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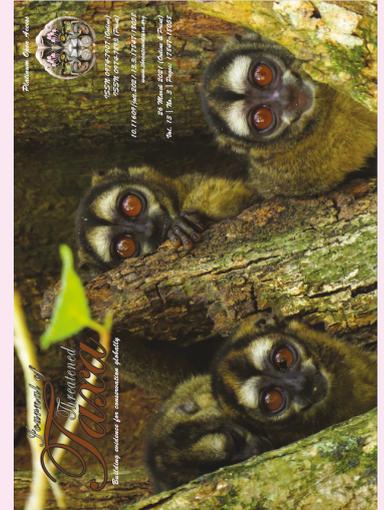
COMMUNICATION

AN ANNOTATED CHECKLIST OF AMPHIBIANS IN AND AROUND DAMPA TIGER RESERVE, MIZORAM, INDIA

Ht. Decemson, Sushanto Gouda, Lalbiakzuala, Lalmuansanga, Gospel Zothanmawia Hmar, Mathipi Vabeiryureilai & H.T. Lalremsanga

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An annotated checklist of amphibians in and around Dampa Tiger Reserve, Mizoram, India

Ht. Decemson¹ , Sushanto Gouda² , Lalbiakzuala³ , Lalmuansanga⁴ , Gospel Zothanmawia Hmar⁵ ,
Mathipi Vabeiryureilai⁶  & H.T. Lalremsanga⁷ 

^{1,3,4,5,6,7} Department of Zoology, Mizoram University, Aizawl, Mizoram 796004, India.

² Amity Institute of Forestry and Wildlife, Amity University, Noida, Uttar Pradesh 201301, India.

¹ htdecemson@gmail.com, ² sushantogouda@gmail.com (corresponding author), ³ bzachawngthu123@gmail.com,

⁴ muanapunte16@gmail.com, ⁵ goszhmar@gmail.com, ⁶ m.vabeiryureilai@gmail.com, ⁷ htlrta@yahoo.co.in

Abstract: Amphibians are an integral part of the ecosystem and act as an ecological indicator. As several species are added to the list of threatened species every year due to loss of habitat, it is important to understand the role of unmanaged landscape for sustenance of amphibian diversity. In this study, 28 amphibian species were recorded from different modified habitat including 19 new records for Dampa Tiger Reserve (DTR) and its surrounding areas. Further, six species, *Amolops indoburmanensis*, *Limnonectes khasianus*, *Microhyla mukhlesuri*, *M. mymensinghensis*, *Raorchestes rezakhani*, and *Sylvirana lacrima* are new distribution records for the state of Mizoram and out of these, two species, *Raorchestes rezakhani* and *Sylvirana lacrima*, are new country records for India. Amongst the recorded species, four species are Data Deficient, two Vulnerable, 14 Least Concern, and eight species are not assessed as per the IUCN Red List. Within the core and buffer areas of DTR, we found that natural perennial stream, puddles, canals, natural ponds, fish ponds, roadside, primary forest, secondary forest, paddy fields, and human settlement areas are excellent microhabitats for amphibian population and need to be conserved for their rich ecological niches.

Keywords: Conservation, microhabitat, protected area, *Raorchestes rezakhani*, recovery, secondary forest, *Sylvirana lacrima*.

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Competing interests: The authors declare no competing interests.

Author details: See end of this article.

Author contribution: Ht. Decemson has led the field work, sample collection, initiate the manuscript writing and took some photographs. Sushanto Gouda has compiled the manuscript, designed the study area map and communicated the manuscript. Lalbiakzuala assist in the field work, contribute in the manuscript design and did molecular analysis for the collected samples. Lalmuansanga assist in the field work, sample collection and examination of the collected samples. Gospel Zothanmawia Hmar assist in the field work, sample collection and help in the manuscript editing. Mathipi Vabeiryureilai has assisted in the field work, sample collection and perform molecular identification for the collected samples. He also contributed in the manuscript write-up. H.T. Lalremsangais supervised the field work, sample collection, taken important photographs, did identification, provided valuable inputs and made necessary correction to the manuscript.

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INTRODUCTION

Change in matured forest lands into modified landscape through agriculture and other human activities had resulted in severe loss of biodiversity. Herpetofauna that contributes for over 48% of the terrestrial vertebrates is one of the most threatened groups of animals due to habitat loss, environmental pollution, international trade, and agroforestry (Palacios et al. 2013; Jayakumar & Nameer 2018; Prasad et al. 2018). As per IUCN, of the 8,126 described amphibian species, about 2,202 amphibians are categorized as threatened species (Frost 2020). In the past 20 years, the number of Critically Endangered species has also increased from 25 in the year 2000 to an alarming 587 species by 2020 (IUCN 2020). Dampa Tiger Reserve (DTR) in Mizoram, northeastern India, is a biodiversity hotspot that falls within the Indo-Burma region, and is also greatly affected from shifting cultivation and other anthropogenic activities (Pawar et al. 2004). About 80% of the State's population practices slash and burn method of agriculture that are highly dependent on forest resources, resulting in clearing of large areas of matured forest lands every year (Sati & Rinawma 2014). While most researchers have mostly emphasized on the conservation of faunal diversity in protected and matured forest, the importance of secondary or modified habitats has gained recognized in recent times (Dunn 2004; Teegalapalli et al. 2009; Mandal & Raman 2016; Vega-Pérez et al. 2019). Secondary forest types such as suburbia remnant forests, riverbanks, plantation sites, abandoned crop fields, and home gardens are reported to serve as an important refuges and breeding grounds for variety of amphibian fauna (Dunn 2004; Banville & Bateman 2012; Nowakowski et al. 2017; Prasad et al. 2018). Only a few studies on amphibians diversity has been reported from DTR that include amphibian survey by Pawar & Birand (2001), where the presence of 18 species were reported from different habitats like mature and secondary forest, open forest and even plantation sites. Recently, occurrences of *Leptobrachella tamdil* and *Hoplobatrachus litoralis* in DTR were reported by Vanlalsiammawii et al. (2020) and Kundu et al. (2020), respectively.

Thus, further studies that focus on the distribution, ecology and other quantitative aspects of amphibians are important to understand the fluctuations in ecosystem functioning and prioritize areas for conservation (Myers et al. 2000). Considering such rich and untamed amphibian diversity and paucity of research in the region, it is important to understand and evaluate the amphibian

diversity in the modified ecosystems around the reserve.

MATERIALS AND METHODS

Study area

The study was carried out in the modified or secondary forested areas around Dampa Tiger Reserve, Mizoram, India. DTR is situated between 23.324–23.413 °N & 92.131–92.272 °E and encompasses a core area of 500km² and a buffer zone of 448km² (Figure 1). DTR consists of undulating and medium hills and slopes of mostly bamboo forest. Flat mainlands and patches of grasslands with lofty and evergreen run in parallel along the rivers (Pawar & Birand 2001). The climatic condition in DTR ranges 10–35 °C and receives an annual rainfall ranging 2,000–2,500 mm between the months of May to August (Pawar & Birand 2001). The area remains mostly moist due to presence of several small perennial streams thus forming an ideal habitat for biological assemblages for different groups of species. The region has a rich and diverse faunal diversity including Malayan Sun Bear, Clouded Leopard, Marbled Cat, Golden Cat, Hoolock Gibbon, Phayre's Leaf Monkey, King Cobra, and Burmese Python (Gouda et al. 2016; Singh & Macdonald 2017; Gouda et al. 2020a). Previous studies on the herpetofauna in DTR include works of Pawar & Birand (2001), Pawar et al. (2004), Lalrinchhana & Solanki (2015), and Vanlalsiammawii et al. (2020). Locals around DTR are mostly forest dwellers and are dependent on the available forest resources besides engaging in slash and burn practice of agriculture (Solanki et al. 2016).

Methods

Multiple approaches including visual encounter surveys (VES), acoustic surveys, drift fences, and pitfall traps were used for determination of amphibian diversity in different gradients of fallow forest lands along DTR. The study was carried out from September 2018 to July 2020 in three different seasons repeatedly. VES were carried out during early morning hours (06.30–10.00 h) and at night (18.00–24.00 h) for an average of five days each week using torch lights. Apart from passive observation, active searches were carried out in leaf litter, perennial streams, rocky outcrops, under rocks, peeling barks, abandoned crop fields, gooseberry, plantations (oil palm, rubber, mixed farms, etc.), and temporary rain puddles (Banville & Bateman 2012; Prasad et al. 2018). Opportunistic observations like road kills, canals along roadside and other areas were also noted during the survey. Identification of species

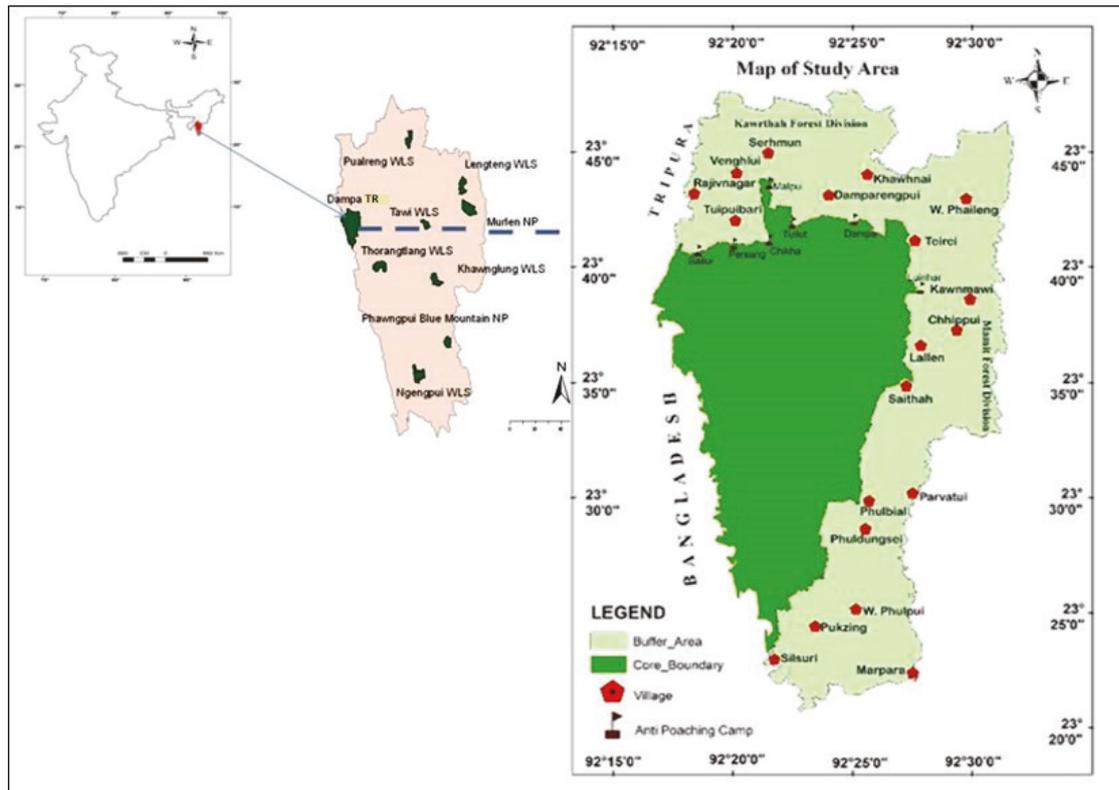


Figure 1. Representation of Dampa Tiger Reserve and its surrounding areas.

was made through reference catalogs available at the Departmental Museum of Zoology, Mizoram University and from literature (Boulenger 1890, 1920; Chanda 2002; Ahmed et al. 2009). Each location was covered on foot and individual species when encountered were photographed in their natural habitats wherever possible and GPS readings were recorded (Garmin etrex 10). Most of the collected specimens were released back in their natural habitat after examining and measurement. The species global distribution ranges are given according to Frost (2020).

For delimiting the identification of cryptic species, molecular approach was employed in which genomic DNA was extracted from the liver tissues of *Sylvirana lacrima* (MZMU 1632), *Raorchestes rezakhani* (MZMU 1785), *Microhyla berdmorei* (MZMU 1824), *Microhyla mukhlesuri* (MZMU 1766), *Microhyla mymensinghensis* (MZMU 1747), *Fejervarya multistriata* (MZMU 1360), and *Amolops indoburmanensis* (MZMU 1374) using DNeasy (Qiagen™) blood and tissue kits with the protocol given by the manufacturer. The fragment of mitochondrial 16S rRNA marker gene was amplified using forward primer L02510 (Palumbi 1996) and reverse primer H3056 (Rassmann 1997) in a 25µl volume following standard polymerase chain reactions (PCR) with standard thermal

profiles for each primer pairs. Samples were sequenced in both directions using Sanger’s dideoxy method on a sequencer at Agrigenome Labs Pvt. Ltd., Kochin, India. The chromatograms of the partial 16S rRNA sequences were screened through nucleotide BLAST (<https://blast.ncbi.nlm.nih.gov/>) and ORF finder (<https://www.ncbi.nlm.nih.gov/orffinder/>), the generated sequences were deposited in the GenBank repository and acquired the accession numbers (MW440531; MW165448; MW165451; MW165454; MW165457; MT627444; MT627446). Our sample sequences and of the closely related taxa downloaded from GenBank database were aligned by using Muscle algorithm in MEGA 7 (Kumar et al. 2016), the uncorrected p-distances were calculated using MEGA 7 (Kumar et al. 2016).

RESULTS

In the study, 28 species from seven families and 24 genera (Tables 1,2) were recorded from various modified forest patches in the vicinity of DTR (Images 1,2,3,4; Figure 2). This study reported 19 new distribution records from DTR (Table 1). Amongst the 28 documented species, four species are categorized as Data Deficient,



two as Vulnerable, 14 as Least Concern and eight species as not assessed as per IUCN Red List. Two species *i.e.* *Raorchestes rezakhani* and *Sylvirana lacrima* are first country records. A brief account of species recorded and their microhabitats are discussed here:

Species accounts

A. Order Anura

I. Family Bufonidae Gray, 1825

1. Indian Common Toad *Duttaphrynus melanostictus* (Schneider, 1799) (Image 1a)

It was the most commonly available toad recorded around Dampa Tiger Reserve (DTR). The species was sighted mostly at noon (12.16h) and dawn (18.02h) on the roadside and canals in an open forest of the fringe villages of Teirei and Damparengpui (260–430 m). Head broader than long; distinct angular dark ridges on head with tympanum large and distinctly clear; toes blunt, half webbed. Tip of warts and ridges are dark brown to black. It is distributed throughout south and southeastern Asia. *n* = 3 (two females and one male), SVL (Snout-vent length): 84–96 mm.

I. Family Dicroglossidae Anderson, 1871

1. Paddy Frog *Fejervarya multistriata* (Hallowell, 1861) (Image 1b)

An amplexing pair was recorded from muddy spot at Teirei Village at elevation 262m close to human settlement at 19.08h on 27 July 2019. Head triangular in dorsal view, nostrils closer to snout tip, males with characteristic laterally dark, medially pale colored throat, and vertebral line on dorsum. Distribution ranges from China, Hong Kong, Myanmar, India, Taiwan, Laos, Vietnam, and Thailand. The species is a new record for DTR. *n* = 2, SVL: 38.65mm (male) and 43.10mm (female). Genetic sequence of our specimen (MT627446) is similar to the sequences sampled from China (AB354241) and Japan (AB354239) for the species *Fejervarya multistriata* available in GenBank database showing uncorrected *p*-distances of 0.000 and 0.002 with our sample, respectively.

2. Bangladeshi Cricket Frog *Minervarya asmata* (Howlader, 2011) (Image 1c)

The species was collected from paddy field near Teirei Forest village, DTR at 19.30h on 26 August 2019. Head large and triangular, longer than wide, hind limbs relatively long, line on both sides of belly, smooth skin with minute warts or folds, fingers free of webbing, toes not fully webbed. Distribution ranges in Mizoram, India and Bangladesh. It is a new record for DTR. *n* = 3 (two

males and one female), SVL: 29–33 mm.

3. Bangladesh Skittering Frog *Euphlyctis kalasgramensis* Howlader, Nair, Gopalan & Merilä, 2015 (Image 1d)

It is common and observed in all natural and constructed water bodies in the low lying surrounding the Reserve during early morning hours (08.00–10.00 h). An adult female was collected from a fish pond near Teirei Stream at an elevation of 248m. Skin color varies from grey to brownish. Head slightly broader, snout long and pointed; nostrils equidistant to eye. Fingers and toes pointed; toes fully webbed. It has a range of distribution throughout Bangladesh, India (Mizoram and western Punjab), and Pakistan. *n* = 1 (adult female), SVL: 64mm.

4. Indian Bull Frog *Hoplobatrachus tigerinus* (Daudin, 1802) (Image 1e)

The species was collected from a low lying area of Sunhlului in Damparengpui during the night survey (21.58h) on 20 May 2019. Skin is creamy or yellow colored with mid and dorsolateral lines from tip of the snout to posterior end. Found in low to moderate elevated areas in Afghanistan, Bangladesh, Nepal, India, and Pakistan. *n* = 1 (male), SVL: 129mm.

5. Coastal Bull Frog *Hoplobatrachus litoralis* Hasan, Kuramoto, Islam, Alam, Khan & Sumida, 2012 (Image 1f)

Recorded from Tuidamlui (230m) at 20.00h on 12 July 2020, the species is commonly available around DTR. Distinct black margins in the upper arm, dorsum dark gray with many large black spots. Dorsal ground colour varies from yellowish to dark brown with many dark brown to black spots. Global distribution includes Bangladesh, India, and Myanmar. *n* = 1 (male), SVL: 122mm.

6. Northern Trickle Frog *Ingerana borealis* (Annandale, 1912) (Image 1g)

Fairly common in northeastern India, a single individual of this species was collected from a boulder of Selinglui Stream, around DTR at an elevation of 244m during night survey (18.26h) on 19 November 2019. It is a seasonal breeder, *i.e.*, during April to August. Small-sized frog; head small and triangular; snout bluntly rounded; tympanum rounded; legs and fingers free and toes half webbed. Dorsum and flanks are reticulated and with small net-like ridges and tiny glandular warts. Distributions are in China, Bhutan, Nepal, India, Bangladesh, and Myanmar. It is a new record for DTR. *n* = 1 (male), SVL: 29mm.

Table 1. Checklist of amphibian species recorded from different habitats in and around DTR during 2018–2020. The frog species with asterisk (*), hash (#), and plus (+) are new records from DTR, Mizoram, and India, respectively.

Family	Common name	Species	IUCN RL status
Bufo	Common Asian Toad	<i>Duttaphrynus melanostictus</i>	Least Concern
Dicroglossidae	Paddy Frog	<i>Fajervarya multistriata*</i>	Data Deficient
	Bangladeshi Cricket Frog	<i>Minervarya asmati*</i>	Least Concern
	Bangladesh Skittering Frog	<i>Euphyctis kalasgramensis*</i>	Least Concern
	Indian Bull Frog	<i>Hoplobatrachus tigerinus</i>	Least Concern
	Coastal Bull Frog	<i>Hoplobatrachus litoralis</i>	Not assessed
	Northern Trickle Frog	<i>Ingerana borealis*</i>	Vulnerable
	Khasi Wart Frog	<i>Limnonectes khasianus*#</i>	Data Deficient
Megophryidae	Red-eyed Frog	<i>Leptobrachium smithi</i>	Least Concern
	Tamdiil Leaf-litter Frog	<i>Leptobrachella tamdil</i>	Not assessed
	Beautiful Pygmy Frog	<i>Megophrys major*</i>	Least Concern
	Serchhip Horned Frog	<i>Megophrys serchhipii*</i>	Data Deficient
Microhylidae	Mukhlesur's Narrow-mouthed Frog	<i>Microhyla mukhlesuri*</i>	Not assessed
	Mymensingh Narrow-mouthed Frog	<i>Microhyla mymensinghensis*#</i>	Not assessed
	Berdmore's Narrow-mouthed Frog	<i>Microhyla berdmorei*</i>	Least Concern
	Painted Balloon Frog	<i>Kuloula pulchra</i>	Least Concern
Ranidae	Indo-Burma Torrent Frog	<i>Amolops indoburmanensis*#</i>	Not assessed
	Pointed-nose Frog	<i>Clinotarsus alticola*</i>	Least Concern
	Indo-Burma Stream Frog	<i>Sylvirana lacrima*##+</i>	Least Concern
	Assam Forest Frog	<i>Hydrophylax leptoglossa</i>	Least Concern
	Green-backed Stream Frog	<i>Odorrana chloranota*</i>	Least Concern
	Khare's Gliding Frog	<i>Pterorana khare*</i>	Vulnerable
Rhacophoridae	Common Tree Frog	<i>Polypedates teraiensis*</i>	Not assessed
	Annandale's Pygmy Tree Frog	<i>Chirixalus simus*</i>	Least Concern
	Giant Tree Frog	<i>Zhangixalus smaragdinus</i>	Not assessed
	Twin-spotted Tree Frog	<i>Rhacophorus bipunctatus</i>	Least Concern
	Reza Khan's Bush Frog	<i>Raorchestes rezakhani*##+</i>	Not assessed
Ichthyophidae	Manipur Moustached Ichthyophis	<i>Ichthyophis moustakius*</i>	Data Deficient

Table 2. Amphibian family, species, and genera accounted from different habitats around DTR during 2018–2020.

Family	Genera	Species
Ichthyophidae	1	1
Bufo	1	1
Dicroglossidae	6	7
Megophryidae	3	4
Microhylidae	2	4
Ranidae	6	6
Rhacophoridae	5	5
Total	24	28

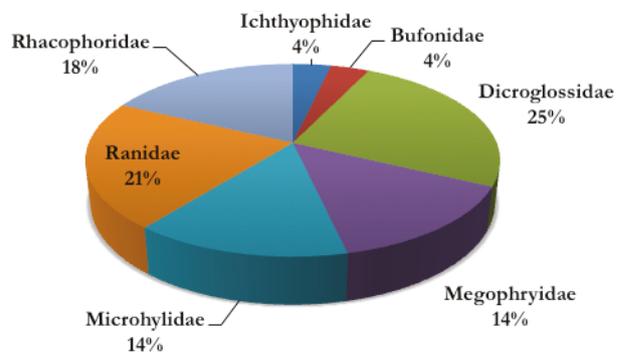


Figure 2. Family composition of amphibian species recorded in the study.



Image 1. Frog species with asterisk (*), hash (#), and plus (+) are new records for DTR, Mizoram, and India, respectively: a—*Duttaphrynus melanostictus* | b—*Fejervarya multistriata** | c—*Minervarya asmati** | d—*Euphlyctis kalasgramensis* | e—*Hoplobatrachus tigerinus* | f—*Hoplobatrachus litoralis** | g—*Ingerana borealis** | h—*Limnonectes khasianus**# | i—*Leptobrachium smithi* | Photographs: a,d,e,f,h,i © H.T. Lalremsanga; b,c,g © Ht. Decemson.

7. Khasi Wart Frog *Limnonectes khasianus* (Anderson, 1871) (Image 1h)

A single female individual Khasi Wart Frog was recorded from a stream along the reserve boundary at Khawthlabung Fall at Teirei Stream near Lallen Village (17.15h) on 11 July 2018. They are mostly of medium-sized, short and thick body. Eyes are large and prominent. Skin smooth throughout, no trace of tubercles. This is a new record for the state of Mizoram. The species is endemic to northeastern states of Assam, Meghalaya, and Mizoram. n= 1 (female), SVL: 35.61mm.

I. Family Megophryidae Bonaparte, 1850

1. Red-eyed Frog *Leptobrachium smithi* Matsui, Nabhitabhata & Panha 1998 (Image 1i)

A male and female individual of the species were recorded from the secondary forested area near the Forest Guest House of Teirei Forest complex at an elevation 240m during noon time (11.54h) on 24 April 2018. Head is broader and long; nostrils nearer to tip of

snout; eyes large; mouth wide; limbs slender and weak; fingers free; toes webbed; finger and toe tips blunt. Dorsum ash to black in colour with several black spots and markings. Distribution ranges include Thailand, Myanmar, Malaysia, Laos, India, and Bangladesh. n= 2, SVL: 42mm (male) and 61mm (female).

2. Tamdil Leaf-litter Frog *Leptobrachella tamdil* (Sengupta, Sailo, Lalremsanga, Das & Das 2010) (Image 2a)

The record of this species in DTR is based on Vanlalsiamawii et al. (2020). n= 1 (male), SVL: 31mm.

3. Beautiful Pygmy Frog *Megophrys major* Boulenger, 1908 (Image 2b)

A male pygmy frog was recorded around fallen dried bamboo forest around Khawthlabung fall at Teirei Stream near Lallen Village at 19.18h on 10 June 2018. Head broader than long; triangular, eyes large, prominent, jutting out above head; snout broadly pointed; nostril

closer to eye. Dorsum dark brown in colour. Distribution ranges include India, Myanmar, Thailand, Laos, Vietnam, and Cambodia. It is a new report for DTR. $n = 1$ (male), SVL: 79mm.

4. Serchhip Horned Frog *Megophrys serchhipii* (Mathew & Sen, 2007) (Image 2c)

A female narrowed-mouth frog was recorded from Seling Stream at an elevation of 244m during the night survey (21.33h) on 22 August 2019. Head moderately large, distinct oval tympanum, snout rounded in dorsal view, nostril oval. Skin of dorsal surfaces of head, body and limbs, smooth to rugose with small weak granular tubercles. V-shaped mark on head covering the middle of the eyelids. It is native to the states of Meghalaya, Mizoram, and Tripura in India. Also found in southeastern Bangladesh and southwestern Myanmar. This is also a new report for DTR. $n = 1$ (female), SVL: 42mm.

II. Family Microhylidae Günther, 1858

1. Mukhlesur's Narrow-mouthed Frog *Microhyla mukhlesuri* Hasan, Islam, Kuramoto, Kurabayashi & Sumida, 2014 (Image 2d)

The species was identified from shallow perennial stream, beneath submerged leaf debris situated near roadside at Zodin locality of Damparengpui Village at elevation 407m at 19.33h on 16 February 2020. Broad head and pointed; snout obtuse, and broadly rounded; tongue elliptical; inter orbital width broader than eye diameter; tympanum invisible. Limbs moderate, tibia-tarsal articulation up to eye level; fingers free; toes webbed at the base; tips of finger and toes not swollen; subarticular tubercles distinct; an inverse U-shaped mark on the anus: a distinct X-shaped marking on the dorsum. Skin smooth, brownish or grayish. The species is distributed across Bangladesh, Thailand, Laos, Vietnam, and northeastern India. $n = 1$ (male), SVL: 18.5mm. Genetic sequence of our specimen (MW165451) is similar to the GenBank database sequences of *Microhyla mukhlesuri* sampled from Mizoram, India (MH549575), Bangladesh (MN534585), and Myanmar (KC179995) with the uncorrected p-distances of 0.000, 0.000, and 0.021 from our sample, respectively.

2. Mymensingh Narrow-mouth Frog *Microhyla mymensinghensis* Hasan, Islam, Kuramoto, Kurabayashi & Sumida, 2014 (Image 2e)

A female individual was collected from a grass in the backyard of ranger officer's quarter at Teirei range at elevation 261m at 21.45h on 10 July 2020. Broad head and pointed; snout truncate; a crescent-shaped marking on

the anus an X-shaped marking on the dorsum; tympanum hidden. Limbs moderate, tibia-tarsal articulation up to the level from the eye to the tip of the snout; fingers free; toes webbed at the base; skin smooth, reddish or grayish; inverted crescent mark around anus. The species is distributed across central and northeastern parts of Bangladesh and Wet Bengal, Assam, and Nagaland in India. $n = 1$ (female), SVL: 20.8mm. Genetic sequence of our specimen (MW165448) is similar to the GenBank database sequences of *Microhyla mymensinghensis* sampled from Tripura, India (MH549589), Assam, India (MH549576), Manipur, India (MH549580), Nagaland, India (MH549584), and Bangladesh (MK635493); showing the uncorrected p-distances of 0.002, 0.004, 0.004, 0.016, and 0.004 with our sample, respectively.

3. Berdmore's Narrow Mouthed Frog *Microhyla berdmorei* (Blyth, 1856) (Image 2f)

It was sighted along the puddle at road side of Damparengpui Village at elevation point 407m in evening survey (19.27h) on 18 February 2020. A pointed and broad head; snout obtusely pointed; tympanum hidden; bronze or pinkish above; a dark slightly light blue edged, large mid dorsal spot on back. Distribution ranges in Arunachal Pradesh, Assam, Manipur, Mizoram, Tripura, & Meghalaya (India), northern Bangladesh, Yunnan (China), Myanmar, Thailand, through Laos, most of Vietnam north of the Mekong River, Cambodia south to peninsular Malaysia, Sumatra, and Borneo (Indonesia). This is also a new report for DTR. $n = 5$ (four male and one female), SVL: 32–36 mm. Genetic sequence of our specimen (MW165457) is similar to the GenBank database sequences of *Microhyla berdmorei* sampled from Assam, India (MH807388), and Bangladesh (MN534602) with an uncorrected p-distance of 0.004 with our sample.

4. Painted Balloon Frog *Kaloula pulchra* Gray, 1831 (Image 2g)

The species was recorded from two separate locations. The SVL of the female frog from a pot-hole on the boulder near Teirei IB guest house (elevation 241m at 20.28h on 20 April 2020) measured 82mm, while the other individuals were collected from a burrow in the vicinity of Sesihlui (764m elevation at 14.49h on 9 April 2019) measured 86mm (female) and 79mm (male). Head broader than long, snout short round and nostrils closer to tip of snout. Dorsum is dark brown with bright orange broad band extending from tip to either side of body. It is common in India, Bangladesh, Myanmar, Thailand, China, Singapore, Sumatra, Borneo, and is introduced into the Philippines.

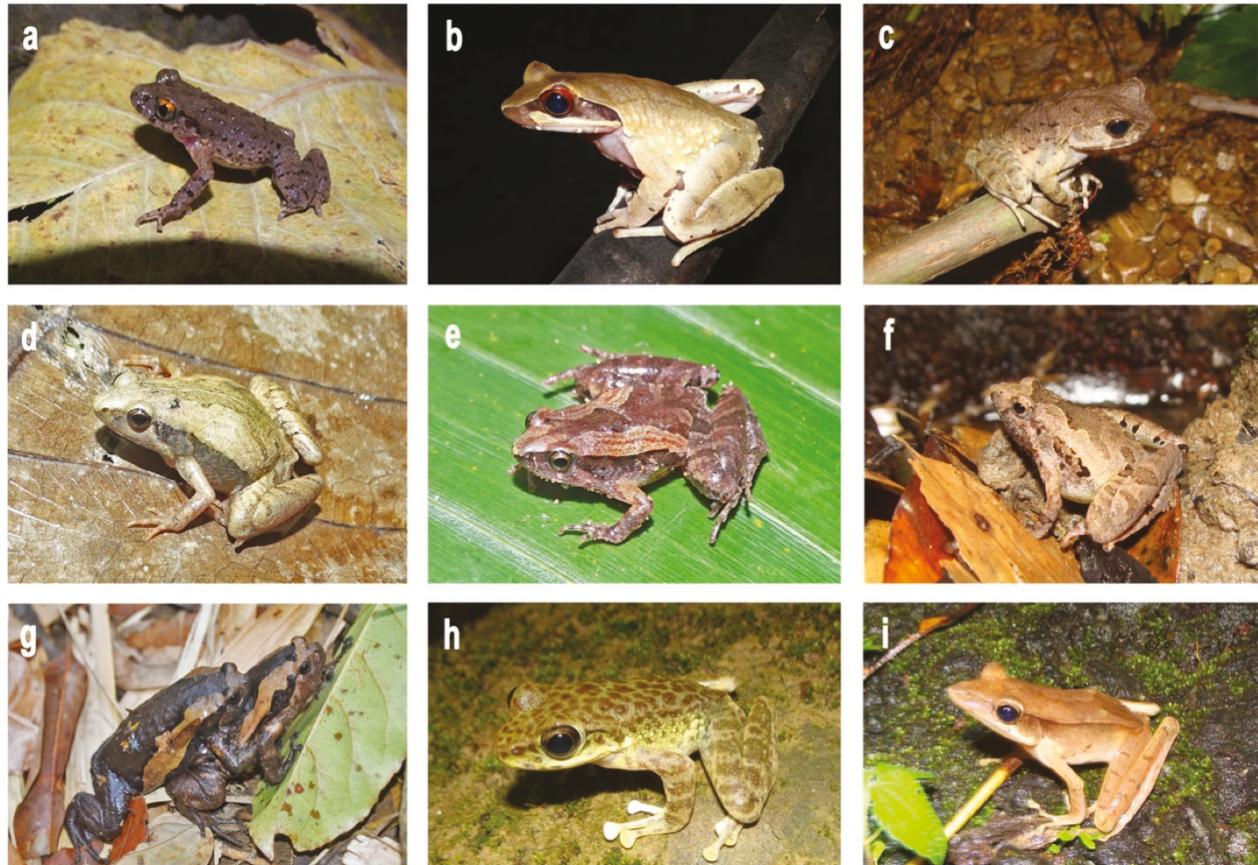


Image 2. Frog species with asterisk (*), hash (#), and plus (+) are new records for DTR, Mizoram, and India, respectively: a—*Leptobranchella tamdil* | b—*Megophrys major** | c—*Megophrys serchhipii** | d—*Microhyla mukhlesuri** | e—*Microhyla mymensinghensis**# | f—*Microhyla bermorei** | g—*Kuloula pulchra* | h—*Amolops indoburmanensis**# | i—*Clinotarsus alticola** | Photographs: a,b,c,d,e,f,h,i © H.T. Lalremanga; g © Ht. Decemson.

IV. Family Ranidae

1. Indo-Burma Torrent Frog *Amolops indoburmanensis* Dever, Fuiten, Konu & Wilkinson, 2012 (Image 2h)

A male Indo-Burma Torrent Frog was collected along the concrete wall of the forest guest house at Teirei Village at 20.44h on 8 June 2019. Three more individuals were collected from Dampa stream near Damparengpui Village at 19.00–20.00 h. It is a large-sized frog with a brown dorsum, scattered with dark brown sharp spots from snout to vent. Skin mid-dorsally smooth becoming tuberculated laterally. Large prominent discs present on tips of digits. It is reported from Myanmar in Chin State, Rakhine State, southern Sagaing Division, and western Bago Division, possibly into Manipur, India. It is a new report for DTR as well as Mizoram. n= 4 (two males and two females), SVL: 68–92 mm. Genetic sequence of our specimen (MT627444) is similar to the GenBank database sequence of *Amolops indoburmanensis* sampled from Mizoram, India (MH059579) with an uncorrected

p-distance of 0.000 between them.

2. Pointed-nosed Frog *Clinotarsus alticola* (Boulenger, 1882) (Image 2i)

A female species was found perching on the rock in a riparian stream close to the secondary forest between Khawhnai and Teirei villages at around 17.26h on 19 November 2019. Head longer; skin smooth; tympanic fold ending in glandules at corner of mouth. Males are green and female are orange in colour. Distribution ranges include Bangladesh and India. n= 1 (female), SVL: 68mm.

3. Indo-Burma Stream Frog *Sylvirana lacrima* Sheridan & Stuart, 2018 (Image 3a)

The species was recorded in early hours at 05.30h on 19 November 2019 from the Selinglui flowing through Tuicharlui to core areas of DTR. Another individual of the same species was recorded at 18.32h in leaf litter of the bamboo forest floor outside the reserve. Broader

head, an oblique, triangular or tear drop shaped marking slightly posterior to the tympanum. Skin was finely granular above and smooth below with thin dark stripe just ventral dorso-lateral glandular fold prominent. The postaxial side of toe IV webbed to base of disc. This species is known from Chin and Mandalay states in western Myanmar. The species is a new country report. $n = 2$, SVL: 42mm (male) and 68mm (female). Earlier presumed to be *Amnirana* cf. *nicobariensis*; upon molecular analysis the species was found to be actually *Sylvirana lacrima*. The data on molecular analysis are attached as supplementary files. Genetic sequence of our specimen (MW440531) is similar to the sequences (MG606590; MG606592; MG935996) for the species *Sylvirana lacrima* available in GenBank database by the uncorrected p-distances of 0.000–0.009 with our sample.

4. Assam Forest Frog *Hydrophylax leptoglossa* (Cope, 1868) (Image 2b)

We recorded two individuals of this species at different occasions at 09.35h from human settlement area of Damparengpui Village at 403m and another individual at 12.20h on 1 December 2019 near Sunhlului Stream along foot trails with elevation of 689m. Head was long; nostrils lateral, nearer to tip of snout, tympanum almost as large as eye, rictal gland present at the base of forelimb, hind limbs moderate, toes 2/3rd webbed. Males have external vocal sacs. Distribution ranges in Bangladesh, India, Myanmar, and Thailand. $n = 2$ (two females), SVL: 54–61 mm.

5. Green-backed Stream Frog *Odorrana chloronota* (Günther, 1876) (Image 3c)

We recorded the species near an anti-poaching camp situated in the buffer zone of DTR at 17.04h on 21 September 2018 at an elevation of 242m. Head broader than long, much depressed. Dorsum green, with a row of large black spots on the mid-dorsum. A prominent white streak is present on both sides of upper jaw. Glandular fold originates from posterior corner of eyes to the shoulder, which is followed by a glandule. Tympanum brown with white circular rim. Originally described as '*Polypedates chloronotus*', the species distribution ranges from Darjeeling region of West Bengal, Sikkim and mountains of northeastern India (Assam, Meghalaya, and Mizoram), through Myanmar to southern China and southern Vietnam. It is a new report for DTR. $n = 1$ (male), SVL: 48mm.

6. Khare's Gliding Frog *Pterorana khare* Kyasetuo & Khare, 1986 (Image 3d)

A male individual (SVL: 65.8mm) was collected from Khawthlabung at Teirei Stream near Lallen Village at 16.30h on 20 September 2018 at an elevation of 547m. Head broader than long; nostrils laterally placed equidistant to eyes and tip of snout; tympanum distinct a dark band from corner of eye to shoulder along tympanic fold. Dorsum slate dark brown, ventrally white. Toes fully webbed. A lateral skin expanded from behind the tympanum up to the groin including thighs. Flap on the left measured 18mm width when stretched. The species is known from the northeastern states of India and Chin State of Myanmar. It is also a new record to DTR and a small population was observed in this section of stream.

V. Family Rhacophoridae Hoffman, 1932 (1858)

1. Common Tree Frog *Polypedates teraiensis* (Dubois, 1987) (Image 3e)

It was collected from the human settlement areas of Teirei Forest village at 16.40h on 24 September 2018 at an elevation of 253m. A large-sized frog, dorsal skin smooth, tips of fingers and toes with large discs, webbing moderate, dorsal color light brown with longitudinal brown lines, and has ossified cephalic skin on head. Distribution ranges are Nepal, India, Bangladesh, Myanmar, and China. It is a new record for DTR. $n = 1$ (female), SVL: 80mm.

2. Annandale's Pygmy Tree Frog *Chirixalus simus* Annandale, 1915 (Image 3f)

The species was observed near the forest guest house of Teirei forest at an elevation of 240m at 20.25h on 26 August 2019. A small tree frog, head are long; nostrils, closer to tip of snout; dorsum greyish to brownish; a dorsolateral white band on either side. Distributions are reported from India and Bangladesh. It is a new record for DTR. $n = 1$ (female), SVL: 23mm.

3. Giant Tree Frog *Zhangixalus smaragdinus* (Blyth, 1852) (Image 3g)

The species was collected from litter along the road edges with stagnant water at 12.49h on 3 April 2019 near Damparengpui Village at an elevation of 455m. Head broader than long; tympanum distinct, fingers webbed, discs prominent; dorsum, green; ventrally yellowish; dorsal skin smooth, ventral and lateral sides minutely granulated; toes fully webbed. It is distributed in India, Nepal, China, and Bangladesh. $n = 1$ (female), SVL: 93mm.



Image 3. Frog species with asterisk (*), hash (#), and plus (+) are new records for DTR, Mizoram, and India, respectively: a—*Sylvirana lacrima**#+ | b—*Hydrophylax leptoglossa** | c—*Odorrana chloronota** | d—*Pterorana khare** | e—*Polypedates teraiensis** | f—*Chiromantis simus** | g—*Zhangixalus smaragdinus* | h—*Rhacophorus bipunctatus** | i—*Raorchestes rezakhani**#+ | j—*Ichthyophis moustakius** | Photographs: b,c,d,f,g,h,i,j © H.T. Lalremsanga; a,e © Ht. Decemson.

4. Twin-spotted Tree Frog *Rhacophorus bipunctatus* Ahl, 1927 (Image 3h)

A female species was sighted which was resting on a leaf of *Licuala peltata* along the road leading to jhum fields at an elevation of 725m at around 11.58h on 1 December 2019. Head broader than long; nostril equidistant between the tip of snout and eye. The species

distribution region is considered to be well documented from Bangladesh, China, Laos, Vietnam, Cambodia, Myanmar, Thailand, and India. Recently, the occurrence of the species in DTR was confirmed by Decemson et al. (2020). n= 1 (female), SVL: 59mm.

5. Reza Khan's Bush Frog *Raorchestes rezakhani* Al-Razi, Maria & Muzaffar, 2020 (Image 3i)

The female specimen (SVL: 19.5mm) was found from the bushes at the peak of Pathlawilunglentang, near Damparengpui Village at ca. 18.00h on 7 July 2019 at an elevation of 578m. It is having a grayish-brown dorsum with “)- (“mark, less distinct bars on arms and legs; rounded snout, indistinct supratympanic fold and tympanum; pupil oval, horizontal; vomerine teeth absent; rounded discs on tips of digits; inner and outer metacarpal tubercles absent; metatarsal tubercles absent; belly pale white. Genetic sequence of our specimen (MW165454) is similar to the GenBank database sequences sampled from Bangladesh (MN072374; MN615902) by the uncorrected p-distance of 0.007 with our sample.

B. Order Gymnophiona

VI. Family Ichthyophidae Fitzinger, 1826

1. *Ichthyophis moustakius* Kamei, Wilkinson, Gower & Biju, 2009 (Image 3j)

A single *Ichthyophis moustakius* individual was collected from a roadside near the entry of the forest guest house, Teirei (241m) at 23.50h on 12 July 2020. The species identification is based on the original description by Kamei et al. (2009). Its known distribution range includes Aziuram, Nswanram, Nriangluang, Guwahati Metropolitan, and Bamgaizaeng in Tamenglong District, Manipur, and Sawleng Village in Aizawl District, Mizoram, in northeastern India. This is a new record for DTR. n= 1, dorsal annular groove: 275, head length: 11mm, head width: 9mm, SVL: 195mm, total length: 199mm.

DISCUSSION

In the study, 28 species were documented from different habitat types including streams, roadside, secondary forest, and human settlements (Image 5). While 19 species are new records from DTR and six species, *Amolops indoburmanensis*, *Limnonectes khasianus*, *Microhyla mukhlesuri*, *M. mymensinghensis*, *Raorchestes rezakhani*, and *Sylvirana lacrima* are new to the State's amphibian fauna and out of these, two species *Raorchestes rezakhani* and *Sylvirana lacrima* are new records for the country (Table 1). From the present study, we assumed that the report of *Euphylyctis cyanophlyctis*, *Limnonectes laticeps*, *L. limnocharis*, and *Raorchestes (Philautus) parvulus* by Pawar & Birand (2001) might possibly be *Euphylyctis kalasgramensis*, *L. khasianus*, *Minervarya asmati*, and *Raorchestes rezakhani*, respectively. Although Pawar & Birand (2001)

reported *Megophrys parva* from this area, Mahony et al. (2020) recently removed *M. parva* from the Indian faunal list and reassigned it as *M. serchhipii*. This is also evidenced by our morphological and molecular analysis of the specimens collected from this area. We also suggested *Microhyla ornata* and *Odorrana (Rana) livida* reported by Pawar & Birand (2001) supposed to be *M. mukhlesuri* or *M. mymensinghensis* and *O. chloronota* in viewing their current distribution records and genetic data, respectively. The reports of the species *Rhacophorus bipunctatus* and *Microhyla berdmorei* based on secondary source of information by Pawar & Birand (2001) was confirmed through direct records in our study and are listed as new records to DTR. Also, the record of *Amolops marmoratus* and *A. cf. viridimaculatus* by Pawar & Birand (2001) are most likely to be *A. indoburmanensis* depending upon the morphological and molecular analysis from the present collection. *Polypedates leucomystax cf. sexvirgatus* which was previously reported in the area (Pawar & Birand 2001) is also supposed to be *P. teraiensis* based on the current distribution.

Most of the species were recorded from natural perennial streams flowing from the core region towards the buffer areas of DTR. The Teirei Forest Guest House situated at the edge of DTR is also an ideal microhabitat for amphibians as it is surrounded by the juxtaposition of primary and secondary forests comprising rubber and oil palm plantations, cultivation, riparian forest, paddy field, streams, and human settlements with a mixture of hilly and undulating terrain. Studies on amphibian recovery pattern by Pawar et al. (2004) and Dunn (2004) has found that amphibians tend to recover to their full strength between the first 10 years of their habitat alteration. They also reported that, there is no significant age determinacy along different gradient of habitat recovery, however, factors such as soil moisture content, organic matter content, and ground litter cover are positively correlated and crucial for recovery of amphibian and reptiles in a modified habitat. Many other researchers have also identified such modified areas as excellent habitat for small mammals, birds, and reptilian species (Dunn 2004; Pawar et al. 2004; Palacios et al. 2013; Mandal & Raman 2016; Vega-Pérez et al. 2019). DTR has a buffer area of about 448km², where over 22,000 people are residing and practice shifting or jhum cultivation. The jhum fields are often left fallow after harvesting, thereby creating a mosaic of microhabitats that attracts several forms of faunal diversity (Gouda et al. 2020b). As amphibians are an important link in the food chain in terrestrial and aquatic ecosystems, it is important to understand their



distribution in both modified and natural ecosystems for planning their long term conservation.

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Author details: HT. DECEMSON: He has completed his MSc. (Zoology) from the Department of Zoology, Mizoram University and is currently perusing his Doctorate degree in the same department under the supervision of Dr. H.T. Lalremsanga. He is working as a Senior Research Fellow in the NMHS project and focuses mainly on primates and amphibian diversity in Dampa Tiger Reserve. DR SUSHANTO GOUDA has recently completed his PhD from Amity Institute of Forestry and Wildlife, Amity University, Noida. He is also working as a Senior Research Fellow in the NMHS project and focuses mainly on mammalian diversity in and around the Dampa Tiger Reserve. LALBIAKZUALA is working as a Junior Research Fellow under DBT project. He is currently perusing his PhD from the Department of Zoology, Mizoram University. His area of interest is amphibian and reptile diversity, taxonomy and molecular systematic. LALMUANSANGA has completed his MSc. from the Department of Zoology, Mizoram University and is presently enrolled as a PhD Scholar in the same department. He is working as a Junior Research Fellow under DRDO project, Ministry of Defense, Government of India. His area of interest is amphibian and reptile diversity from Mizoram, India. GOSPEL ZOTHANMAWIA HMAR has completed his MSc. from the Department of Zoology, Mizoram University and is presently enrolled as a PhD Scholar in the same department. He is also a Junior Research Fellow under DST- SERB project. His subject area is Chenonians throughout Mizoram. DR MATHIPI VABEIRYUREILAI was awarded Doctorate degree in the field of Cancer Biology from the Department of Zoology, Mizoram University, in 2017. At present he is actively engaged as a Research Associate under the ongoing DBT project mainly focusing from the ground level of field work to molecular analysis. DR H.T. LALREMSANGAIS designated as an Associate Professor and is also the Head of the Department of Zoology, Mizoram University. He is currently running four major projects under DBT, DST-SERB, DRDO and NMHS. He is also supervising PhD Scholars in the field of Herpetology and developmental biology.





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