan-Oriental narrow-mouth toad *Microhyla ornata* as revealed by mtDNA analyses (Amphibia, Anura, Microhylidae). *Zoological Science*, 22(3): 489–495.

Matsui, M., A. Hamidy, D.M. Belabut *et al.* (2011). Systematic relationships of Oriental tiny frogs of the family Microhylidae (Amphibia, Anura) as revealed by mtDNA genealogy. *Molecular Phylogenetics & Evolution*, 61(1): 167–176.

Poyarkov, N.A., A.B. Vassilieva, N.L. Orlov *et al.* (2014). Taxonomy and distribution of narrow-mouth frogs of the genus *Microhyla* Tschudi, 1838 (Anura: Microhylidae) from Vietnam with descriptions of five new species. *Russian Journal of Herpetology*, 21(2): 89–148.

Toledo, L.F., I.A. Martins, D.P. Bruschi *et al.* (2015). The anuran calling repertoire in the light of social context. *Acta Ethologica*, 18(2): 87–99.

Trofimets, A.V., C. Dufresnes, P. Pawangkhanant *et al.* (2024). Four in one: an integrative taxonomic revision of the *Microhyla berdmorei* complex (Amphibia: Anura: Microhylidae) illustrates the tremendous amphibian diversity of Southeast Asia. *Vertebrate Zoology*, 74(3): 595–641.

Tschudi, J.J.V. (1838). *Classification der Batrachier, mit Berücksichtigung der fossilen Thiere dieser Abtheilung der Reptilien*. Petitpierre, Neuchâtel: 98pp.

Vogt, T. (1911). Beitrag zur Amphibien-fauna der Insel Formosa. *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin*, 1911(8): 179–184.

Yuan, Z-Y., C. Suwannapoom, F. Yan *et al.* (2016). Red River barrier and Pleistocene climatic fluctuations shaped the genetic structure of the *Microhyla fissipes* complex (Anura: Microhylidae) in southern China and Indochina. *Current Zoology*, 62(6): 531–543.

Zweifel, R.G. (1986). A new genus and species of microhylid frogs from the Cerro de la Neblina region of Venezuela and a discussion of relationships among New World microhylid genera. *American Museum Novitates*, 2863: 1–24.