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Amphibians of the Dibang River Basin, Arunachal Pradesh: an annotated checklist with distribution records.

Jayanta K. Roy [1], Ramie H. Begum [2] & M. Firoz Ahmed [3]

[1,2] Department of Life Science and Bioinformatics, Assam University, Diphu Campus, Karbi Anglong, Assam 782460, India
[1,3] Herpetofauna Research and Conservation Division, Aaranyak, 13 Tayab Ali Byelane, Bishnu Rabha Path, Beltola Tinali, Beltola, Guwahati, Assam 781028, India
[1] roy.jayantakumar47@gmail.com, [2] ani.ara73@gmail.com, [3] mfa.aaranyak@gmail.com (corresponding author)

Abstract: The present study across the Dibang River Basin is being presented as an annotated checklist from Arunachal Pradesh. A systematic survey was conducted during 2014–2017 by visual encounter surveys, as well as opportunistic records across the basin. Thirty-eight species of amphibians belonging to 17 genera in six families were recorded. Five new distribution records for Arunachal Pradesh, and one genus *Oreolalax* was recorded for the first time from India. Further, a rare report on *Theloderma moloch* and *Rhacophorus tuberculatus* from northeastern India provided significant information on species microhabitat and updated the amphibian distribution records from Arunachal Pradesh.

Keywords: Five new state records, microhabitat, one new genus record for India, *Oreolalax*, *Rhacophorus tuberculatus*, *Theloderma moloch*.

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Author Details: Jayanta Kumar Roy is a biologist with Herpetological Research and Conservation Division of Aaranyak and has been working on amphibians of northeast India for last seven years. Currently he is focusing on ecology of amphibians of Dibang River Basin in the Eastern Himalaya and completed his PhD research from Assam University, Diphu Campus. He has recorded several rare and threatened amphibian species from the region. Ramie H, Begum is a Biomedical Scientist working in the field of animal disease monitoring and surveillance for more than 14 years. A DBT overseas associate and a visiting professor at University of California, USA, she currently Heads the Department of Life Science and Bioinformatics at Assam University Diphu Campus. M Firoz Ahmed has been involved in conservation research on herpetofauna and tigers in India since 1998. He has been working on herpetofauna and reported new species to science. He has carried out herpetofaunal inventory and taxonomy work in northeast India with specialization in Rhacophorids. He currently heads the Herpetological Research and Conservation Division of Aaranyak.

Author Contribution: JKR - study design, field data collection, analysis and manuscript writing. RHB - manuscript writing and guided JKR. MFA - study design and manuscript writing.

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INTRODUCTION

Arunachal Pradesh, a part of the eastern Himalayan Biodiversity Hotspot is still poorly inventoried for flora and fauna. Studies carried out in the state till now have reported 39 amphibians species from Arunachal Pradesh (Sarkar & Ray 2006). Although, the first and most extensive survey on amphibians was carried out by Annandale (1912), where 25 species were documented during the Abor Hill expedition. Subsequently, 22 species from Arunachal Pradesh were reported by Chanda (1994), 28 species from East Kameng (Pakhui Tiger Reserve), Changlang (Namdapha National Park) & Upper Siang (Mouling National Park) District by Pawar & Birand (2001), 50 species from Dihang–Dibang Biosphere Reserve by Borah & Bordoloi (2003), and 35 species from Eaglenest Wildlife Sanctuary by Athreya (2006).

Systematic studies and empirical observations on amphibian species distribution in northeastern region was found to be seriously lacking, although several studies recorded amphibian species from the region (Annandale 1912; Chanda 1994; Pawar & Birand 2001; Bordoloi et al. 2002; Athreya 2006; Sarkar & Ray 2006; Ahmed et al. 2009; Mathew & Sen 2010). In the present study, we presented an updated amphibian species distribution and detailed microhabitat characteristics from Arunachal Pradesh.

MATERIALS AND METHODS

The Dibang River Basin (Fig. 1) is situated in the foothills flanked by the eastern Himalaya. It covers two districts of Arunachal Pradesh: the Lower Dibang Valley and Dibang Valley with a total geographic area of 13,029km^2 are situated between 27.99–28.98 ^{0}N and 95.78–95.81 ^{0}E. The Dibang River flows from the southern flank of the eastern Himalaya and joins the Brahmaputra River in eastern Assam near Tinsukia Town. The entire basin is a mountainous tract and altitude ranges from 200m to 4900m; the annual rainfall varies from 3500–5000 mm (CGWB 2013). The rocky headwater streams with thick canopy cover is the characteristic habitat features of the study area that provide a suitable habitat for rare and range restricted amphibian species (Morse et al. 1993; Meyer & Wallace 2001).

We conducted an extensive survey across the Dibang River Basin covering altitude from 200m to 3500m from 2014–2017. Systematic surveys were conducted along different stream and in forested habitat. The amphibian survey includes two hour (1830–2030 h) visual encounter survey (VES) (Crump & Scott 1994) followed by opportunistic observations during the study period. We monitored amphibian breeding pools located in very remote places in the valley in deep forest during short expeditions of 10–15 days. All amphibian encounters

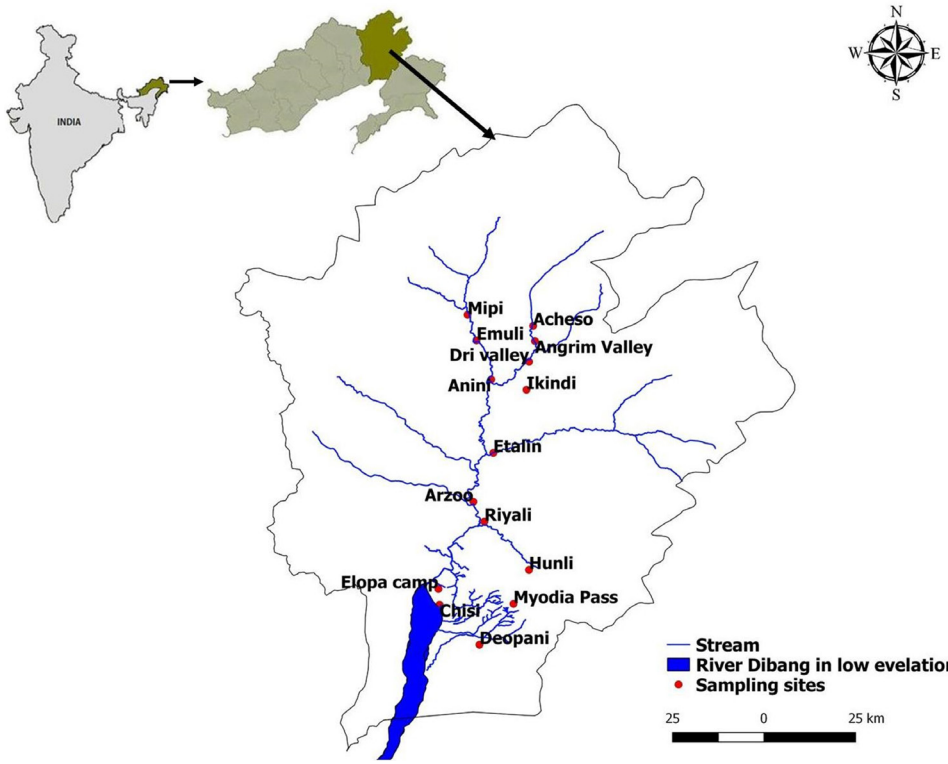

Figure 1. Map of the study area showing sampling sites for amphibian species distribution across the Dibang River Basin, Arunachal Pradesh, India during 2014–2017.

were marked using Garmin GPS map 62s and recorded on a standard data sheet. When possible, amphibians were measured on the spot (SVL: snout vent length) using dial calliper (to the nearest 0.1 mm) and released at the same habitat immediately.

RESULTS

This study recorded a total of 38 amphibian species across the Dibang River Basin. The amphibians were recorded from an altitudinal gradient of 200m to 3,300m. The study did not encounter any species of Gymnophiona. The summary of the species recorded is presented in Table 1.

This study recorded the genus *Oreolalax* from India for the first time. Five distribution records confirmed from the state of Arunachal Pradesh for the first time, viz.: *Nanorana chayuensis*, *Odorrana chloronota*, *Hydrophylax leptoglossa*, *Minervarya pierrei*, and *Minervarya syhadrensis*. Further, additional distribution records for *Theloderma moloch* and *Rhacophorus tuberculatus* have been obtained.

A brief account of species recorded with their natural habitats are given below:

Table 1. Number of amphibian species recorded from the Dibang River Basin, Arunachal Pradesh, India.

Genus	No. of species
Amolops	4
Duttaphrynus	3
Euphlyctis	1
Minervarya	4
Hoplobatrachus	2
Humerana	1
Hydrophylax	1
Kurixalus	1
Liurana	2
Odorrana	1
Nanorana	1
Oreolalax	1
Philautus	4
Polypedates	1
Rhacophorus	5
Theloderma	2
Xenophrys	4
17 genera	**38 species**

Species accounts

Family: Ceratobatrachidae

***1. Liurana medogensis* (Fei et al., 1997)**

Head broader than long; tympanum distinct; supra tympanic fold thick. Dorsally smooth and light brown; ventrally chest and belly smooth, thigh finely granulated. Fingers and toes were free. We have recorded *Liurana medogensis* (Image 1a) throughout the study area at different localities (851–2448 m) during May–August. Borah et al. (2013) reported occurrence of this species from Basar, West Siang District (950m) and Pang, Lower Subansiri District (2000–2500 m). Inhabits forests as well as edge of streams with thick litter fall. SVL: 21.27–23.17 mm (n=12).

***2. Liurana* sp.**

Head broader than long; tympanum distinct; supra tympanic fold thick. Dorsally and ventrally dark brown in colour, smooth; ventrally smooth, dark brown with irregular white spots. Fingers and toes free. We have recorded this unconfirmed *Liurana* sp (Image 1b) from Ikindi in the Dibang Valley (2800–3235 m) in the month of May. Males were found calling from under litter fall at the base of a large tree, under a decaying fallen tree inside a humid forest. SVL: 21.27–23.17 mm (n=8).

Family: Bufonidae

***3. Duttaphrynus melanostictus* (Schneider, 1799)**

Head broader than long; distinct angular dark ridges on head; two large kidney-shaped parotid glands behind eyes; tympanum distinct; supra tympanic ridge present. Dorsal skin with rough spiny warts and tubercles. Ventral surface granular. Fingers free; toes nearly half webbed. We have recorded *D. melanostictus* (Image 1c) across Dibang River Basin at different localities (350–2000 m). Earlier this species has been reported from Abor hills (Annandale 1912); West Kameng, East Kameng, Lower Subansiri, West Siang, East Siang, Lohit and Tirap districts (Sarkar & Sanyal 1985; Sarkar & Ray 2006); Dihang–Dibang Biosphere Reserve (Bordoloi et al. 2002) and Eaglenest (Athreya 2006). *D. melanostictus* usually common around human settlements, but also encountered in forested habitats. SVL: 52.31–76.30 mm (n=10).

***4. Duttaphrynus stuarti* (Smith, 1929)**

Head broader than long; parietal ridges absent; parotid glands elongated; tympanum distinct, supra tympanic ridge absent. Dorsal skin with keratinized spiny warts. Ventral surface granular. Fingers free; toes half webbed. We have recorded *D. stuartii* (Image 1d) from Lower Dibang Valley at different localities (285–

1486 m) during April–August. Agarwal & Mistry (2008) recorded this species from Eaglenest Wildlife Sanctuary (1250–2100 m) from western Arunachal Pradesh. They were present along edge of stream, forest trails with litter fall. SVL 36.42–73.13 mm (n=12).

***5. Duttaphrynus* sp.**

Head broader than long. parietal ridge absent. Tympanum distinct; parotid glands wider and elongated. Dorsal skin with smooth warts and large tubercles. Ventral surface granular with large tubercles. Fingers free, toes half webbed. We have recorded this unconfirmed typical Indo-China species of *Bufo* (Image 1e) from Anini, Angrim Valley and Mipi (1403–1678 m) during February–March. They are early breeders in the area (early February–mid March). Males were observed calling from temporary roadside water pools as well as permanent pool of water after a heavy thundershower. SVL: 81.25–91.12 mm (n=4).

Family: Megophryidae

***6. Oreolalax* sp.**

Head broader than long. Tympanum not distinct; supra tympanic fold thick. Dorsally olive to greenish-grey with numerous longitudinal bars. Ventrally smooth, dark brown with two blotch or outgrowths on chest. Fingers and toes free. A single individual of this species was recorded from Ikindi at 3235m in May. This record of *Oreolalax* sp (Image 1f) from the study area is a new distribution record of the genus to the country. It was observed in the night on an elevated tree trunk covered with mosses in a rhododendron forest. SVL: 39.21mm (n=1).

***7. Xenophrys robusta* (Boulenger, 1908)**

Head as broad as long. V–shape marked behind head. Tympanum distinct; supra tympanic fold thick. Dorsally smooth or finely granulated, reddish brown to dark brown. Ventrally smooth, dark grey in colour. Fingers free; toes rudimentarily webbed. We have recorded *X. robusta* (Image 1g) species during March–September across the Dibang River Basin (297–1612 m). Previously known from the Dihang–Dibang Biosphere Reserve (Bordoloiet al. 2002) and from Namdapha and Mouling National Park (Pawar & Bindra 2001). They inhabit along the edges of gently flowing streams with large boulders and thick riparian vegetation cover. SVL: 80.79–120.12 mm (n=6).

***8. Xenophrys* sp1.**

Head longer than wide. Tympanum distinct and concealed by supra tympanic fold. Greenish to brown dorsum with benzene ring marked on dorsum. Ventrally smooth; dark grey in colour. Fingers and toes free. We have recorded this unconfirmed *Xenophrys* sp1 (Image 1h) across the Dibang River Basin (679–2541 m) during March–July. Males were found calling from shrubs and large boulders near stream banks. They were abundant along the edges of narrow stream reaches as well as road side wall with thick and wet vegetation. This was the smallest among all the *Xenophrys sp.* recorded during this study. SVL: 28.98–34.37 mm (n=5).

***9. Xenophrys* sp2.**

Head broader than long. V–shaped preorbital ridge and a second inverted V–shaped marked on the mid–dorsum. Tympanum distinct; supra tympanic fold present. Dorsally dark brown with fine tubercles, smooth. Ventral surface smooth, grey with black blotches. Fingers free; toes rudimentarily webbed. We have recorded this unconfirmed species of *Xenophrys* sp. 2 (Image 1i) (947–2079 m) from Anini during May–July. The microhabitat was same as the *X. robusta*; however distribution in mid elevation. The SVL measured for one individual of the species was 60.34mm.

***10. Xenophrys* sp3.**

Head broader than long. V–shaped preorbital ridge and a second inverted V–shaped marked on the mid–dorsum. Tympanum distinct and concealed by supra tympanic fold. Dorsally reddish brown, smooth. Ventrally smooth, grey with dark orange blotches. Fingers free; toes rudimentarily webbed. We have recorded this unconfirmed species of *Xenophrys* sp 3 (Image 1j) from high altitude in Ikindi (2184–3060 m) in May. They were observed along the edge of a stream as well as on forest litter fall near a water pool at a high elevation. SVL: 45.2–47.6 mm (n=5).

Family: Dicroglossidae

***11. Euphlyctis cyanophlyctis* (Schneider, 1799)**

Head slightly broader than long. Tympanum distinct. Dorsum greyish to brownish, smooth with dark, round spots uniformly distributed; small tubercles and warts present on dorsum. Ventral surface almost white and smooth. Fingers free; toes fully webbed. We have recorded *E. cyanophlyctis* (Image 1k) across the Dibang River Basin at all the sampling sites (232–1738 m) during the year. It has a wide distribution range in Arunachal Pradesh (Annandale 1912; Chanda 1994; Pawar & Bindra 2001; Bordoloi et al. 2002; Sarkar & Ray 2006). *Euphlyctis cyanophlyctis* locally common and abundant

Image 1 (a-o): Amphibian species recorded from the Dibang River Basin of Arunachal Pradesh during 2014–17.
a) *Liurana medogensis*; b) *Liurana* sp; c) *Duttaphrynus melanostictus*; d) *Duttaphrynus stuarti*; e) *Duttaphrynus* sp.; f) *Oreolalax* sp.; g) *Xenophrys robusta*; h) *Xenophrys* sp1; i) *Xenophrys* sp2; j) *Xenophrys* sp3; k) *Euphlyctis cyanophlyctis*; l) *Minervarya nepalensis*; m) *Minervarya pierrei*; n) *Minervarya syhadrensis*; o) *Minervarya teraiensis*. © Image i - M. Firoz Ahmed; rest of the images - Jayanta K. Roy.

in temporary and permanent water bodies, paddy fields, marshy areas in plain grassland. SVL=44.5–66.5 mm (n=10).

***12. Minervarya nepalensis* (Dubois, 1975)**

Head longer than wide. Tympanum distinct; supra tympanic fold narrow. Dorsally greyish-brown with dark irregular spots, narrow mid dorsal line present. Ventrally smooth and grey in colour. Fingers free; toes half webbed. We have recorded *Minervarya nepalensis* (Image 1l) from lowland areas in the Lower Dibang Valley (224–796 m asl). Bordoloi et al. (2002) recorded this species from the Dihang–Dibang Biosphere Reserve of Arunachal Pradesh without mentioning any specific locality. M*. nepalensis* is present in different habitats such as agricultural land, temporary or permanent pools and grassland etc. SVL=33–37 mm (n=12).

***13. Minervarya pierrei* (Dubois, 1975)**

Head slightly longer than wide. Tympanum distinct; supra tympanic fold narrow. Dorsum olive to brownish with serrated longitudinal bars; broad mid–dorsal line present on the dorsal side of body. Ventrally smooth, grey in colour. Fingers free; toes half webbed. We have recorded M*. pierrei* (Image 1m) from lowland Nijamghat areas in the Lower Dibang Valley (232m) in June. It inhabits agricultural land, small temporary water bodies and grassland. Previously not reported from Arunachal Pradesh. SVL=40.20–44.62 mm (n=4).

***14. Minervarya syhadrensis* (Annandale, 1919)**

Head slightly broader than length. Tympanum distinct; supra tympanic fold narrow. Dorsally greyish- to brownish-olive with black irregular spots; very narrow mid–dorsal line present on dorsum. Ventrally smooth, grey to dark grey in colour. Fingers free; toes half webbed. We have recorded *M. syhadrensis* (Image 1n) from lowland areas of Nizamghat in the Lower Dibang Valley (274–387 m) during April–July. It inhabits small temporary water pools; paddy field; grassland. There is no earlier report of this species from Arunachal Pradesh. SVL=25.10–29.33 mm (n=16).

***15. Minervarya teraiensis* (Dubois, 1984)**

Head broader than long. Tympanum distinct; supra tympanic fold present. Dorsally greyish to brownish with fine granules; narrow mid–dorsal line present or absent. Ventrally smooth, dark grey in colour. Fingers free; toes half webbed. Nine individuals of *M. teraiensis* (Image 1o) recorded; eight from lowland areas of Nizamghat (232masl) and one individual from Chisindo (795m) during April–May. Earlier, Bordoloi et al. (2002) reported this species from Dehang Debang Biosphere Reserve of Arunachal Pradesh without any specific locality mention. *F. teraiensis* was observed in temporary or permanent water bodies, paddy field, shallow pool in forest. SVL=44.6–47.54 mm (n=9).

***16. Hoplobatrachus tigerinus* (Daudin, 1802)**

Head longer than broad. Tympanum distinct; supra tympanic fold very prominent and thick. Dorsally yellowish to olive green, marked with large irregular blackish spots, irregular glandular folds on dorsum; mid–dorsal line present. Ventrally smooth and white. Fingers free; toes fully webbed. We have recorded *H. tigerinus* (Image 2p) from the lowland areas of Nizamghat in Lower Dibang Valley (215–500 m) in April. Earlier records from Arunachal Pradesh (Annandale 1912; Chanda 1994; Pawar & Bindra 2001; Bordoloi et al. 2002; Sarkar & Ray 2006) suggested a wide distribution of the species in the region. *H. tigerinus* inhabits paddy fields, marshy grassland and also near large water bodies in floodplain. SVL: 82.30–118.30 mm (n=25).

***17. Hoplobatrachus crassus* (Jerdon, 1853)**

Head broader than long. Tympanum distinct; supra tympanic fold thick. Dorsum greenish or olive, granulate with prominent warts and irregular longitudinal glandular folds; mid-dorsal line absent. Ventrally smooth, grey in colour. Fingers free; toes fully webbed. We have recorded a single individual of *H. crassus* (Image 2.q) in a temporary roadside pool at New Chidu (297m) in July. Previously reported by Pawar & Bindra (2001) from Pakke Tiger Reserve followed by Borah & Bordoloi (2003) in Chessa and Papumpare (500m). This is also the first record of *H. crassus* from the Dibang Valley as well as eastern Arunachal Pradesh. It is also the easternmost distribution of the species in the Brahmaputra Valley since it was reported by Saikia et al. (2000). *H. crassus* inhabits marshy and shrub wetlands, paddy field, temporary or permanent water bodies. SVL=70.81mm (n=1).

***18. Nanorana chayuensis* (Ye, 1977)**

Head broader than long. Tympanum distinct; supra tympanic fold thick. Dorsally olive brown to dark brown with irregular warts on dorsum. Ventrally grey, two oval patches of spine groups with 33 to 56 spines on each patch on male chest during breeding season. Fingers free; toes fully webbed. We have recorded *N. chayuensis* (Image 2r) across the Dibang River Basin (816–2539 m) during April–July. This report is a first

record of the species from northeast India as well as new distribution record of this species from Arunachal Pradesh. Earlier Deuti & Ayyaswamy (2008) reported this species from Darjeeling District of West Bengal (1860m). *N. chayuensis* inhabits fast flowing first order streams with slippery boulders and steep bank angle. SVL=62.11–84.11 mm (n=18).

Family: Ranidae

***19. Amolops marmoratus* (Blyth, 1855)**

Head broader than long. Tympanum distinct; supra tympanic fold not distinct. Dorsally brown with olive green to brown gray irregular spots, granulated. Ventrally yellowish-white and granulated. Fingers free; toes fully webbed. We have recorded *A. marmoratus* (Image 2s) from the Lower Dibang Valley at different locations (273–1294 m) during March–August. Previously recorded from the Upper Renging (655m) (Annandale 1912) followed by Bordoloi et al. (2002) from Namdapha and Boleng, and Dihang–Dibang Biosphere Reserve without any specific locality (500–2000 m). *A. marmoratus* inhabits perennial streams; rocky streams bed (riffles). SVL 27.10–72.9 mm (n=15).

***20. Amolops viridimaculatus* (Jiang, 1983)**

Head slightly longer than broad. Tympanum not distinct; supra tympanic fold narrow. Dorsally smooth, brown with numerous greenish blotch on dorsum. Ventrally smooth, grey greenish. Fingers free; toes fully webbed. Observed *A. viridimaculatus* (Image 2t) common across the Dibang River Basin at different localities (679–2538 m) during April–July. Previously reported from the Mouling National Park (Pawar & Bindra 2001) and from the Eaglenest Wildlife Sanctuary (Athreya 2006) at Bompu (2200m) and New Khellong (1250m). *A. viridimaculatus* inhabits undisturbed rocky perennial streams with thick canopy cover. SVL 65.20–78.20 mm (n=12).

***21. Amolops* cf. *chunganensis* (Pope, 1929)**

Head slightly longer than broad. Tympanum distinct; supra tympanic fold not clear. Dorsally Olive green to gray brown or reddish brown; dorsolateral line running from posterior eye to vent. Ventrally smooth, pale yellow. Fingers free; toes fully webbed. Recorded *A. chunganensis* (Image 2u) from Etalin (720 m) during May–July. Athreya (2006) recorded this species as unconfirmed from Sessni (1250m), Eaglenest Wildlife Sanctuary. *A. chunganensis* inhabits at the edges of large streams with large boulders and thick canopy cover. SVL 29.07–33.80 mm (n=3).

***22. Amolops* sp.**

Head broader than long. Tympanum distinct; supra tympanic fold narrow or indistinct. Dorsally brown with numerous spiny granules serrated on abdominal side; thick dorsolateral line present, Ventrally smooth, grey in colour. A single individual of this unconfirmed species of *Amolops* (Image 2v) was recorded from Riyali (1468m) in July. It inhabits wet and slippery boulders along the edge of a fast flowing stream. SVL: 51.3mm (n=1).

***23. Humerana humeralis* (Boulenger, 1887)**

Head longer as broad. Tympanum distinct; supra tympanic fold not distinct. Dorsally light brown to bright green; uniformly tuberculated; thick dorsolateral line (Ahmed et al. 2009). Ventrally whitish, smooth. Fingers free; toes two-third webbed. We have recorded *H. humeralis* (Image 2w) from lowland areas in Nizamghat (232–420 m) during March–July. Previously recorded from the Pakke Tiger Reserve (Hussain et al. 2007). It inhabits paddy field; marshy areas with thick vegetation and tall grasses. SVL: 53.71–63.78 mm (n=4).

***24. Hydrophylax leptoglossa* (Cope, 1868)**

Head long as broad. Tympanum distinct; supra tympanic fold indistinct or absent. Dorsally brown with small to large black spots or markings; dorsolateral line from posterior eye to vent. Ventrally smooth, white spotted brown. Fingers free; toes two–third webbed. We have recorded *H. leptoglossa* (Image 2x) from the Sally Lake (488m) in June. This species was known to occur at low elevations in Assam and Mizoram, (Chanda 1994; Lalremsanga et al. 2007a; Ahmed et al. 2009; Bortamuli et al. 2010). Recorded two males calling from thick bushes by the lake. Also inhabits slow flowing forest streams and swampy habitats with thick vegetation (Ahmed et al. 2009). SVL: 49.37–50.34 (n=2).

***25. Odorrana chloronota* (Gunther, 1876)**

Head as long as broad. Tympanum distinct; supra tympanic fold not present. Dorsally bright green with 5–6 dark spots. A prominent golden streak present on the upper jaw. Ventrally smooth, dark grey. Fingers free; toes fully webbed. We have recorded *O. chloronata* (Image 2y) from the lowland areas of Nizamghat (252m) and Etalin (680m) during March–July. This is the first record of *O. chloronata* from Arunachal Pradesh. *O. chloronata* has been originally reported from Darjeeling (Gunther 1876) and later from Mizoram (Lalremsanga et al. 2007b); Meghalaya and Assam (Mathew & Sen 2010) with no specific location. The microhabitat recorded for *O. chloronata* was near small and fast flowing streams

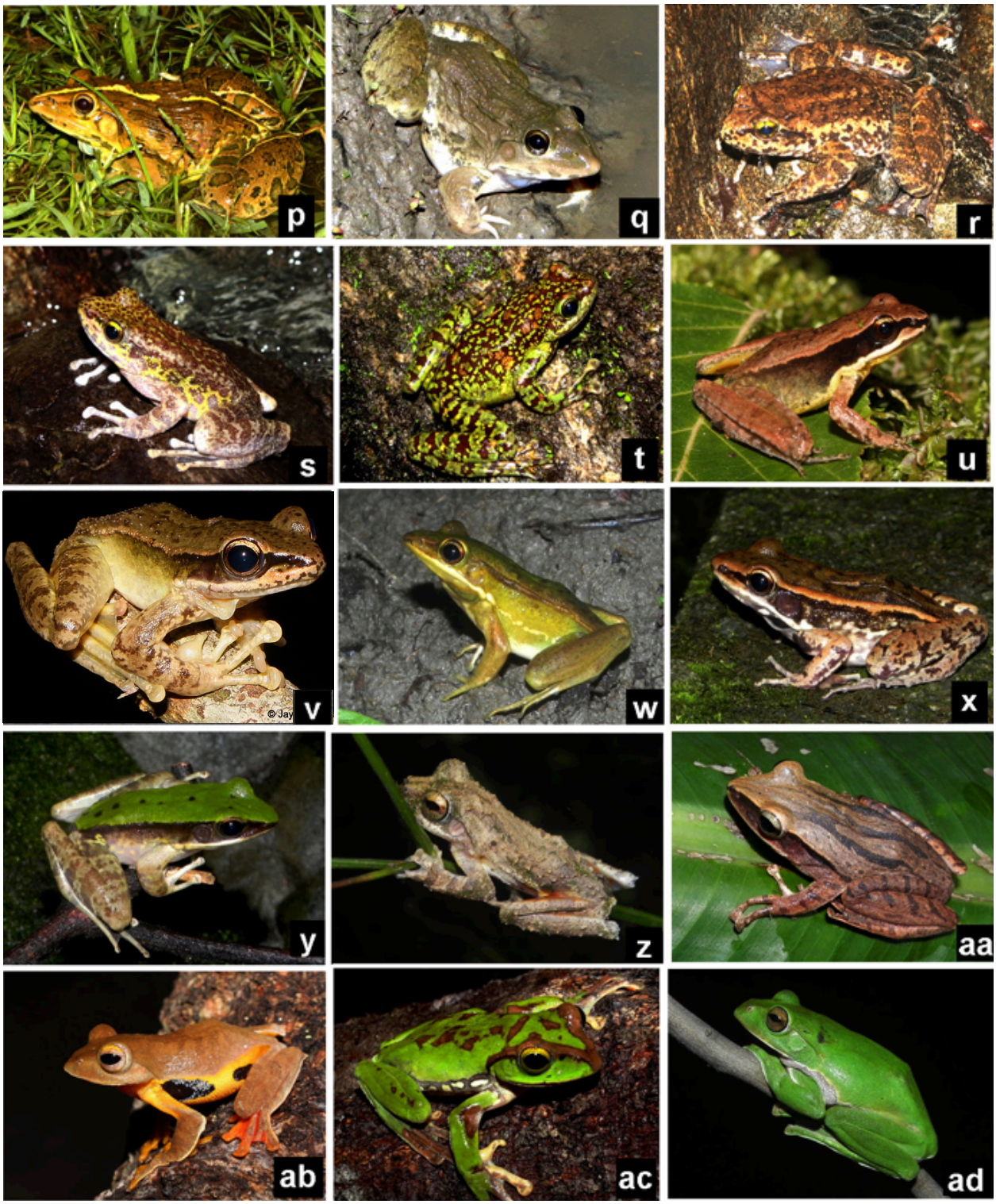

Image 2 (p-ad): Amphibian species recorded from the Dibang River Basin of Arunachal Pradesh during 2014–17.
p) *Hoplobatrachus tigerinus*; q) *Hoplobatrachus crassus*; r) *Nanorana chayuensis*; s) *Amolops marmoratus*; t) *Amolops viridimaculatus*; u) *Amolops* cf. *chunganensis*; v) *Amolops* sp; w) *Humerana humeralis*; x) *Hydrophylax leptoglossa*; y) *Odorrana chloronota*; z) *Kurixalus naso*; aa) *Polypedates himalayensis*; ab) *Rhacophorus bipunctatus*; ac) *Rhacophorus burmanus* ad) *Rhacophorus maximus*.
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with thick canopy cover. SVL: 70.81mm (n=1).

Family: Rhacophoridae

***26. Kurixalus naso* (Annandale, 1912)**

Head broader than long. Tympanum distinct; supra tympanic fold present, narrow. Dorsally light to dark brown in colour with prominent pustules and folds including dorsal part of limbs. Ventrally whitish and granular. *K. naso* (Image 2z) was recorded from Nizamghat (252–1631 m) during April–June. Earlier, Annandale (1912) reported this species from the Egar stream between Renging and Rotung and later from the Mouling National Park (Pawar & Bindra 2001); Doimara in Eaglenest Wildlife Sanctuary (Athreya 2006). *K. naso* lives near the edge of forest and stream with thick understory vegetation or bushes. SVL: 33.4–35.3 mm (n=8).

***27. Polypedates himalayensis* (Gray, 1830)**

Head broader than long. Tympanum distinct; supra tympanic fold thick. Dorsally smooth, brownish with light darker spots. Ventrally dull whitish and granular. Fingers free; toes three–fourth webbed. *P. himalayensis* (Image 2aa) was recorded from different localities (297–1486 m) during May–July. Annandale (1912) recorded this species from Arunachal Pradesh as a subspecies of *P. maculatus himalayensis* from the collection of the Abor Hill Expedition followed by Pawar & Bindra (2001) from the Mouling National Park. Sarkar & Ray (2006) reported it from the West Kameng, East Siang and the Tirap districts without mention of any specific locality. *P. himalayensis* inhabits near stagnant water bodies temporary or permanent with thick vegetation (herbs and shrubs). Males were found calling from thick grasses and shrubs in shallow pools of water as well as from terrace paddy. SVL: 37.50–44.39 mm (n=10).

***28. Rhacophorus bipunctatus* (Ahl, 1927)**

Head broader than long. Tympanum not distinct; supra tympanic fold narrow. Dorsally light green to green with fine black dots. Ventrally white, granular. Dark characteristic spots on side by arm and groin. Fingers two–third webbed; toes fully webbed. *R. bipunctatus* (Image 2ab) was recorded from the Maruli (1290m) and Tiwarigaon (1486m) in May and July respectively. Earlier, Annandale (1912) recorded this species from the Rotung and consequently from the Tirap (Sarkar & Sanyal 1985), and the Siang (Chanda 1994; Borah & Bordoloi 2003), without any mention of specific locality; and from the Sessni in Eaglenest Wildlife Sanctuary (Athreya 2006). Males were found calling from branches of shrubs at the edge of forest as well as roadside water pool and marshy areas. SVL: 40.80–55 mm (n=12).

***29. Rhacophorus burmanus* (Andersson, 1939)**

Head slightly longer than broad. Tympanum distinct; supra tympanic fold very thick. Dorsally green with dark brown blotches; milky white blotches on lateral sides of the body. Ventrally granulated, grey in colour. Fingers one-fourth webbed; toes two-third webbed. *R. burmanus* (Image 2ac) was recorded from Aropo (1367m) and Maruli (1408m) in May. This is the first record of the species from Arunachal Pradesh which was recently reported from Nagaland and Manipur (Sengupta et al. 2017). Individuals were observed on the ground at the edge of forest and roadside with thick shrubs near a small water pool respectively. SVL: 56.21–52.30 mm (n=2).

***30. Rhacophorus maximus* (Gunther, 1858)**

Head slightly broader than long. Tympanum distinct; supra tympanic fold present, narrow. Dorsally green, smooth. Ventral and lateral sides of body granulated. Fingers two–third webbed; toes fully webbed. *R. maximus* (Image 2ad) was recorded across the Dibang River Basin at different localities (297–2000 m) during April–July. It has been reported widely from Arunachal Pradesh; the upper Rotung (Annandale 1912); Pakke, Namdapha and the Mouling National Park (Pawar & Birand 2001); Siang, Namdapha, Itanagar and the Dihang-Dibang Biosphere Reserve (Borah & Bordoloi 2003); Lower Subansiri (Sarkar & Ray 2006). During the breeding season *R. maximus* is generally encountered near stagnant water bodies, temporary or permanent, marshy area and roadside water bodies. SVL: 38.55–93.00 mm (n=16).

***31. Rhacophorus translineatus* (Wu, 1977)**

Head longer than broad. Tympanum distinct; supra tympanic fold present, thick. Dorsally reddish-brown to light brown in color; very fine granules on dorsum with narrow 9–12 transverse dark brown line from snout to vent. Ventrally whitish with thin network markings. Fingers two–third webbed; toes fully webbed. *R. translineatus* (Image 3ae) was recorded from Tiwarigaon (1480m) and the Ahini Ango (920m) in July and August respectively. Previously, it was reported from the Dihang–Dibang Biosphere Reserve (Bordoloi et al. 2002) without any specific locality or voucher specimens, and from Eaglenest Wildlife Sanctuary (Athreya 2006). *R. translineatus* inhabits marshy pools under thick canopy and males were found calling from nearby vegetation, bushes and trees. SVL: 58.25–59.68 mm (n=4).

***32. Rhacophorus tuberculatus* (Anderson, 1871)**

Head slightly longer than broad. Tympanum distinct; supra tympanic fold present, narrow. Dorsally deep brown with numerous fine black spots on dorsum. Ventrally whitish, granular mixed with large tubercles. *R. tuberculatus* (Image 3af) was recorded from Nizamghat (395m) in July. *R. tuberculatus* has been reported from Janakmukh (183m), Rotung (396m) and Kalek (1158m) during the Abor hill expedition (Annandale 1912). We observed a single *R. tuberculatus* sitting on a branch along the edge of a narrow stream covered by thick bushes. SVL: 41.8 mm (n=1).

***33. Theloderma asperum* (Boulenger, 1886)**

Head broader than long. Tympanum distinct; supra tympanic fold indistinct. Dorsally dark gray to brown with small to large spinules. Ventrally smooth, dark. Fingers free; toes half webbed. *T. asperum* (Image 3ag) was recorded from New Chidu (344m) and Elopa (851m) in May. Annandale (1912) recorded this species from the Egar stream between the Renging and the Rotung in East Siang District; subsequently, from Namdapha and the Mouling National Park (Pawar & Birand 2001). Males were found calling from water accumulated in a tree trunk hole inside a tropical humid forest. Also found in an artificial water tank near agricultural land close to the forest. SVL: 28.9–30.8 mm (n=4).

***34. Theloderma moloch* (Annandale, 1912)**

Head broader than long. Tympanum distinct; supra tympanic fold indistinct. Dorsally greyish-brown with prominent ridge more or less serrated warts on dorsum. Ventrally black, granulated, tubercles around vent. Fingers free; toes three–fourth webbed. *T. moloch* (Image 3ah) was recorded from Elopa (780m) and Chisindo (910m) in May and July, respectively (Roy et al. 2017). Annandale (1912) originally described this species from the Upper Rottung, East Siang District and later it was reported from the Eaglenest Wildlife Sanctuary (Athreya 2006). It is also reported from Namdapha by Biju et al. (2016). The microhabitat and other natural history notes are reported by Roy et al. (2017). SVL 36.10–39.46 mm (n=4).

***35. Philautus* sp1**

Head broader than long. Both tympanum and supra tympanic fold indistinct. Dorsally smooth, reddish-brown. Ventrally granular, whitish. Fingers free; toes one–third webbed. Recorded this unconfirmed *Philautus* sp.(*Philautus* sp1, Image 3ai) from moist forest areas of Nizamghat, New Chidu and Ejengo (232–947 m) during March–July. Inhabits along the edge of forest and males were observed calling from thick bushes under a moderate canopy cover. Also observed near human habitations. SVL 19.5–20.2 mm (n=3).

***36. Philautus* sp2**

Head broader than long. Tympanum fairly distinct; supra tympanic fold present, narrow. Dorsally smooth, grey brown; 2–3 dark brown spots on flanks near to ventrum. Ventrally granular, grey in colour. Fingers free; toes one–third webbed. Recorded this unconfirmed species of *Philautus* (*Philautus* sp 2., Image 3aj) from the Nizamghat, Elopa, Chisindo, Tiwarigaon, Challis (40 Kilo), Etalin and Riyali (329–2071 m) during March–July. Inhabits along the edge of streams with thick riparian vegetation cover. SVL: 22.81–25.10 mm (n=6).

***37. Philautus* sp3**

Head broader than long. Tympanum fairly distinct; supra tympanic fold present; narrow. Dorsally brown, slightly granular with irregular dark bands on dorsum. Ventrally granular, grey with irregular dark spots. Fingers free; toes one–third webbed. Recorded this unconfirmed species of *Philautus* (*Philautus* sp3, Image 3ak) from nearby Tiwarigaon (1545m) in July. A single male individual of this species was observed calling from shrubs by a roadside wall with thick moist vegetation grown on it. SVL: 17.59 mm (n=1).

***38. Philautus* sp4**

Head broader than long. Tympanum fairly distinct; supra tympanic fold present, thick. Dorsally brown with irregular fine granules. Ventrally granular, grey mixed with brown spots. Fingers free; toes one–third webbed. Recorded this unconfirmed species of *Philautus* (*Philautus* sp4, Image 3al) from the Etalin (752m) in May. A single male individual of this species was observed calling from a stem of *Alocasia* sp. approximately three feet above ground along the edge of a stream. SVL: 21.20mm (n=1).

DISCUSSION

This study presented the distribution record of 38 amphibian species from across the Dibang River Basin for the first time from an altitudinal gradient of 224m to 3,235m of a Himalayan river. Previously, Annandale (1912) and Bordoloi et al. (2002) reported amphibian diversity from Abor Hills (Siang River Basin) and the Dihang–Dibang Biosphere Reserve (Siang and Dibang

Image 3 (ae-al): Amphibian species recorded from the Dibang River Basin of Arunachal Pradesh during 2014–17.
ae) *Rhacophorus translineatus*; af) *Rhacophorus tuberculatus*; ag) *Theloderma asperum*; ah) *Theloderma moloch*; ai) *Philautus* sp1; aj) *Philautus* sp2; ak) *Philautus* sp3; al) *Philautus* sp4. © Jayanta K. Roy.

river basins), respectively. The species described as new to science by Annandale (1912) has been encountered during this study for the first time since it was described. This study further confirms some record of species previously described by other authors (Bordoloi et al. 2002; Sarkar & Ray 2006; Mathew & Sen 2010; Borah et al. 2013) and at the same time we could record altitude, microhabitats and geolocate the occurrences from the river basin.

As the inventories of amphibians are very few in the state, this study reports five new distribution records of amphibians for Arunachal Pradesh. In addition, one species is recorded for the first time from India (*Orelalax* sp), however, species level identity of the species is yet to be confirmed and is in progress. In this study, we have comparatively described the present species distribution with regards to their previous known distribution records from Arunachal Pradesh, their microhabitat characteristics and specific morphological characteristics.

Biogeographically, when compared to biogeographic regions (Duellman 1999) we found that the amphibian (unconfirmed species excluded) distribution from the study area shows an overlapping and sharing of species from India/Sri Lanka (42.9%), southern Himalaya (85.7%), northeastern montane (78.6%), and China (32.1%).

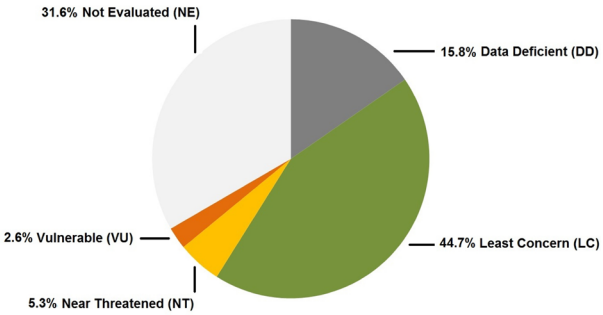

Figure 2. IUCN red list status for 38 amphibian species recorded across the Dibang River Basin, Arunachal Pradesh, India during 2014–17.

The conservation status (IUCN 2017) of the amphibians encountered (Fig. 2) include, two Near

Threatened (NT) 5% anurans: *Amolops viridimaculatus* and *Rhacophorus burmanus*; one vulnerable (VU) 2.5%: *Theloderma moloch*; Least Concern (LC) 44.5% (N=17); Data deficient (DD) 16% (N=6) and Not Evaluated (NE) 31.5% (N=12). It is interesting to note that nearly 50% of the 38 species are data deficient and not evaluated yet. This study would further help in assessing the conservation status of those species that needs evaluation and reevaluation. This study also observed that unscientific developments including many large hydroelectric projects at various stages of implementations as well as various roads planned within the study area are most likely to have irreversible effects on the ecology in the river basin during the next few decades.

The river basin approach of this study has helped in planning long term ecological study on amphibians including patterns of distributions along an altitudinal gradient from the plains of Assam to the high Himalayas. Long term ecological studies in the river basin would help in understanding factors that influence and limit distribution of species to understand the possible effect of weather change on species that are restricted by the Himalayan mountain ranges and mid elevation foothills. Amphibians, being indicators of the health of the environment, could help understand the impact of changing weather on ecosystems if monitored in the river basin.

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