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DNA barcoding reveals unprecedented diversity in Dancing Frogs of India (Micrixalidae, *Micrixalus*): a taxonomic revision with description of 14 new species

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ABSTRACT

In this study, we investigate species level diversity in the monotypic frog family Micrixalidae, which is endemic to the Western Ghats of Peninsular India. Attempting the first near-complete taxon sampling of Indian dancing frogs from the entire Western Ghats, we use 138 tissue samples collected from 70 localities over the last 12 years for DNA barcoding. Our results of multiple mitochondrial gene (16S and COI) barcoding reveal unexpectedly high species level diversity in the genus *Micrixalus*. Based on molecular and morphological evidence, we herein describe 14 new species, leading to a more than two-fold increase in the number of known species in this ancient lineage. Additionally, certain taxonomic uncertainties about the status of previously known taxa in this genus are resolved. *Micrixalus narainensis* and *M. swamianus* are considered as junior subjective synonyms of *M. kottigeharensis*, whereas *M. herrei* is resurrected from synonymy of *M. fuscus* and confirmed as a valid species. Taxonomic accounts of three species—*M. elegans*, *M. silvaticus* and *M. thampii*—are provided for the first time after their original descriptions. For nomenclatural stability, *M. fuscus*, *M. saxicola* and *M. silvaticus* are lectotypified, and *M. elegans* and *M. kottigeharensis* are neotypified. Detailed descriptions, morphological and genetic comparisons, illustrations, data on distribution, and natural history are provided for all species. We also provide the first osteological description of *M. fuscus*, the type species of the genus *Micrixalus*, and we report foot-flagging behaviour in a total eight species, including two for which it has been studied previously. Overall, our results highlight the underestimation of true diversity in several amphibian groups of the Western Ghats, suggesting that spatial patterns of amphibian richness and endemism in this region need to be further re-examined.

Keywords: Western Ghats, biodiversity, endemic family, ancient lineage, taxonomy, systematics, foot-flagging, osteology

INTRODUCTION

The Western Ghats is one of the major centers of global biodiversity, remarkable for its diverse flora and fauna as well as their origin and patterns of evolution (Biju and Bossuyt, 2003; Bossuyt and Milinkovitch, 2001; Bossuyt *et al.*, 2004; Briggs, 2003; Mittermeier *et al.*, 2004; Roelants *et al.*, 2004; Van Bocxlaer *et al.*, 2012). The Western Ghats primarily consists of a long north-south orientated mountain chain, extending from Gujarat in the north (21.00° N) to the southern tip of Peninsular India in Tamil Nadu (08.25° N) and covering a distance of approximately 1,600 km. Its historical isolation from neighbouring regions and consistent history of humid tropical to subtropical climate has resulted in ideal conditions for amphibian speciation and a high level of generic and familial endemism (Biju and Bossuyt, 2003, 2009; Biju *et al.*, 2008, 2009, 2011; Bossuyt *et al.*, 2004; Roelants *et al*., 2004).

One of the Western Ghats endemic monotypic family, Micrixalidae Dubois, Ohler and Biju, 2001, was only recently recognised as an ancient group of frogs that diversified from the super-family Ranidae during the Upper-Cretaceous or Palaeocene period (Roelants *et al*., 2004). This ancient lineage of small-sized (SVL 13–35 mm) frogs currently has only 11 valid species (Frost *et al*., 2006). The genus *Micrixalus*, commonly known as 'Tropical frogs' (Frank and Ramus, 1995), comprises of species that usually occur in splash zones of fast flowing perennial hill streams for which some are even called 'Torrent frogs' (Das and Dutta, 1998). However, most notable is that some of the species exhibit the remarkable behaviour of foot-flagging (Gururaja, 2010; Krishna and Krishna, 2006; Reddy *et al.*, 2002; Vasudevan, 2001) akin to 'dancing', and for this

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unique behaviour we propose the common name 'Indian dancing frogs' for this genus.

Micrixalidae, currently contains only one genus, *Micrixalus* Boulenger, 1888 that was created to accommodate five species; four that were originally described in Rhacophorid genera, *Ixalus*: *Ixalus fuscus* Boulenger, 1882 (= *Micrixalus fuscus*), *Ixalus opisthorhodus* Günther, 1869 "1868" (= *Micrixalus opisthorhodus*), *Ixalus silvaticus* Boulenger, 1882 (= *Micrixalus silvaticus*); *Polypedates?*: *Polypedates? saxicola* Jerdon, 1854 "1853" (= *Micrixalus saxicola*), and one species, *Ixalus sarasinorum* Müller, 1887 (= *Pseudophilautus sarasinorum*) later returned back to Rhacophoridae (Boulenger, 1888; Dubois, 1987 "1986"). After these colonial descriptions, there was a lean period of species discovery from the Western Ghats (Fig. 1), following which, Rao (1937) described four new species in this group, and additional three were described after Indian independence (Pillai, 1978, 1981; Pillai and Pattabiraman, 1990). However, no new species have been discovered in this genus over the last nearly 25 years—the period during which maximum new species were described in Indian herpetology, including a near doubling of the number of amphibian species known from the Western Ghats (Fig. 1).

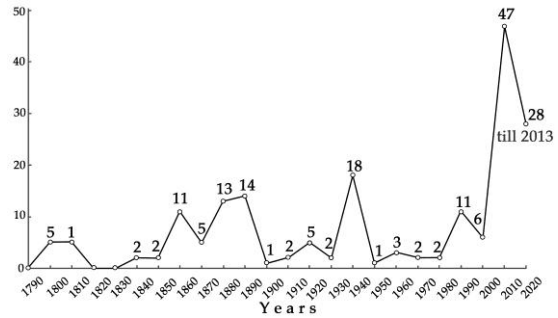

Figure 1. Trend of amphibian species descriptions from the Western Ghats. Numbers of new species shown on the curve at intervals of ten years (up to 2013) are based on Frost, 2014 and AmphibiaWeb, 2014.

Taxonomic placement of species in the genus *Micrixalus* remained confusing for a long time, mostly due to some superficial morphological similarities with other groups (e.g., dilated finger and toe tips, and webbed feet in '*Philautus*') and lack of proper morphological examination of these small-sized frogs. Some of the species, originally described in the Rhacophorid genus *Philautus*, were transferred to *Micrixalus* recently (Bossuyt and Dubois, 2001), and subsequently Micrixalidae was proposed as a distinct family (Dubois *et al*., 2001). Roelants *et al.* (2004) provided the first evidence for ancient origin of this family along with showing Ranixalidae and Nyctibatrachidae as its closest relatives, and further discussed the evolutionary significance of these endemic lineages.

However, members of the genus *Micrixalus* gained the attention of researchers for their unique ecological and behavioural adaptations. Studies have reported habitat features (Reddy *et al.*, 2002), foot-flagging (Krishna and Krishna, 2006; Malhotra and Davis, 1991; Vasudevan, 2001) and reproductive behaviour (Gururaja, 2010) in *Micrixalus* species, and a few have specifically dealt with visual and acoustic communication in these frogs (Preininger *et al*., 2013a, 2013b, 2013c). However, all of these studies concentrated only on two species, *M. fuscus* and *M. 'saxicola'*, and there is no information available for other species in the genus. Furthermore, though *Micrixalus* is among the more widely distributed and well-studied genera of the Western Ghats, extensive surveys to understand species diversity in this ancient and endemic lineage have never been attempted.

Growing interest in the taxonomy and systematics of Indian amphibians within the herpetological community has been accentuated by the knowledge that species diversity on this ancient subcontinent remains poorly understood (Biju, 2001). Though there is a rapidly increasing number of scientific papers and books published every year on the subject, most involve checklists (e.g., Daniels, 2005; Dinesh *et al*., 2009; Gururaja, 2012; Krishnamurthy and Sakunthala, 1993; Purushotham and Tapley, 2011) and sightings of species (*e.g*., Aravind, 2002; Dinesh *et al.*, 2010; Gururaja *et al*., 2007; Reddy *et al*., 2001), and only a minority specifically deal with resolving the problematic taxonomic and systematic issues plaguing many taxa in India (*e.g*., Abraham *et al.*, 2013; Biju and Bossuyt, 2009; Biju *et al.*, 2008, 2009, 2011; Kuramoto *et al.*, 2007). For many species, only the historical and often vague original descriptions exist, with type specimens long lost, destroyed or in some cases never deposited in a museum collection (Biju and Bossuyt, 2009; Biju *et al.*, 2011; Bossuyt and Dubois, 2001; Dubois, 1984, 1987 "1986"). Without such essential basic reference specimens to define a species, subsequent descriptions of specimens from localities other than the type localities in various literature have resulted in the

Figure 2. A. The Palghat Gap – approximately 30 km wide area with elevations below 100 m a.s.l., forming a major discontinuity in the Western Ghats; **B–G.** typical habitats of *Micrixalus* species in the Western Ghats: **B.** fast flowing stream inside a wet evergreen forest, Silent valley National Park, **C.** small stream in a secondary forest, Aralam Wildlife Sanctuary, **D.** slow-flowing rivulet in the forests of Siruvani, **E.** hill stream inside a shola forest, Eravikulam National Park, **F.** high altitude forest stream in Amboli, **G.** *Myristica* swamp forest at Kathlekan.

propagation of character misconceptions for several obscure and cryptic species. These errors lead increasingly to the misidentification of extralimital populations in texts, often giving the perception that these species are more widespread than they actually are (e.g., Biju and Bossuyt, 2009; Biju *et al.*, 2011; Mahony *et al.*, 2011).

Considering the current state of knowledge and taxonomic history of *Micrixalus* species, almost half of which are categorized as Data Deficient (IUCN, 2013) and have ambiguous or historically defined distributional extents, a comprehensive study has long been pending not only for taxonomic stability of many of the species but also to understand the true diversity in this unique group of frogs. In this study, we investigate the level of species diversity in Micrixalidae using the DNA barcoding approach, which has emerged as a potential tool for identification and discovery of amphibian species (e.g., Fouquet *et al.*, 2007; Funk *et al.*, 2011; Vences *et al.*, 2005a, 2005b; Vieites *et al.*, 2009). We integrate evidence from multiple gene barcoding along with morphological study of historical and new collections to delineate species boundaries, identify unknown taxa, and to understand patterns of species distribution in this endemic lineage.

MATERIALS AND METHODS

Field Survey and Specimen Collection. Extensive field surveys were conducted through out the Western Ghats from 2001–2012 and we sampled a total of 87 *Micrixalus* populations from 70 localities. Typical habitats of *Micrixalus* species range from wet evergreen forests, high altitude shola forests, *Myristica* swamps to secondary forests. The study sites were usually closed canopy perennial forest streams (Fig. 2). Adult specimens were mostly collected during the day, either by locating calling males or through opportunistic surveys. Special emphasis was laid on photography of live animals with minimal disturbance in the wild, and with a few exceptions in captivity. Animals were euthanized using Tricaine methanesulphonate and a portion of tissue sample was taken from the thigh muscle or liver, preserved in 95% ethanol and stored at -20°C in the Systematics Lab, University of Delhi (SDBDU) for molecular analysis. Specimens were fixed in 4% formalin and preserved in 70% ethanol. GPS coordinates of sampling localities were recorded in the field and maps were prepared using QGIS (http://www.qgis.org). Details of collection localities and species recorded at the respective sites are provided in Table 1, and the geographical ranges of species in the present study are shown in Figure 3.

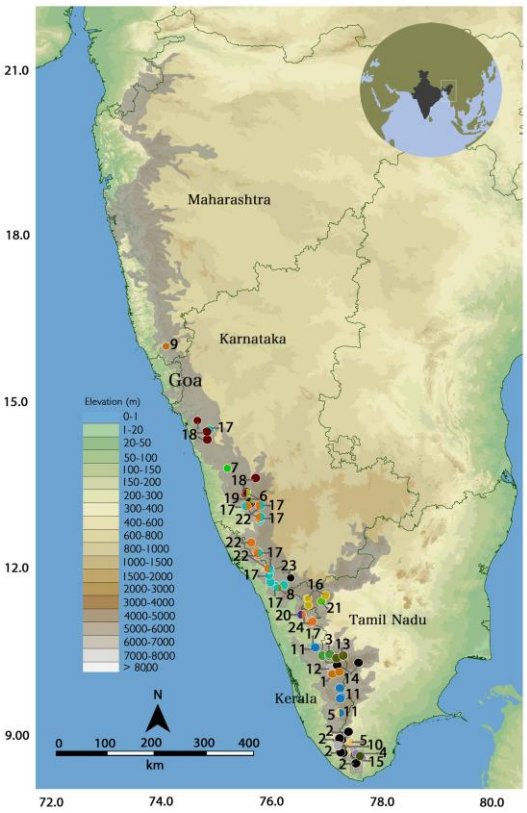

Figure 3. Distribution of 24 *Micrixalus* species in the Western Ghats, India. Species numbers are cross-referenced in Figure 7A. The Western Ghats are shown in grey.

Reproductive Behaviour. Observations of the breeding behaviour were made during the years 2001 to 2012. Opportunistic surveys were conducted through out the year, in three broad phases: monsoon (June-September), post-monsoon (October-November) and dry period (December-May). Our searches were mostly conducted during daytime and focused on torrential as well as cascading sections of streams. Breeding behaviour observations were made applying the focal animal approach (Martin and Bateson, 1986). Foot-flagging behaviour was recorded by direct observation of males. In cases where foot-flagging was not directly observed, we presumed the occurrence of a suite of characters, *i.e.* flashy white coloration on dorsal surface of foot, degree of webbing and torrent waters as habitat preference, to be indirect inference of foot-flagging. All observations were made without disturbing the animals, with exception in cases where animals were collected and preserved after the observation period.

DNA Extraction, PCR, and Sequencing. Whole genomic DNA was extracted from ethanol-preserved muscle or liver tissue using standard extraction protocol (Sambrook *et al.*, 1989) or Qiagen© DNeasy tissue kit following manufacturer's protocol. Two mitochondrial gene fragments, 16S rRNA (≈ 540 bp) and COI (≈ 650 bp), were PCR-amplified and cycle sequenced on both strands using ABI 3730 automated DNA sequencer (Applied Biosystems). Primers used in the study follow Simon *et al*. (1994) and Che *et al.* (2012). Sequences were checked and assembled in ChromasPro v1.34 (Technelysium Pty Ltd.); MEGA 5.0 (Tamura *et al.*, 2011) was used to create alignment by ClustalW, edit and manually optimize the dataset. Sequences were deposited in the GenBank under accession numbers KJ711257–KJ711526 (Table 2).

DNA Barcoding Analysis. Separate datasets were created for both the barcoding genes (16S and COI) using MEGA 5.0 (Tamura *et al.*, 2011). A total of 138 sequences of 16S (535 characters) and 132 sequences of COI (611 characters) were used in the study for two independent barcoding analyses. Neighbor Joining (NJ) trees were constructed using the Kimura 2-parameter (K2P) distance model as implemented in PAUP* 4.0b10 (Swofford, 2002), with *Nyctibatrachus* species as the out group taxa (Roelants *et al.*, 2004). PAUP* 4.0b10 (Swofford, 2002) was used to compute intra and interspecific uncorrected pairwise distances and data matrices were constructed for total 3970 pairwise comparisons from both 16S and COI sequences. Interspecific pairwise sequence comparisons were made between genetically related species, based on grouping of species in individual NJ trees. Intra and interspecific genetic distance values are provided in Tables 3 and 4, respectively. Frequency of maximum intraspecific and minimum interspecific genetic divergence values were plotted to understand the barcode gap and identify threshold values for species delineation by the 16S and COI markers.

Morphology and Recognition of New Species. In our study, we identified candidate species by integrating morphological data with molecular evidences from multiple gene barcoding. These were compared with available types, other museum specimens and new collections from across the geographic range of *Micrixalus*. For species whose types have been lost/destroyed, new specimens were collected from the type locality. All illustrations of dorsal and lateral sides of head, ventral sides of hand and feet were made using the stereomicroscope Camera Lucida (Nikon SMZ 1500). Sex and maturity were determined by examining gonads through a small lateral or ventral incision and only adult animals were used for morphological analysis, species comparisons and type series. In cases where identity of sub-adult specimens was confirmed through molecular data, we included the collection localities in the distribution (Table 1).

Measurements and associated terminology follow Biju *et al*. (2011); the webbing formulas follow Savage and Heyer (1967) as modified by Myers and Duellman (1982). The amount of webbing relative to subarticular tubercles is described by numbering the tubercles 1–3, starting from the toe discs. The term shank is used here to refer to the part of the leg containing the tibia, and thigh is used for the part containing the femur. Measurements of all specimens were taken by SDB using a digital slide-caliper, or a binocular microscope with a micrometre ocular, to the nearest 0.1 mm. All measurements and photographs were taken for the left side of the specimen, except when a character was damaged, in which case the measurement was taken on the right side. Measurements of fingers and toes were taken from the base (joint to the next digit) of each digit to the tip (including disc). All measurements provided in the taxonomy section are in millimetres. Range, average and standard deviation of the 'comparison' section without mentioning the sex are for males. Abbreviations: SVL (snout–vent length), HW (head width, at angle of jaws), HL (head length, from rear of mandible to tip of snout), MN (distance from rear of mandible to nostril), MFE (distance from rear of mandible to anterior orbital border), MBE (distance from rear of mandible to posterior orbital border), SL (snout length, from tip of snout to anterior orbital border), EL (eye length, horizontal distance between bony orbital borders), IUE (inter upper eyelid width, shortest distance between upper eyelids), UEW (maximum upper eyelid width), IFE (internal front of eyes, shortest distance between anterior orbital borders), IBE (internal back of eyes, shortest distance between posterior orbital borders), FAL (forearm length, from flexed elbow to base of outer palmar tubercle), HAL (hand length, from base of outer palmar tubercle to tip of third finger), FD_{III} (disc width of finger III), FW_{III} (width of finger III, measured at the base of disc), $F_{III}L$ (length of finger III), $T_{III}L$ (length of toe III), SHL (shank length), TL (thigh length), FOL (foot length, from base of inner metatarsal tubercle to tip of fourth toe), TFOL (distance from heel to tip of fourth toe).

Taxonomic Grouping. For morphological comparisons, the present study grouped species in the genus *Micrixalus* based on their morphological similarities. We identified five groups: (1) *Micrixalus elegans* group (*Micrixalus candidus* sp. nov., *M. elegans*, *Micrixalus kurichiyari* sp. nov., *Micrixalus niluvasei* sp. nov., *Micrixalus sairandhri* sp. nov., *Micrixalus spelunca* sp. nov. and *Micrixalus uttaraghati* sp. nov.); (2) *Micrixalus fuscus* group (*Micrixalus adonis* sp. nov., *M. fuscus*, *M. herrei*, *Micrixalus mallani* sp. nov., *Micrixalus nelliyampathi* sp. nov. and *Micrixalus kodayari* sp. nov.); (3) *Micrixalus nudis* group (*M. gadgili*, *M. nudis*, *Micrixalus sali* sp. nov. and *M. thampii*); (4) *Micrixalus saxicola* group (*M. kottigeharensis*, *M. saxicola* and *Micrixalus specca* sp. nov.); and (5) *Micrixalus silvaticus* group (*Micrixalus frigidus* sp. nov., *Micrixalus nigraventris* sp. nov., *M. phyllophilus* and *M. silvaticus*). Degree of webbing, presence or absence of dorsolateral folds, snout shape and dorsal markings (observed both in life and preservation), were found to be intraspecifically stable diagnostic characters for distinguishing species in the genus. A special effort was made to represent new species through photographs of live specimens, in order to provide a better understanding of body coloration and markings in life, and thus also aid their identification in field. The following characters are common to all species of *Micrixalus* examined, and are consequently not repeated in the descriptions: Finger and toes with dermal fringes, and discs dilated with dorsoterminal grooves; pupil oval; webbing absent on hand; pineal ocellus, vomerine teeth and ridge absent.

Osteology. An adult specimen of *Micrixalus fuscus* was cleared and double-stained using Alizarin Red S and Alcian blue; procedures follow Taylor and Dyke (1985). Osteological description of cranial and postcranial characters was provided following terminologies that of Duellman and Trueb (1986). Photographs were taken either using a digital camera or captured with the aid of a QImaging camera mounted on Nikon SMZ 1500 stereomicroscope. The specimen was scored for presence of bones within one day after the staining process. We noted the presence and absence of sixteen skull bones, including exoccipital, frontoparietals, nasal, parasphenoid, prootics, pterygoids, sphenethmoid, septomaxilla, squamosal, vomer, angulosplenial, dentary, mentomeckelians, maxilla, premaxilla and quadratojugal. Along with bones constructing the axial skeleton, pectoral girdle, fore limb, pelvic girdle and the hind limb were observed.

Abbreviations. For museums and frequently used terms, abbreviations are as follows: BNHS (Bombay Natural History Society, Bombay, India), SDBDU (S. D. Biju collection at University of Delhi, Delhi, India), NHM (The Natural History Museum, London, United Kingdom, formerly British Museum Natural History), BMNH (The British Museum Natural History, London, United Kingdom), ZSIC (Zoological Survey of India, Kolkata, India), SRS-ZSI (South Regional station, Zoological Survey of India, Chennai, India), SDB (S. D. Biju), SG (Sonali Garg), KVG (K. V. Gururaja), RS (Robin Suyesh), GS (Gargi Sircar). In the 'Material studied' section and 'Table 5' the following abbreviations after specimen numbers refer to: HT (holotype), PT (paratype), LT (lectotype), NT (neotype), PL (paralectotype), RS (referred specimen) and TT (topotype). In figure legends: (m) refers to male, (f) refers to female. In 'Table 1' and species distribution sections abbreviations refer to: NP (National Park), WLS (Wildlife Sanctuary), TR (Tiger Reserve), PA (Protected Area), m asl (meters above sea level).

RESULTS

REPRODUCTIVE BEHAVIOUR. Males were mostly observed calling from surface of wet rocks emerging from streams, usually near small waterfalls and rapids. The present study documents foot-flagging behaviour in *Micrixalus elegans*, *M. fuscus*, *M. herrei*, *M. kottigeharensis*, *Micrixalus nelliyampathi* sp. nov., *Micrixalus niluvasei* sp. nov., *M. saxicola*, *Micrixalus specca* sp. nov. and *Micrixalus uttaraghati* sp. nov. (Figs 4, 5). Calling males in these species were found close to flowing waters, with their noticeable flashy white vocal sacs. Along with calling, males occasionally tapped their foot and thigh, followed by stretching of the entire hind limb away from body and waving their fully stretched foot. In cases of male-male combats, kicking the intruder by foot was also observed in *M. elegans*, *M. fuscus*, *M. herrei*, *M. kottigeharensis*, *Micrixalus nelliyampathi* sp. nov., *M. saxicola* and *Micrixalus specca* sp. nov. Similar observations have been reported for *M. fuscus* (Vasudevan, 2001) and *M.* '*saxicola*' (Krishna and Krishna, 2006; Gururaja, 2010). Furthermore, Gururaja (2010) reported the reproductive behaviour in *M.* '*saxicola*'. In this study, we made observations of different *Micrixalus* species and found this unique reproductive behaviour (Figs 5, 6) in five species (to be published elsewhere). Direct observation of foot-flagging was made in nine species

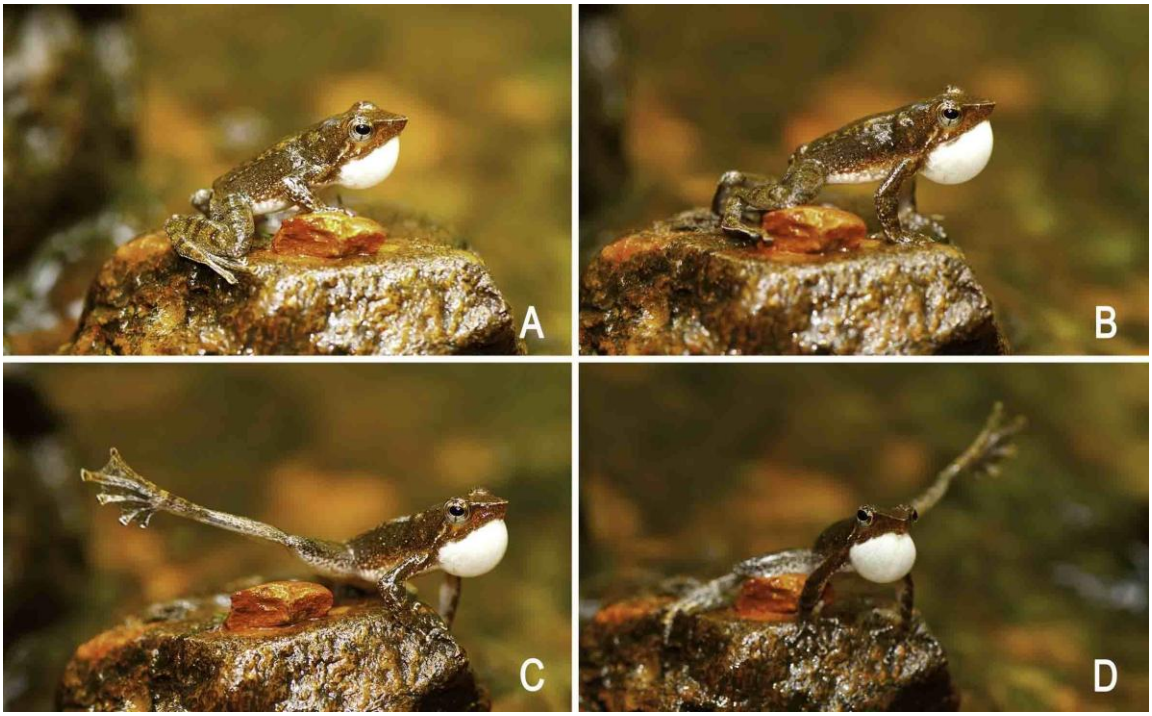

Figure 4. 'Foot-flagging' behaviour in a male of *Micrixalus kottigeharensis*, observed at Kathlekan in Karnataka state: **A.** calling and foot tapping, **B.** posture just before raising the hind limb, **C.** foot-flagging with the right foot, **D.** foot-flagging with the left foot. Photos: SDB.

(mentioned above), while in the cases of *Micrixalus adonis* sp. nov., *Micrixalus candidus* sp. nov., *Micrixalus kodayari* sp. nov., *Micrixalus kurichiyari* sp. nov., *Micrixalus mallani* sp. nov., *Micrixalus sairandhri* sp. nov. and *M. thampii*, presence of flashy coloration on dorsal surface of foot in combination with degree of webbing and habitat preference, were considered as indirect evidence of foot-flagging. Though males of many of the above species were seen actively calling during the monsoon period (June–August), foot-flagging and breeding were mostly recorded during the late (September) or post-monsoon period (October–November). The reason for this could be the need for shallow waters for breeding, egg-laying and development of tadpoles.

Our study did not observe foot-flagging in *Micrixalus sali* sp. nov., while the presence of this behaviour could not be known in *Micrixalus frigidus* sp. nov., *M. gadgili*, *Micrixalus nigraventris* sp. nov., *M. nudis*, *M. phyllophilus*, *M. silvaticus* and *Micrixalus spelunca* sp. nov. In general, species in which foot-flagging was not observed, the webbing on foot was reduced (fourth toe webbing did not extend beyond the second subarticular tubercle on either side) compared to the foot-flagging species. We also found the latter to be associated with flowing water in streams, while the former occurred on the sides of streams or in leaf litter. On one occasion we observed an egg clutch of *M. gadgili* (identity confirmed through DNA) under wet leaf litter away from flowing water. These observations probably indicate that within the genus *Micrixalus*, reproductive behaviour and ovipostion sites could vary depending on the habitat preference of species, and therefore require further investigation at species level. It would also be interesting to undertake studies to confirm the presence and absence of foot-flagging behaviour in all *Micrixalus* species. This can provide insights into origin of the foot-flagging behaviour, which could have evolved multiple times in this ancient lineage.

DNA BARCODING. Neighbor Joining (NJ) trees for 16S (Fig. 7A) and COI (Fig. 8A) produced identical grouping of taxa, corresponding to 24 morphologically confirmed species. The clade relationships varied to a certain extent in both the trees. However, since the NJ analyses were performed only for delineation of species and their geographical ranges, both our trees were successful in reproducing clades that correspond to nine known *Micrixalus* species: *M. elegans*, *M. fuscus*, *M. gadgili*, *M. kottigeharensis*, *M. nudis*, *M. phyllophilus*, *M. saxicola*, *M. silvaticus* and *M. thampii*; one species, *M. herrei*, currently considered as synonym; and another 14

representing potential new species (Figs 7A, 8A). Species could be discriminated at threshold values of minimum 3% for 16S and 6.5% for COI, while the mean thresholds were above 3.9% (16S) and 7% (COI) for all the species identified as new in this study. The maximum intraspecific and minimum interspecific genetic distances were overlapping at divergence values that included different species in 16S and COI, respectively (Figs 7B, 8B; Tables 3, 4). Three known species (*M. elegans*, *M. nudis* and *M. thampii*) were found to be genetically cryptic. Few other species, *M. fuscus*, *M. herrei*, *M. kottigeharensis* and *M. saxicola* showed high intraspecific variations and could possibly be complexes of cryptic species. Though previous studies have discussed differential ability of 16S and COI to distinguish candidate species (e.g., Vences *et al.*, 2005b; Xia *et al.*, 2012), a critical examination of datasets available for both the barcoding markers in our study allowed us to define threshold values for delineation of new species. These values were also in agreement with earlier amphibian studies (e.g., Fouquet *et al.*, 2007; Smith *et al.*, 2008). We exercised caution while interpreting our results in the case of *Micrixalus candidus* sp. nov., *Micrixalus frigidus* sp. nov., *Micrixalus kodayari* sp. nov., *Micrixalus kurichiyari* sp. nov., *Micrixalus sali* sp. nov., *M. silvaticus*, *Micrixalus specca* sp. nov. and *Micrixalus uttaraghati* sp. nov., where there were few samples for calculating intraspecific divergences. However, not only did the above clades show high interspecific divergence from genetically related species, but also possessed distinct morphological characters. Therefore, our results do not raise doubts on their validity as genetically and morphologically distinct species, and further suggest that these could probably have restricted distribution ranges.

MORPHOLOGICAL RECOGNITION OF SPECIES. In this study, we identified 24 *Micrixalus* species based on detailed morphological comparison of available types, original descriptions, museum specimens and new collections, along with molecular evidences from multiple gene barcoding. Our study included specimens for 11

Figure 5. Schematic illustration of breeding behaviour in *Micrixalus*: **A.** male calling and foot tapping, **B.** male foot flagging with simultaneous calling, **C.** male kicking another intruding male, **D.** female approaching a calling male, **E.** male and female in amplexus, moving inside the water, **F.** amplected pair with their heads emerging out of water, and female digging a cavity on the stream bed with the help of hindlimbs, **G.** female releasing eggs inside the cavity, **H.** male detaching from the female, **I.** female covering the eggs with sand and gravel using hindlimbs. In the illustration, male is shown in light grey, and female in dark grey.

known *Micrixalus* species (Frost *et al.*, 2006), including three previously considered as 'lost', one species currently in synonymy (Inger *et al.*, 1985 "1984"), and several unidentified populations. Our results confirm the presence of 14 unnamed species in this genus, in addition to taxonomic revision of the available 12 names. *Micrixalus herrei* Myers, 1942 is considered as a valid species and removed from synonymy of *M. fuscus* (Boulenger, 1882). Two species, *M. narainensis* (Rao, 1937) and *M. swamianus* (Rao, 1937) are considered as junior subjective synonyms of *M. kottigeharensis* (Rao, 1937). *Micrixalus fuscus*, *M. saxicola* and *M. silvaticus* are lectotypified, and *M. elegans* and *M. kottigeharensis* are neotypified, for taxonomic stability. Fourteen new species are herein described as: *Micrixalus adonis* sp. nov., *Micrixalus candidus* sp. nov., *Micrixalus frigidus* sp. nov., *Micrixalus kodayari* sp. nov., *Micrixalus kurichiyari* sp. nov., *Micrixalus mallani* sp. nov., *Micrixalus nelliyampathi* sp. nov., *Micrixalus nigraventris* sp. nov., *Micrixalus niluvasei* sp. nov., *Micrixalus sairandhri* sp. nov., *Micrixalus sali* sp. nov., *Micrixalus specca* sp. nov., *Micrixalus spelunca* sp. nov. and *Micrixalus uttaraghati* sp. nov. The first-ever comprehensive taxonomic revision of all members of the endemic frog family Micrixalidae is provided, with detailed species accounts and descriptions in the 'Taxonomy' section.

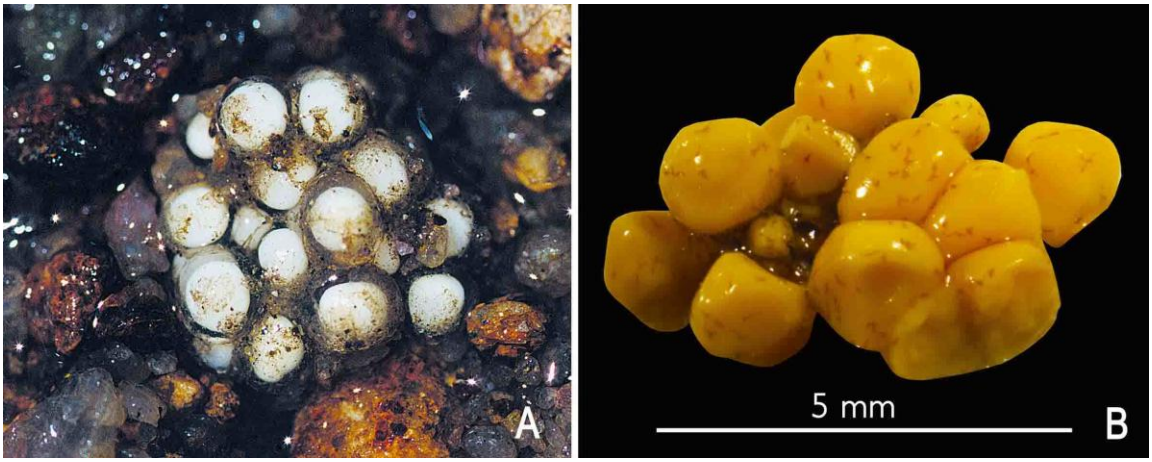

Figure 6. Eggs of *Micrixalus herrei*: **A.** an egg clutch at the oviposition site (inside a cavity), observed by removal of gravel after five minutes of egg laying, **B.** eggs from a preserved specimen (BNHS 5680), with minute brown markings.

ENDEMISM AND SPECIES DISTRIBUTION. Several studies have highlighted the uniqueness of flora and fauna along the Western Ghats (Biju and Bossuyt, 2003; Bossuyt and Milinkovitch, 2001; Bossuyt *et al.*, 2004; Roelants *et al.*, 2004; Van Bocxlaer *et al.*, 2009) but not many have focused on understanding the role of geographic discontinuities or gaps along the Western Ghats, in influencing patterns of species distribution and diversification in amphibians of this region. Van Bocxlaer *et al.* (2012) first discussed patterns of endemism that were most likely caused by restricted dispersal across the three major gaps in the Western Ghats (Figs 7C–D), observed in their study of another Western Ghats endemic genus *Nyctibatrachus*. Our findings corroborate similar patterns in the genus *Micrixalus*. Most species showed restricted distribution with respect to either the Palghat, Shencottah or Goa gap; three species (*M. fuscus*, *Micirixalus kodayari* sp. nov. and *Micrixalus sali* sp. nov.) were only found south of Shencottah gap, along a stretch that forms southern limits of the Western Ghats; six species (*Micrixalus adonis* sp. nov., *Micrixalus frigidus* sp. nov., *M. gadgili*, *Micrixalus nelliyampathi* sp. nov., *Micrixalus nigraventris* sp. nov. and *M. silvaticus*) were found between the Shencottah and Palghat gap; 12 species (*Micrixalus candidus* sp. nov., *M. elegans*, *M. kottigeharensis*, *Micrixalus kurichiyari* sp. nov., *Micrixalus niluvasei* sp. nov., *M. nudis*, *M. phyllophilus*, *M. saxicola*, *Micrixalus sairandhri* sp. nov., *Micrixalus specca* sp. nov., *Micrixalus spelunca* sp. nov. and *M. thampii*) between the Palghat and Goa gap; and one species (*Micrixalus uttaraghati* sp. nov.) crossed the Goa gap and formed the northern most distribution limit of this genus. *Micrixalus mallani* sp. nov. was the only species that was found on both sides of the Shencottah gap, but not beyond the Palghat gap, while *M. herrei* also occurred at low elevations of Shencottah along with its distribution south of the gap (Figs 3, 7A–E, 8A). While studies have cited the Palghat gap as a barrier promoting distinct patterns of distribution

in diverse amphibian genera (Bossuyt *et al.*, 2004; Van Bocxlaer *et al.*, 2012), the role of Palghat, Shencottah and Goa gaps in case of peculiar dispersal and speciation of *Micrixalus* remains to be investigated. The state-wise occurrence of known and newly described *Micrixalus* species, was found to be maximum in Kerala which had the highest number of species in both categories (eight known, eight new), followed by Karnataka (three known, three new), Tamil Nadu (three known, six new) and Maharashtra (one new) (Fig. 8C).

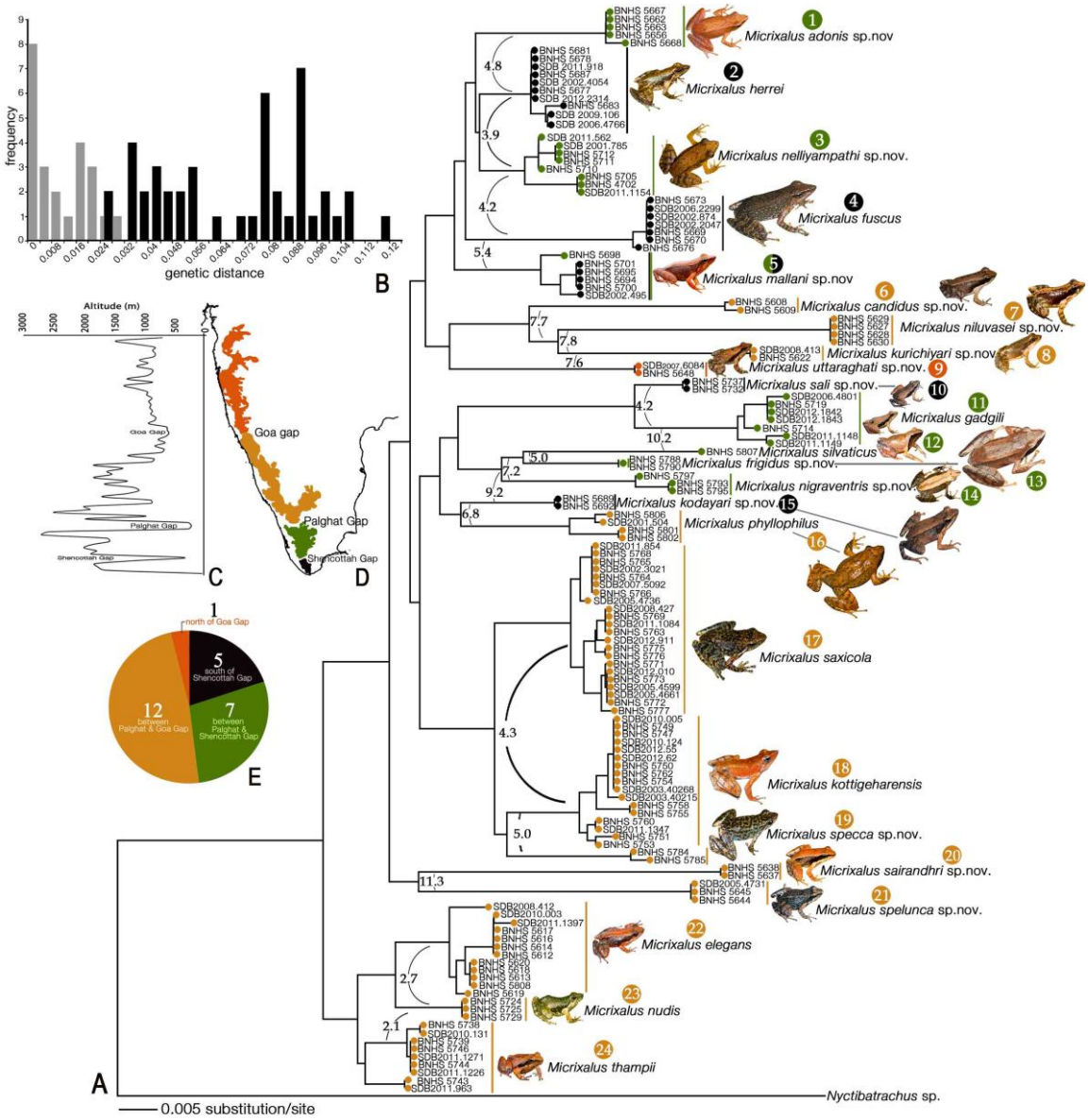

Figure 7. A. NJ tree based on K2P distances for 16S rRNA gene sequences of 137 samples, belonging to 24 *Micrixalus* species from the Western Ghats. Voucher numbers are cross-referenced in Table 2; clades representing species are numbered (1–24) from top to bottom; colour of terminal nodes indicate distribution of species based on regions shown in Figure 7D; and number towards internal nodes of the tree represents mean interspecific genetic distance (in percent) between the species, **B.** intra (grey) and interspecific (black) uncorrected pairwise genetic distances for 16S, **C.** elevational profile of the Western Ghats (adapted from Ramesh *et al.*, 1997 and Robin *et al.*, 2010), **D.** the Western Ghats showing four broad regions divided by three major elevational discontinouties, **E.** number of species occuring in four regions of the Western Ghats.

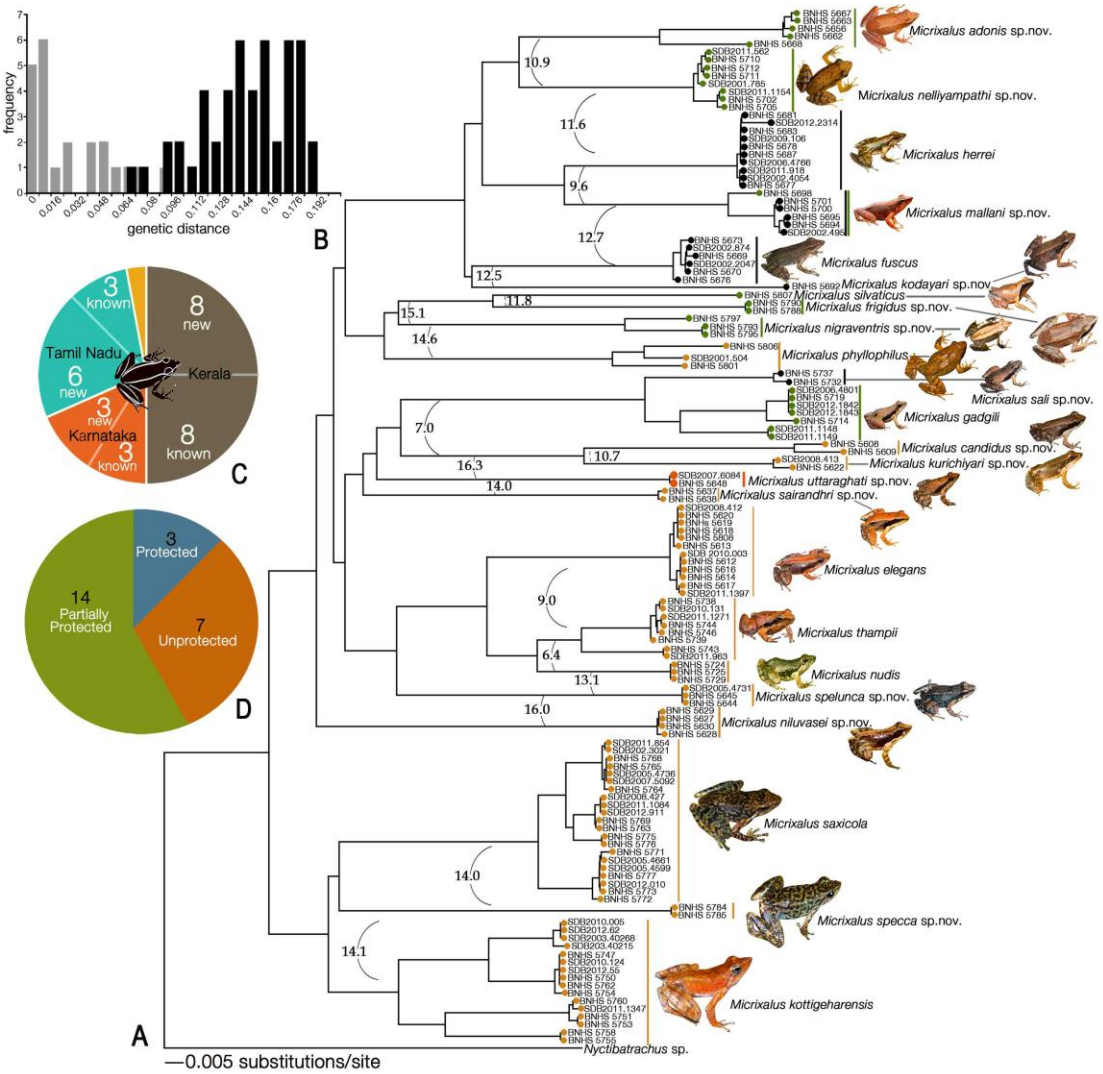

Figure 8. A. NJ tree based on K2P distances for COI gene sequences of 131 samples, belonging to 24 *Micrixalus* species from the Western Ghats. Voucher numbers are cross-referenced in Table 2; colour of terminal nodes indicate distribution of species based on regions shown in Fig. 7D, **B.** intra (grey) and interspecific (black) uncorrected pairwise genetic distances for COI, **C.** number of previously known and new species found in four states of the Western Ghats, **D.** number of species occuring inside and outside Protected Areas. Species only found inside protected areas (blue); species found outside protected areas (red); species with one or more populations inside protected or undisturbed forest areas (green).

CONSERVATION IMPLICATION. Our study also made an attempt to understand the occurance of species in protected areas of the Western Ghats (Fig. 8D). We demonstrate that seven species (nearly 30%), *Micrixalus adonis* sp. nov., *Micrixalus candidus* sp. nov., *Micrixalus niluvasei* sp. nov., *M. silvaticus*, *Micrixalus specca* sp. nov., *Micrixalus spelunca* sp. nov. and *Micrixalus uttaraghati* sp. nov., are found only in regions outside protected areas; while in the case of 14 species (58%), *M. elegans*, *M. fuscus*, *M. gadgili*, *M. herrei*, *Micrixalus kodayari* sp. nov., *M. kottigeharensis*, *Micrixalus kurichiyari* sp. nov., *Micrixalus mallani* sp. nov., *Micrixalus nelliyampathi* sp. nov., *Micrixalus nigraventris* sp. nov., *M. phyllophilus*, *Micrixalus sali* sp. nov., *M. saxicola* and *M. thampii*, at least one or more populations are either inside a protected area or undisturbed forest in close vicinity of a protected area. Three species, *Micrixalus frigidus* sp. nov, *M. nudis* and *Micrixalus sairandhri* sp. nov., are currently reported only from protected areas. Further studies are required to understand population status and threats in case of all the species. More importantly, considering the revised state of knowledge with respect to diversity and distribution of species in the family Micrixalidae, our results present a strong need to revisit conservation status of all the recognized species.

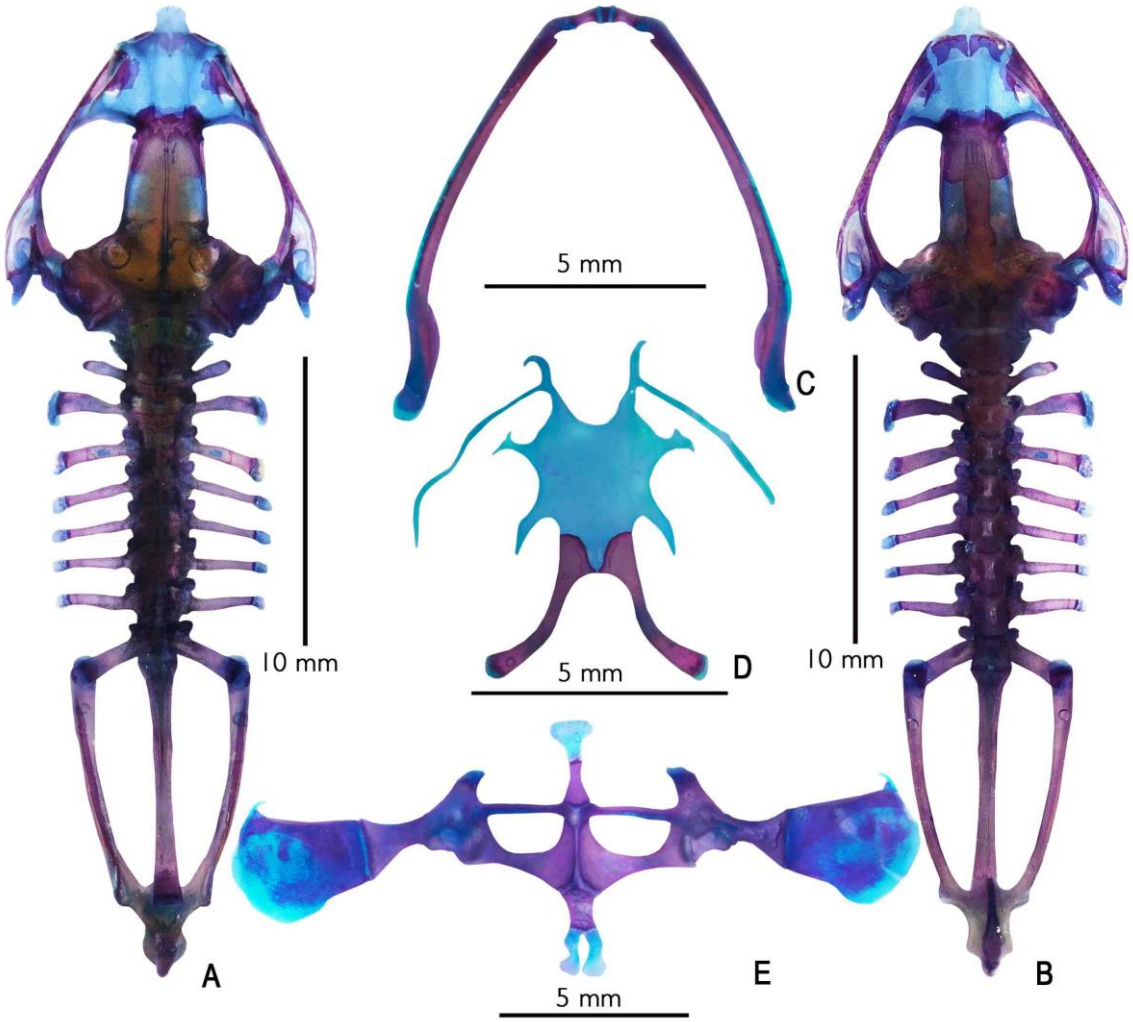

Figure 9. Skull, vertebral column, hyobranchial skeleton and pelvic girdle of *Micrixalus fuscus* (SDBDU 2006.2296): **A.** skull, vertebral column (dorsal view), **B.** skull, vertebral column (ventral view), **C.** mandible (dorsal view), **D.** hyobranchial skeleton (ventral view), **E.** pectoral girdle (ventral view).

OSTEOLOGY. The following osteological description of type species of the genus *Micrixalus* (*M. fuscus*) is based on a cleared-and-double stained adult male specimen (SDBDU 2006.2296, SVL = 27.9 mm), collected by SDB from Kakkachi, Tirunelveli dist., Tamil Nadu, on 28 May 2006.

Cranium. Skull is narrower anteriorly, at the orbital region, and widest posteriorly at the otic region. ***Neurocranium.*** The sphenethmoid, paired exoccipitals and prootics form the neurocranium of *M. fuscus*. *Sphenethmoid* is an unpaired bone, constructing the anterior portion of the brain case and also the medial and posterior walls of the nasal capsules. It is visible between the frontoparietals and nasals when observed dorsally, and between parasphenoid and vomers when viewed ventrally. *Prootics* are paired bones and the posterolateral ossifications of these bones give rise to auditory capsules. *Exoccipitals* fused with the prootics form the auditory capsules, and also form the posterior end of the neurocranium by bordering the foramen magnum. Medially the exoccipitals are separated from one another. ***Auditory apparatus.*** The stapes (also known as the pars media plectra) and the footplate of the stapes (pars interna plectra) are ossified. The operculum remains oval and cartilaginous. ***Dermal investing bones.*** Dorsal bones encompass nasals and frontoparietals. *Nasals* are paired, triangular shaped bones, roofing the nasal capsule. These are formed anterior to the Sphenethmoid. They do not articulate with the maxilla and are separated from one another. Paired *frontoparietals* are long and slender, cover the frontoparietal fenestra. These bones are separated by a narrow gap. They are fused with the prootics posteriorly. Ventral bones of the cranium are denoted by

vomers, palatines, parasphenoid and pterygoids. Paired *vomers* form the floor of the nasal capsules and part of the palate. Vomerine teeth are absent. T-shaped azygous *parasphenoid* invests the ventral side of the neurocranium. Posterolateral alae cover the auditory capsules laterally. Parasphenoid extends up to the vomerines, but does not fuse with them. *Palatines* are paired bones and are present as a transverse slim ridge. They are connected laterally with the maxillae. *Pterygoid* being a triradiate bone has an inverted Y shape. The anterior arm connects with the maxilla, and the lateral arms connect to the auditory capsules and the quadrate. Lateral bones investing the cranium are *squamosals*. They are paired, triradiate bones. Ventral arm extends along the quadrate. Otic (posterior) ramus fuses with the prootics. Zygomatic (anterior) ramus extends towards the maxilla, but does not fuse with it. Otic ramus is shorter compared to the other two arms of the squamosals (Figs 9A–B).

Maxillary arcade. Upper jaw consists of premaxilla, maxilla and quadratojugals. *Premaxillae* are paired bones composed of three parts: alary process, pars dentalis and pars palatina. Pars dentalis houses 8-9 teeth in each premaxilla. Paired *maxilla* made of pars facialis, palatina and dentalis, are dentate. Pars dentalis bears 23-25 teeth on each bone. *Quadratojugals* are paired bones. The anterior parts of each bone invest the posterior and external surface of maxilla and ventrally fuse with the pars articulates of the quadrate (Figs 9A–B).

Mandible. Angulosplenial, dentary and mentomeckelians give rise to the lower jaw. They are edentate paired bones. *Mentomeckelians* are seen in the anterior part, separated from each other by a narrow space. *Dentaries* invest the anterior margin of the meckel's cartilage and the paired *angulosplenials* occupy more than half of the meckel's cartilage along its posterior margin. Dentaries fuse with angulosplenials at their proximal ends (Fig. 9C).

Hyoid apparatus. Hyoid plate (central corpus) is completely cartilaginous. The width is narrower than the antero-posterior medial length. Posteromedial processes are ossified. Cartilaginous anterolateral and posterolateral processes are present having pointed ends. Posterolateral processes are short compared to the ossified posteromedial processes. Cornua, arising anterolaterally from the hyoid plate, extends posterolaterally and articulates with the auditory capsules (Fig. 9D).

Pectoral girdle. Scapula is expanded and articulates with the cartilaginous base of the suprascapula, which takes the form of a blade. Anterior margin of the suprascapula is ossified, denoting the cleithrum. Zonal components of the pectoral girdle, which include clavicles (formed on the anterior margin of the procoraccoid cartilage), coracoids (bone deposition occurring on anterior and posterior margins of the coracoid cartilage) and cartilaginous arc, were observed in the stained *M. fuscus* specimen. The pre-zonal and post-zonal elements, omosternum and sternum respectively showed ossifications starting from the point of attachment to the cartilaginous arc (Fig. 9E).

Fore limb. Humerus, being the proximal element of the forelimb is attached to the pectoral girdle via the articular surface, glenoid fossa. Radio-ulna is present by fusion of radius and ulna. Manus consists of five ossified carpals, radiale, ulnare, carpal 2, carpals 3-5, centrale and central. Prepollex is ossified. Relative lengths of the metacarpals are IV > III > V > II. The phalangeal formula is 2-2-3-3. Distal phalanges are forked (Figs 10A–E).

Pelvic girdle. It is made up of ilium, ischium and pubis. The ilium articulates with the ventral surface of the sacral diapophysis. Posterior half of the acetabulum is denoted by the ischium. Ventral to the acetabulum, cartilaginous pubis is apparent.

Hind limb. Femur that articulates with the pelvic girdle, and tibiofibula that articulates anteriorly with the femur, are fully ossified. Fibulare and tibiale articulating anteriorly with the tibiofibula are fused medially at their proximal and distal ends. Two tarsal elements, tarsal 1 and tarsal 2-3 were ossified. The prehallux was observed as cartilaginous element with a bony base. The relative lengths of the Metatarsals are IV> V> III> II> I. The phalangeal formula is 2-2-3-4-3, and the distal phalanges were fork-shaped (Figs 10F–J).

Axial skeleton. The presacral region consists of eight presacral vertebrae. Atlas being the most anterior vertebra lacks transverse processes. A pair of atlantal cotyles is seen. The transverse processes of presacral II have an anterolateral orientation, whereas transverse processes III-VIII have a posterolateral orientation. The specialized vertebra, sacrum is positioned in between the presacrals anteriorly, and coccyx posteriorly. Vertebrae starting from II-VIII have prezygapophyses and postzygapophyses on each neural arch. The sacrum has only a pair of prezygapophyses. Sacral diapophyses are formed by the expansions of the sacrum. The last element of the vertebral column, the rod-like coccyx, can be seen between the shafts of ila.

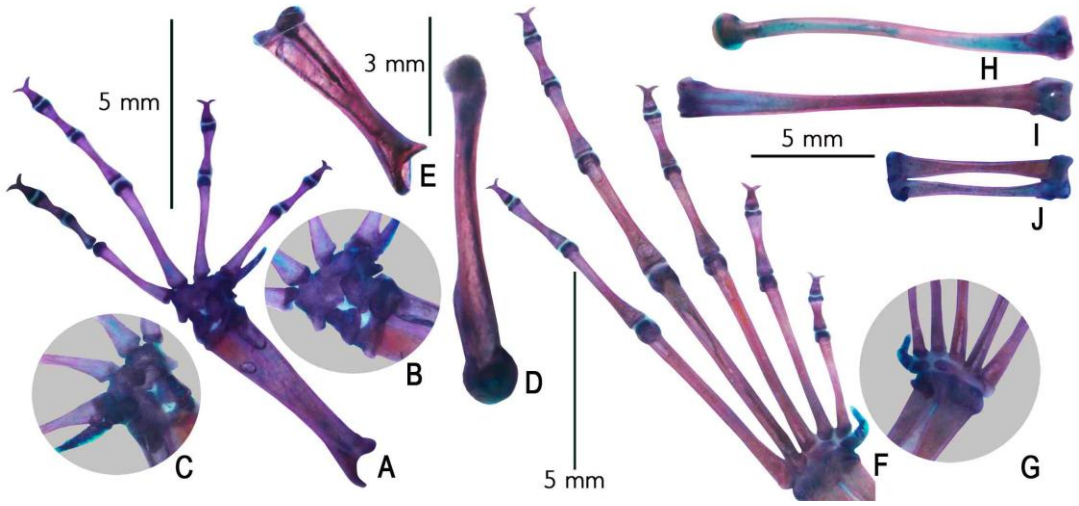

Figure 10. Anterior appendicular skeleton and posterior extremity of *Micrixalus fuscus* (SDBDU 2006.2296). **A.** left hand (dorsal view), **B.** left hand showing six different types of carpals (dorsal view), **C.** left hand showing the six different types of carpals (ventral view), **D.** left humerus (medial view), **E.** left radio-ulna (medial view), **F.** left foot (dorsal view), **G.** left foot revealing two tarsal elements (ventral view), **H.** left femur (medial view), **I.** left tibiafibula (medial view), **J.** left fibulare and tibiale (medial view).

TAXONOMY

Family: Micrixalidae Dubois, Ohler & Biju, 2001
Type genus: *Micrixalus* Boulenger, 1888
Type species: *Micrixalus fuscus* Boulenger, 1882
Common name: Indian Dancing Frogs

Etymology. The name *Micrixalus* is composed of two words, '*Micro'* which is derived from the Greek "*mīkrós*" meaning small, and the word "*ixalus*" which is often used as a suffix in rhacophorid generic names.

Diagnosis. Small-sized frogs with an elongated appearance, male SVL 13–29 mm, female SVL 15–34 mm; presence or absence of dorsolateral skin folds; pupil oval; shagreened to sparsely granular skin; tympanum small or faintly visible externally; vomerine teeth absent; tongue emarginated posteriorly with or without lingual papillae; tip of fingers and toes with discs, with distinct dorsoterminal grooves; webbing absent on fingers; webbing present on toes; posterior parts of thigh usually with a yellow or yellowish-brown longitudinal stripe extending towards the knee, in life.

Distribution. This family is endemic to the Western Ghats mountain range of Peninsular India. The distribution range extends from Kirippara (08.42°N, 77.42°E), Kanyakumari district, Tamil Nadu state in the south to Amboli (15.95°N, 74.00°E), Sindhudurg district, Maharashtra state in the north (Fig. 3).

Taxonomic groups. Based on morphological similarities between members of the genus *Micrixalus*, the present study identified five major groups: *Micrixalus elegans* group, *Micrixalus fuscus* group, *Micrixalus nudis* group, *Micrixalus saxicola* group and *Micrixalus silvaticus* group. Taxonomic accounts of all the species are provided group-wise and each species is morphologically compared only with closely related members within its group.

Micrixalus elegans group

Members. *Micrixalus candidus* sp. nov., *Micrixalus elegans*, *Micrixalus kurichiyari* sp. nov., *Micrixalus niluvasei* sp. nov., *Micrixalus sairandhri* sp. nov., *Micrixalus spelunca* sp. nov. and *Micrixalus uttaraghati* sp. nov.

This group can be distinguished from other *Micrixalus* groups by the combination of following morphological characters: small adult size (male, SVL 11–21 mm; female, SVL 17–23 mm); dorsolateral folds weakly developed or absent; fourth toe webbing extends beyond the second subarticular tubercle on either side; absence of outer metatarsal tubercles; presence of a white streak that extends from margins of the lower jaw, up to the posterior corner of upper arm insertion or beyond (except in *Micrixalus uttaraghati* sp. nov.); lateral sides of head (snout and tympanic area) distinctly lighter in colour compared to the flank (Fig. 11).

Micrixalus candidus sp. nov.

White-Cheeked Dancing Frog
(Figs 3, 11A, 12; Tables 1–5)

Holotype. BNHS 5608, an adult male, Kemmanagundi, Chikmagalur dist., Karanataka state, India, collected by SDB and team, 30 June 2010.

Paratypes. ***Karnataka*****:** *Chikmagalur dist*., Kottigehara, BNHS 5609–BNHS 5611 (three males), collected by SDB and team, 17 November 2010.

Comparison. *Micrixalus candidus* could be confused with *M. elegans*, *M. kurichiyari*, *M. niluvasei*, *M. sairandhri*, *M. spelunca* and *M. uttaraghati*. However, *M. candidus* differs from *M. elegans* by its nostril closer to tip of snout than eye, EN 1.2 ± 0.2 mm, NS 0.9 ± 0.1 mm, *N* = 4 (vs. as close to tip of snout as to eye, EN 1.0 ± 0.1 mm, NS 1.0 ± 0.2 mm, *N* = 5), anterior part of flank brown (vs. dark brownish-black), dorsum light grey to light brown (vs. reddish brown); differs from *M. kurichiyari* by its snout rounded in dorsal view (vs. subelliptical), snout rounded in lateral view (vs. acute), nostril closer to tip of snout than eye, EN 1.2 ± 0.2 mm, NS 0.9 ± 0.1 mm, *N* = 4 (vs. as close to tip of snout as to eye, EN 1.4 ± 0.1 mm, NS 1.4 ± 0.1 mm, *N* = 6), fourth toe webbing just below the first subarticular tubercle on either side (vs. just beyond the second subarticular tubercle on either side); differs from *M. niluvasei* by its snout rounded in dorsal view (vs. subovoid), snout rounded in lateral view (vs. acute); differs from *M. sairandhri* by its nostril closer to tip of snout than eye, EN 1.2 ± 0.2 mm, NS 0.9 ± 0.1 mm, *N* = 4 (vs. as close to tip of snout as to eye, EN 1.3 ± 0.2 mm, NS 1.3 ± 0.1 mm, *N* = 6); interorbital space wider than upper eyelid, IUE 1.5 ± 0.1 mm, UEW 1.0 ± 0.1 mm, *N* = 4 (vs. equal, IUE 1.5 ± 0.1 mm, UEW 1.5 ± 0.1 mm, *N* = 6), snout rounded in lateral view (vs. acute), fourth toe webbing up to the first subarticular tubercle on either side (vs. just beyond the second subarticular tubercle on either side); differs from *M. spelunca* by its snout rounded in dorsal view (vs. subovoid), snout rounded in lateral view (vs. acute), head longer than its wide, HW 5.4 ± 0.6 mm, HL 6.1 ± 0.9, *N* = 4 (vs. equal, HW 5.6 ± 0.2 mm, HL 5.6 ± 0.2, *N* = 6), shank longer to foot length, SHL 8.6 ± 1.1 mm, FOL 7.8 ± 0.4 mm, *N* = 4 (vs. equal, SHL 8.4 ± 0.2 mm, FOL 8.4 ± 0.3 mm, *N* = 6), anterior part of flank brown, in life (vs. bluish-black or brownish-black with light brown reticulations); differs from *M. uttaraghati* by its snout rounded in lateral view (vs. acute), fourth toe webbing below the first subarticular tubercle on either side (vs. up to the disc on either side), dorsal skin shagreened (vs. spinular), dermal fringe along toe V from tip of toe to heel weakly developed, without glandular projections and spinules in males (vs. dermal fringe along toe V from tip of toe to heel well developed, with glandular projections ending with sharp spinules in males).

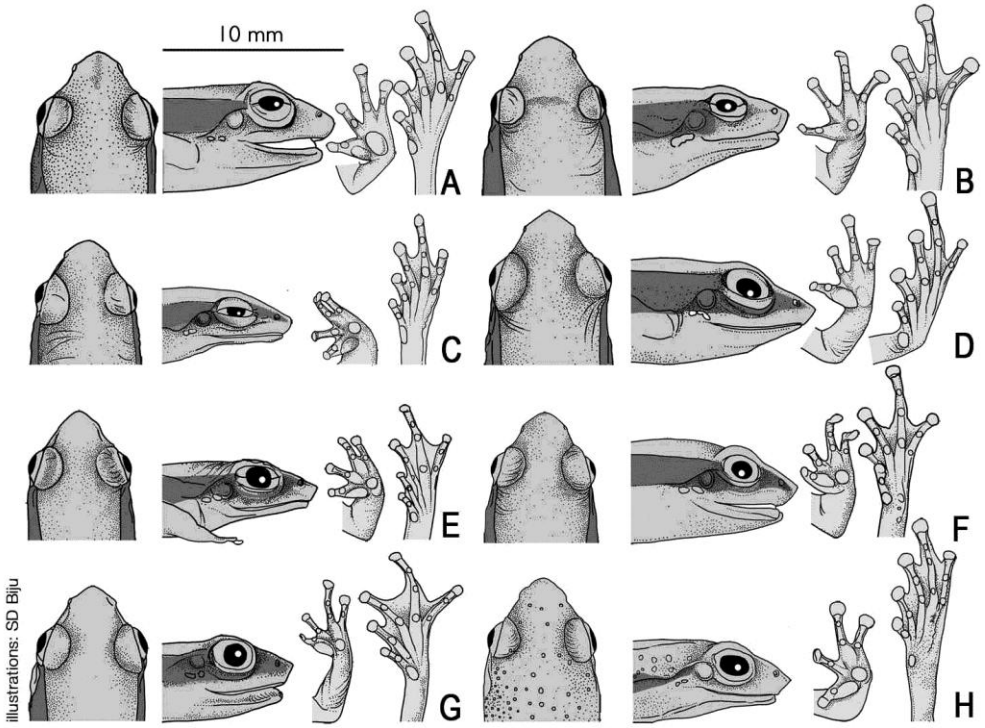

Figure 11. From left to right, dorsal view of head, lateral view of head, ventral view of hand and ventral view of foot of *Micrixalus elegans* group: **A.** *Micrixalus candidus* sp. nov. (HT, BNHS 5608, m), **B.** *M. elegans* (NT, BNHS 5808, f), **C.** *M. elegans* (RS, BNHS 5613, m), **D.** *Micrixalus kurichiyari* sp. nov. (HT, BNHS 5621, m), **E.** *Micrixalus niluvasei* sp. nov. (HT, BNHS 5627, m), **F.** *Micrixalus sairandhri* sp. nov. (HT, BNHS 5633, m), **G.** *Micrixalus spelunca* sp. nov. (HT, BNHS 5640, m), **H.** *Micrixalus uttaraghati* sp. nov. (HT, BNHS 5647, m).

Micrixalus candidus could not be confused with three other species (*M. kottigeharensis*, *M. narainensis* and *M. swamianus*) described from its type locality, Kottigehara. However, in order to avoid any confusion, we compare the new species with the later three species. *Micrixalus candidus* differs from *M. kottigeharensis*, *M. narainensis* and *M. swamianus* by its snout rounded in dorsal view (vs. pointed), snout rounded in lateral view (vs. acute), tongue without lingual papilla (vs. with lingual papilla) and presence of a white streak extending from margins of the lower jaw, up to the posterior corner of upper arm insertion or beyond (vs. absent).

Description of holotype *(measurements in mm)*. Adult male (SVL 20.2); head small (HW 6.2, HL 7.1), longer than wide, flat above; snout rounded in dorsal and lateral view, its length (SL 3.1) longer than horizontal diameter of eye (EL 2.5); loreal region vertical, rounded canthus rostralis; interorbital space flat, wider (IUE 1.5) than upper eyelid (UEW 1.0) and shorter than internarial distance (IN 1.8); distance between back of eye (IBE 5.2) 1.5 times the distance between front of eye (IFE 3.4); nostril oval, closer to tip of snout (NS 1.1) than eye (EN 1.4); tympanum (TYD 0.6) 24% of eye diameter (EL 2.5); tongue moderately large, emarginate, without median lingual papillae; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 3.7) shorter than hand length (HAL 5.0); finger discs moderately wide compared to finger width (fd1 0.6, fw1 0.3; fd2 0.6, fw2 0.3; fd3 0.7, fw3 0.3; fd4 0.6, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present. Thigh length (TL 9.7) equal to shank (SHL 9.7), and longer than foot (FOL 8.2); toe discs wide compared to toe width (td1 0.6, tw1 0.2; td2 0.7, tw2 0.2; td3 0.9, tw3 0.4; td4 0.9, tw4 0.3; td5 0.7, tw5 0.3); webbing present: I1–$1^{3}/_{4}$II1–2III1–2^{+}IV2^{+}–$1^{1}/_{4}$V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles absent.

Skin of snout, between eyes, upper eyelids and posterior part of back shagreened; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, weakly developed; dorsal parts of forelimb shagreened; thigh, tibia and tarsus shagreened; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened.

Colour in preservation. Dorsum light grey with irregular light brown spots; a brown band connecting the eyes; anterior parts of flank dark brown; tympanic area brownish-black; forelimbs, dorsal surfaces of thigh, tibia and feet greyish-brown with dark brown cross-bands, posterior parts of thigh light grey with dark grey reticulations; throat, chest and belly light grey with minute black spots; tibia and feet greyish-brown, webbing blackish-grey.

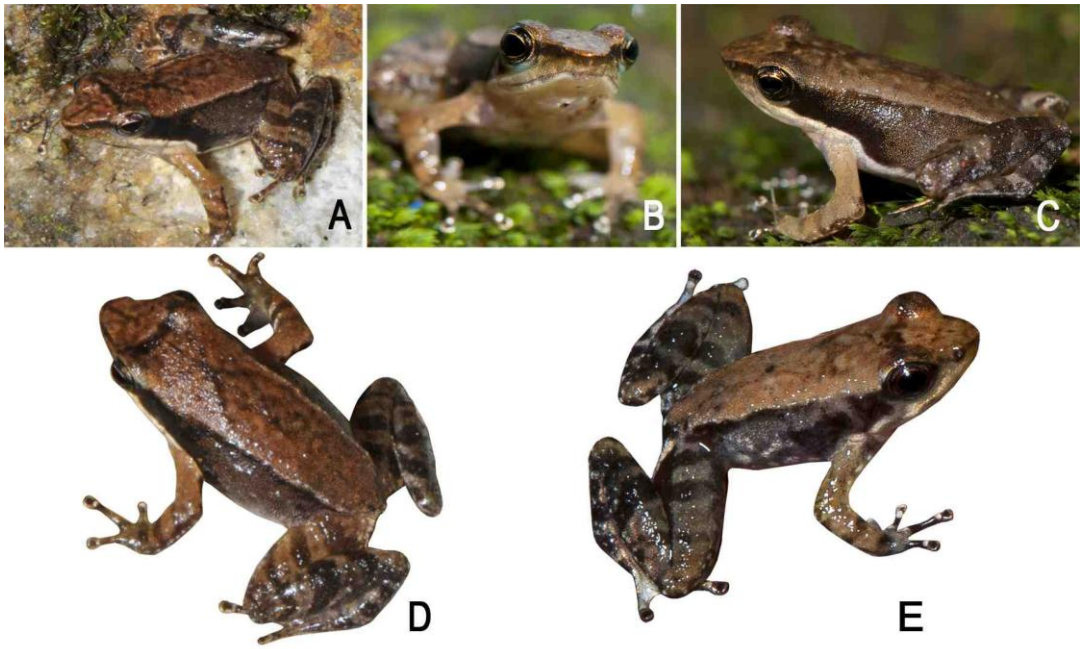

Figure 12. *Micrixalus candidus* sp. nov. in life: **A.** dorsolateral view (HT, BNHS 5608, m); **B.** front view (PT, BNHS 5611, m); **C.** dorsolateral view (PT, BNHS 5609, m); **D.** dorsal view (HT, BNHS 5608, m); **E.** dorsolateral view (PT, BNHS 5610, m). Photos: SDB.

Colour in life. Dorsum uniform light brown; tympanum and surrounding areas light brown; iris light brown with reddish tinge; anterior parts of flank brown, posterior parts of flank light greyish-brown; groin light grey with minute black spots; dorsal surface of limbs light brown with dark brown cross-bands; throat, chest and belly greyish-white.

Variations. See Table 5 for morphometric characters of four adult males. For colour variations see Figure 12.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling.

Etymology. The species epithet is a noun in apposition, therefore invariable, derived from the Latin word *'candidus'* meaning white, referring to the prominent white streak on sides of the head, in this species.

Distribution. *Micrixalus candidus* is known only from the state of Karnataka, with its distribution restricted between the Palghat gap and Goa gap in the Western Ghats. The present study found this species in Kemmanagundi and Kottigehara (Chikmagalur dist.) (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is flowing streams covered with forest canopy. The male specimens were found actively calling and collected between 10:00–16:00 h.

Micrixalus elegans (Rao, 1937)
Elegant Dancing Frog
(Figs 3,11B–C, 13; Tables 1–5)

Original name and description. *Philautus elegans* Rao, 1937. On some new forms of Batrachia from S. India. *Proceedings of Indian Academy Science (B)* 6: 407. **Neotype.** By present designation, BNHS 5808, an adult female (SVL 21.0 mm), collected by SDB, 12 September 2012. **Neotype locality.** Kempholay, Hassan dist., Karnataka state. **Current status of specific name.** Valid name, as *Micrixalus elegans* (Rao, 1937) (Bossuyt and Dubois, 2001).

Referred specimens. *Karnataka*: *Hassan dist.*, Kempholay, BNHS 5612, an adult male, collected by SDB, 30 July 2002, BNHS 5613, an adult male, collected by SDB, 12 September 2012; Maranhalli, Sakleshpur, BNHS 5614–BNHS 5615, two adult males, and BNHS 5616, an adult female, collected by SDB and Systematics lab team, 1 October 2012; *Kodagu dist.*, Bhagamandala, BNHS 5617, an adult female, collected by SDB, 28 June 2012; Yavakapady, Coorg, BNHS 5618, an adult male, BNHS 5619–BNHS 5620, two adult females, collected by SDB and Systematics lab team, 4 October 2012.

Other material studied. *Karnataka*: *Dakshina Kannada dist.*, Charmadi Ghats, SDBDU 2011.1397, collected by SDB and Systematics lab team, 23 October 2011; *Hassan dist.*, Kempholay, SDBDU 2010.003, collected by SDB and Systematics lab team, 16 November 2010; ***Kerala*:** *Kannur dist.*, Meenmutty, Aralam, SDBDU 2008.412, collected by SDB, 5 June 2008.

Comments. Rao (1937) described *Philautus elegans* from "Kempholey, Hassan" based on a sole specimen ("SVL 23.0 mm"). Bossuyt and Dubois (2001) transferred this taxon to the genus *Micrixalus.* However, since the original name-bearing type of this nominal species is unknown and probably lost (Dubois 1987; SDB personal observation), the status interpretation of its name has to rely on the original description (Rao, 1937). For nomenclatural stability, designation of a neotype for *Micrixalus elegans* is necessary. Our new collections from the type locality (Kempholay) are comparable with a few characters stated in the original description of *Philautus elegans*: "SVL 23.0 mm", "crimson above" and "sides of body commencing from behind the eyes black". In order to stabilize this name, we herein designate a neotype for *Philautus elegans* (= *Micrixalus elegans*) Rao, 1937.

Comparison. *Micrixalus elegans* could be confused with *M. candidus*, *M. kurichiyari*, *M. niluvasei*, *M. sairandhri*, *M. spelunca* and *M. uttaraghati*. However, *M. elegans* differs from *M. kurichiyari* by its snout rounded in dorsal view (vs. subelliptical), snout rounded in lateral view (vs. acute), fourth toe webbing extending up to the first subarticular tubercle on either side (vs. just beyond the second subarticular tubercle on either side); differs from *M. niluvasei* by its snout rounded in dorsal view (vs. subovoid), snout rounded in lateral view (vs. acute), nostril as close to eye as to tip of snout, male, EN 1.0 ± 0.1 mm, NS 1.0 ± 0.1 mm, *N* = 6, female, EN 1.3 ± 0.2 mm, NS 1.3 ± 0.2 mm, *N* = 5 (vs. closer to tip of snout than eye, male, EN 1.0 ± 0.1 mm, NS 0.5 ± 0.1 mm, *N* = 2, female, EN 1.8 ± 0.1 mm, NS 1.1 ± 0.1 mm, *N* = 4); differs from *M. sairandhri* by its snout rounded in lateral view (vs. acute), interorbital space wider than upper eyelid, male, IUE 1.7 ± 0.1 mm, UEW 1.0 ± 0.2 mm, *N* = 6, female, IUE 2.3 ± 0.3 mm, UEW 1.2 ± 0.2 mm, *N* = 5 (vs. equal, male, IUE 1.5 ± 0.1 mm, UEW 1.5 ± 0.1 mm, *N* = 6, female, IUE 2.1 mm, UEW 2.0 mm, *N* = 1), shank equal to thigh length, male, SHL 7.9 ± 0.5 mm, TL 7.9 ± 0.5 mm, *N* = 6, female, SHL 10.3 ± 0.4 mm, TL 10.3 ± 0.7 mm, *N* = 5 (vs. shorter, SHL 9.4 ± 0.3 mm, TL 10.1 ± 0.3 mm, *N* = 6, female, SHL 11.5 mm, TL 12.3 mm, *N* = 1); differs from *M. spelunca* by its snout

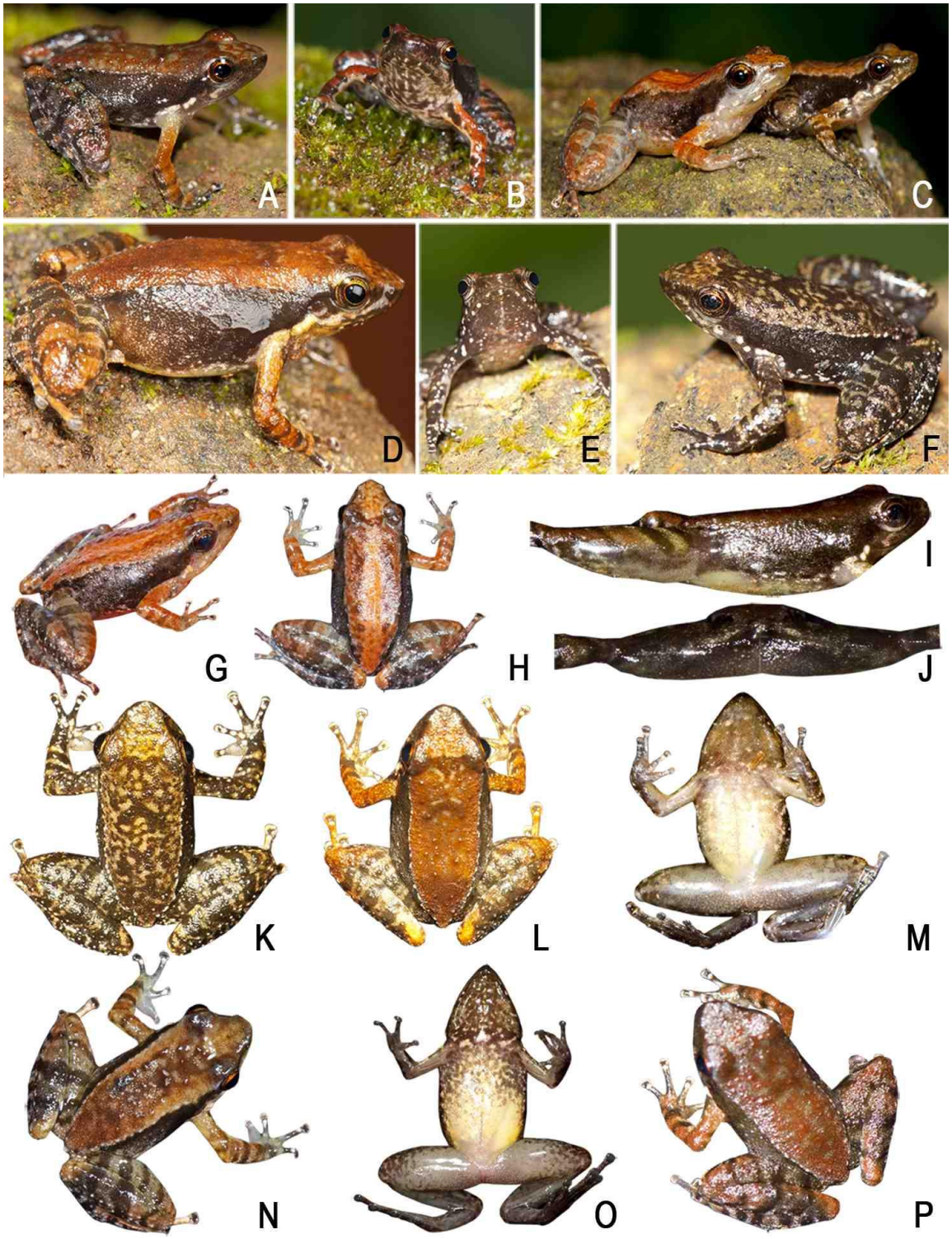

Figure 13. *Micrixalus elegans* in life: **A.** dorsolateral view, **B.** front view (NT, BNHS 5808, f); **C.** dorsolateral view (RS, BNHS 5616, f, on left; RS, BNHS 5614, m, on right); **D.** dorsolateral view (RS 2118, f); **E.** front view, **F.** dorsolateral view (RS, BNHS 5613, m); **G.** dorsolateral view, **H.** dorsal view (RS, BNHS 5614, m); **I.** lateral view of thigh and groin, **J.** posterior side of thighs (NT, BNHS 5808, f); **K.** dorsal view (RS, BNHS 5613, m); **L.** dorsal view, **M.** ventral view (RS, BNHS 5619, f); **N.** dorsal view, **O.** ventral view (RS, SDB2012.2235, m); **P.** dorsal view (RS, BNHS 5618, m). Photos: SDB.

rounded in dorsal view (vs. subovoid), snout rounded in lateral view (vs. acute), head longer than wide, male, HW 4.9 ± 0.3 mm, HL 5.2 ± 0.3, *N* = 6, female, HW 6.0 ± 0.5 mm, HL 6.5 ± 0.4, *N*

= 5 (vs. equal, male, HW 5.6 ± 0.2 mm, HL 5.6 ± 0.2, *N* = 6, female, HW 6.3 mm, HL 6.4, *N* = 1), shank longer than foot length, male, SHL 7.9 ± 0.5 mm, FOL 6.9 ± 0.4 mm, *N* = 6, female, SHL 10.3 ± 0.4 mm, FOL 8.5 ± 0.6 mm, *N* = 5 (vs. equal, SHL 8.4 ± 0.2 mm, FOL 8.4 ± 0.3 mm, *N* = 6, female, SHL 9.1 mm, FOL 9.1 mm, *N* = 1); differs from *M. uttaraghati* by its snout rounded in lateral view (vs. acute), fourth toe webbing below the first subarticular tubercle on either side (vs. up to the disc on either side), colour of flanks blackish-brown, and darker compared to the dorsal colour both in life and preservation (vs. flank colour similar to dorsum, with a dark brownish-black streak from behind the eye to near the groin, on either side).

For differences with *Micrixalus candidus* see 'Comparison' of that species.

Description of neotype (*all measurements in mm*). Adult female (SVL 21.0); head small (HW 6.4, HL 7.0), longer than wide, flat above; snout rounded in dorsal and lateral view, its length (SL 3.5) longer than horizontal diameter of eye (EL 2.4); loreal region vertical with rounded canthus rostralis; interorbital space flat, wider (IUE 2.7) than upper eyelid (UEW 1.2); distance between back of eye (IBE 5.4) 1.4 times the distance between front of eye (IFE 3.8); nostril oval, closer to eye (EN 1.6) than tip of snout **(**NS 2.5); tympanum (TYD 0.8) 33% of eye diameter (EL 2.4); tongue moderately large, emarginate, without lingual papilla; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 4.2) shorter than hand length (HAL 5.6); finger discs moderately wide compared to finger width (fd1 0.5, fw1 0.2; fd2 0.6, fw2 0.3; fd3 0.7, fw3 0.3; fd4 0.7, fw4 0.2); subarticular tubercles well developed, oval, single, all present; prepollex weakly developed; round palmar tubercles present. Thigh length (TL 10.6) subequal to shank (SHL 10.5), and longer than foot (FOL 8.0); toe discs wide compared to toe width (td1 0.6, tw1 0.3; td2 0.8, tw2 0.3; td3 0.9, tw3 0.3; td4 1.0, tw4 0.4; td5 0.9, tw5 0.4); webbing present: I1–$1^{1}/_{2}$II1–2III1–2^{+}IV2^{+}–1V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercle absent.

Skin of snout, between eyes and upper eyelids shagreened; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, weakly developed; thigh, tibia and tarsus shagreened; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened to sparsely granular.

Colour in preservation. Dorsum blackish-brown; a white streak starting just behind the tympanum, continuing over the arm and ending at posterior corner of the shoulder; lateral sides of head (snout and tympanic area) distinctly dark grey; flanks dark blackish-brown; forelimbs, dorsal surfaces of thigh, tibia and feet light brown with dark brown cross-bands, posterior parts of thigh grey with dark grey reticulations; throat, chest and belly light brown with light grey reticulations. **Colour in life.** Dorsum uniform reddish-brown with scattered yellowish-grey spots; lateral sides of head (snout and tympanic area) distinctly dark blackish-brown; iris light brown with reddish tinge; flanks blackish-brown; groin greyish-brown; dorsal surface of limbs reddish-brown with dark brown cross-bands; throat and margins of throat and chest greyish-brownish with light yellowish-grey reticulations; belly light yellowish-grey; thigh and shank grey with light brown spots; foot brownish-black.

Variations. See Table 5 for morphometric characters of six adult males and five adult females. For colour variations see Figure 13.

Secondary sexual characters. Male (SDB 2002.1085): Single prominent oval-shaped nuptial pad on finger I present, cream-coloured. Female (SDB 2012.2245): ova yellowish-white with minute black spots (diameter 1.3–1.5 mm, *N* = 20).

Distribution. *Micrixalus elegans* is known only from the states of Kerala and Karnataka, with its distribution restricted between the Palghat gap and Goa gap in the Western Ghats. The present study found this species only at Aralam (Kannur dist.) in Kerala, and at Kempholay, Sakleshpur (Hassan dist.), Yavakapady and Bhagamandala (Kodagu dist.) in Karnataka (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is damp leaf litter on the banks of fast flowing forest streams. In the present study specimens were collected between 10:00–16:00 h.

***Micrixalus kurichiyari* sp. nov.**

Kurichiyar Dancing Frog

(Figs 3, 11D, 14; Tables 1–5)

Holotype. BNHS 5621, an adult male, Kurichiyarmala, Wayanad dist., Kerala state, India, collected by SDB and SG, 5 June 2012.

Paratypes. *Kerala*: *Wayanad dist.*, Kurichiyarmala, BNHS 5622–BNHS 5626, five adult males, collected along with holotype.

Other material studied. *Kerala*: *Wayanad dist.*, Kurichiyarmala, SDBDU 2008.413, collected by SDB, 5 June 2008.

Comparison. *Micrixalus kurichiyari* could be confused with *M. candidus*, *M. elegans*, *M. niluvasei*, *M. sairandhri*, *M. spelunca* and *M. uttaraghati*, However, *M. kurichiyari* differs from

M. niluvasei by its snout subelliptical in dorsal view (vs. subovoid), nostril as close to eye as to tip of snout, EN 1.4 ± 0.1 mm, NS 1.4 ± 0.1 mm, *N* = 6 (vs. closer to tip of snout as to eye, EN 1.0 ± 0.1 mm, NS 0.5 ± 0.1 mm, *N* = 2), fourth toe webbing just beyond the second subarticular tubercle on either side (vs. extending up to the first subarticular tubercle on either side); differs from *M. sairandhri* by its snout subelliptical in dorsal view (vs. rounded), fourth toe webbing just beyond the second subarticular tubercle on either side (vs. well beyond second subarticular tubercle on either side), interorbital space wider than upper eyelid, IUE 2.2 ± 0.1 mm, UEW 1.4 ± 0.1 mm, *N* = 6 (vs. equal, IUE 1.5 ± 0.1 mm, UEW 1.5 ± 0.1 mm, *N* = 6), thigh subequal to foot length, male TL 9.2 ± 0.1 mm, FOL 9.3 ± 0.3 mm, *N* = 6 (vs. longer, TL 10.1 ± 0.3 mm, FOL 8.9 ± 0.2 mm, *N* = 6); differs from *M. spelunca* by its snout subelliptical in dorsal view (vs. subovoid), head longer than its wide, male, HW 6.0 ± 0.1 mm, HL 7.3 ± 0.2, *N* = 6 (vs. equal, male, HW 5.6 ± 0.2 mm, HL 5.6 ± 0.2, *N* = 6), thigh subequal to foot length, male TL 9.2 ± 0.1 mm, FOL 9.3 ± 0.3 mm, *N* = 6 (vs. longer, TL 9.4 ± 0.3 mm, FOL 8.4 ± 0.3 mm, *N* = 6); differs from *M. uttaraghati* by its snout subelliptical in dorsal view (vs. rounded), fourth toe webbing just beyond the second subarticular tubercle on either side (vs. up to the disc on either side), dermal fringe along toe V smooth in males (vs. dermal fringe along toe V well developed from tip of toe to heel, with glandular projections ending with sharp spinules in males).

For differences with *Micrixalus candidus, and M. elegans* see 'Comparison' of those species.

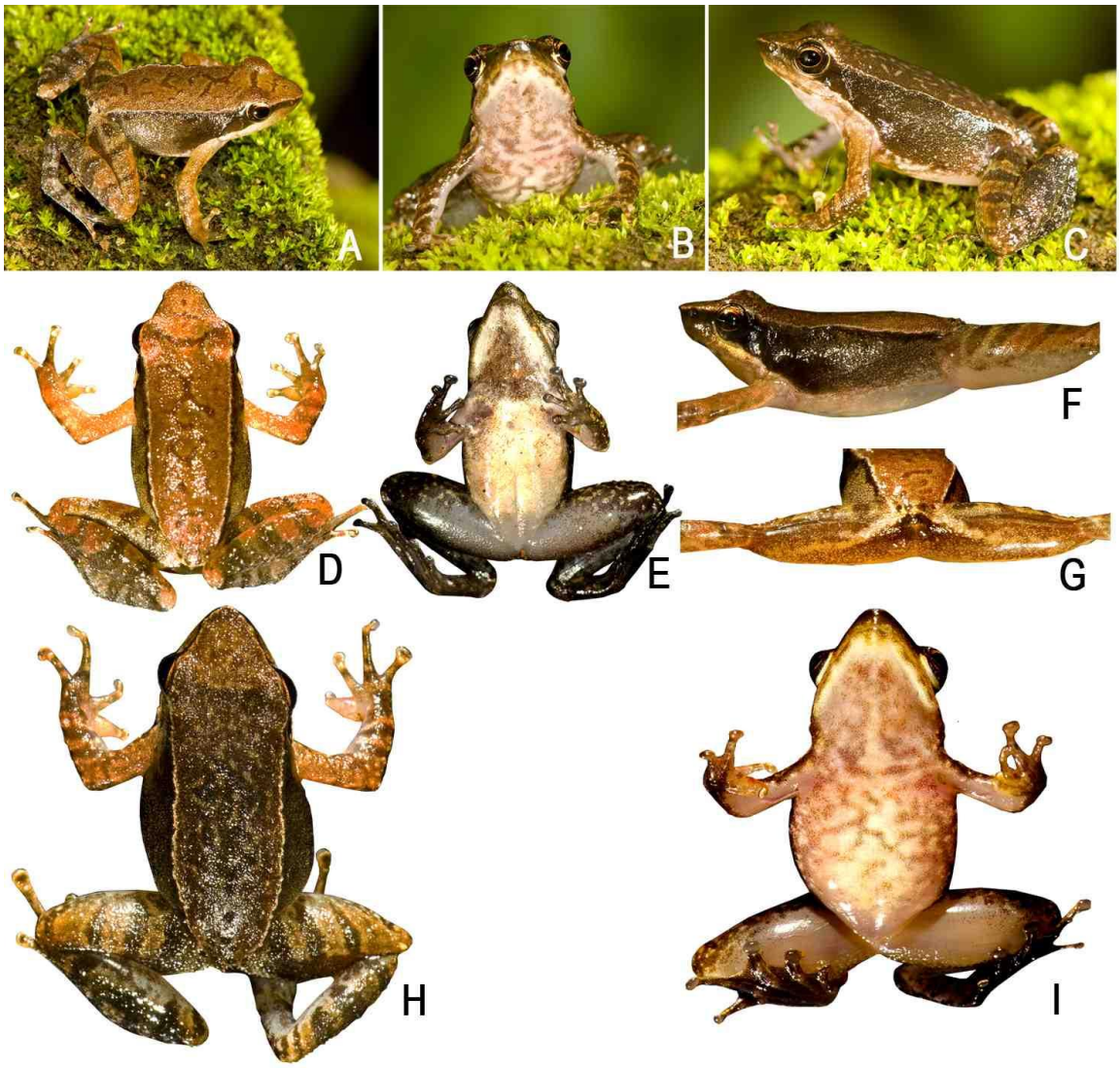

Figure 14. *Micrixalus kurichiyari* sp. nov. in life: **A.** dorsolateral view, **B.** front view (HT, BNHS 5621, m); **C.** dorsolateral view (PT, BNHS 5622, m); **D.** dorsal view, **E.** ventral view, **F.** lateral view of thigh and groin, **G.** posterior side of thighs (HT, BNHS 5621, m); **H.** dorsal view, **I.** ventral view (PT, BNHS 5622, m). Photos: SDB.

Description of holotype *(measurements in mm)*. Adult male (SVL 18.6); head small (HW 6.1, HL 7.3), longer than wide, flat above; snout subelliptical in dorsal view, acute in lateral view, its length (SL 3.2) longer than horizontal diameter of eye (EL 2.6); loreal region vertical, rounded canthus rostralis; interorbital space flat, wider (IUE 2.3) than upper eyelid (UEW 1.5) and subequal to internarial distance (IN 2.4); distance between back of eye (IBE 5.3) 1.8 times the distance between front of eye (IFE 3.0); nostril oval, as close to eye (EN 1.5) as to tip of snout (NS 1.5); tympanum (TYD 1.0) 38% of eye diameter (EL 2.6); tongue moderately large, emarginate, without median lingual papillae; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 4.0) shorter than hand length (HAL 5.0); finger discs moderately wide compared to finger width (fd1 0.5, fw1 0.3; fd2 0.5, fw2 0.2; fd3 0.7, fw3 0.3; fd4 0.7, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present. Thigh length (TL 9.1) shorter to shank (SHL 9.8), and subequal to foot (FOL 9.2); toe discs wide compared to toe width (td1 0.6, tw1 0.3; td2 0.8, tw2 0.3; td3 0.8, tw3 0.3; td4 0.8, tw4 0.3; td5 0.7, tw5 0.3); webbing present: I1–$1^{3}/_{4}$II1–2III1–2^{-}IV2^{-}–1V; subarticular tubercles rather well developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles absent.

Skin of snout, between eyes, upper eyelids and posterior part of back shagreened to sparsely granular; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, weakly developed; flanks shagreened to sparsely granular; dorsal parts of forelimb, thigh, tibia and tarsus shagreened to sparsely granular; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened.

Colour in preservation. Dorsum brown with irregular light grey spots; flanks dark brown; tympanic area brownish-black; forelimbs, dorsal surfaces of thigh, tibia and foot greyish-brown with dark brown cross-bands, posterior parts of thigh light grey with dark grey reticulations; throat, chest and belly light grey with minute black spots; tibia and feet greyish-brown; webbing blackish-grey. **Colour in life.** Dorsum uniform brown; tympanum and surrounding areas dark brown; iris light brown with reddish tinge; anterior parts of flank brownish-black, posterior parts of flanks light greyish-brown; groin light yellow; dorsal surface of limbs light brown with dark brown cross-bands; throat and margins of throat, chest and belly greyish-white; ventral surface of thighs dark grey; foot blackish-grey.

Variations. See Table 5 for morphometric characters of six adult males and for colour variations see Figure 14.

Secondary sexual characters. Male: Single prominent, oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling.

Etymology. The species is named after 'Kurichiyar', where the type series was collected. The species name *kurichiyari* is a noun in the genitive case.

Distribution. *Micrixalus kurichiyari* is known only from its type locality Kurichiyarmala (Wayanad dist., Kerala state), which lies north of Palghat gap in the Western Ghats (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is flowing streams covered with forest canopy. A few male specimens were found calling and collected between 11:00–16:00 h.

Micrixalus niluvasei sp. nov.

Niluvase Dancing Frog

(Figs 3,11E, 15; Tables 1–5)

Holotype. BNHS 5627, an adult male, Niluvase, Shimoga dist., Karnataka state, India, collected by KVG, GS and Sameer Ali, 29 September 2012.

Paratypes. ***Karnataka*****:** *Shimoga dist.*, Niluvase, BNHS 5628, an adult male, BNHS 5629– BNHS 5632, four adult females, collected along with holotype.

Comments. This species was identified as *Micrixalus fuscus* by Gururaja *et al.* (2007).

Comparison. *Micrixalus niluvasei* could be confused with *M. candidus*, *M. elegans*, *M. kurichiyari*, *M. sairandhri*, *M. spelunca* and *M. uttaraghati*. However, *M. niluvasei* differs from *M. sairandhri* by its snout subovoid in dorsal view (vs. rounded), fourth toe webbing up to first subarticular tubercle on either side (vs. extending beyond the second subarticular tubercle on either side), interorbital space wider than upper eyelid, male, IUE 1.9 ± 0.0 mm, UEW 1.2 ± 0.0 mm, *N* = 2, female, IUE 2.0 ± 0.3 mm, UEW 1.2 ± 0.1 mm, *N* = 4 (vs. equal, male, IUE 1.5 ± 0.1 mm, UEW 1.5 ± 0.1 mm, *N* = 6, female, IUE 2.1 mm, UEW 2.0 mm, *N* = 1), thigh equal to shank length, male, TL 8.8 ± 0.1 mm, SHL 8.8 ± 0.1 mm, *N* = 2, female, TL 10.3 ± 0.3 mm, SHL 10.3 ± 0.3 mm, *N* = 4 (vs. longer, TL 10.1 ± 0.3 mm, SHL 9.4 ± 0.3 mm, *N* = 6, female, TL 12.3 mm, SHL 11.5 mm, *N* = 1); differs from *M. spelunca* by its thigh equal to shank length, male, TL 8.8 ± 0.1 mm, SHL 8.8 ± 0.1 mm, *N* = 2, female, TL 10.3 ± 0.3 mm, SHL 10.3 ± 0.3 mm, *N* = 4 (vs. longer, TL 9.4 ± 0.3 mm, SHL 8.4 ± 0.2 mm, *N* = 6, female, TL 10.5 mm, SHL 9.1 mm, *N* = 1), shank longer than foot length, male, SHL 8.8 ± 0.1 mm, FOL 7.0 ± 0.1

mm, *N* = 2, female, SHL 10.3 ± 0.3 mm, FOL 9.0 ± 0.4 mm, *N* = 4 (vs. equal, male, SHL 8.4 ± 0.2 mm, FOL 8.4 ± 0.3 mm, *N* = 6, female, SHL 9.1 mm, FOL 9.1 mm, *N* = 1); differs from *M. uttaraghati* by its snout subovoid in dorsal view (vs. rounded), fourth toe webbing extending up to first subarticular tubercle on either side (vs. up to the disc on either side), dermal fringe along toe V smooth (vs. dermal fringe along toe V well developed from tip of toe to heel, with glandular projections ending with sharp spinules in males).

For differences with *Micrixalus candidus, M. elegans* and *M. kurichiyari*, see 'Comparison' of those species.

Description of holotype *(measurements in mm)*. Adult male (SVL 15.5), head small (HW 4.9, HL 5.3), longer than wide, flat above; snout subovoid in dorsal view, acute in lateral view, its length (SL 1.8) longer than horizontal diameter of eye (EL 1.2); loreal region vertical, rounded canthus rostralis; interorbital space flat, wider (IUE 1.8) than upper eyelid (UEW 1.2) and equal to internarial distance (IN 1.8); distance between back of eye (IBE 4.7) 1.6 times the distance between front of eye (IFE 2.9); nostril oval, closer to tip of snout (NS 0.5) than eye (EN 0.9); tympanum (TYD 0.4) 33% of eye diameter (EL 1.2); tongue moderately large, emarginate, without median lingual papillae; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 2.9) shorter than hand length (HAL 3.6); finger discs moderately wide compared to finger width

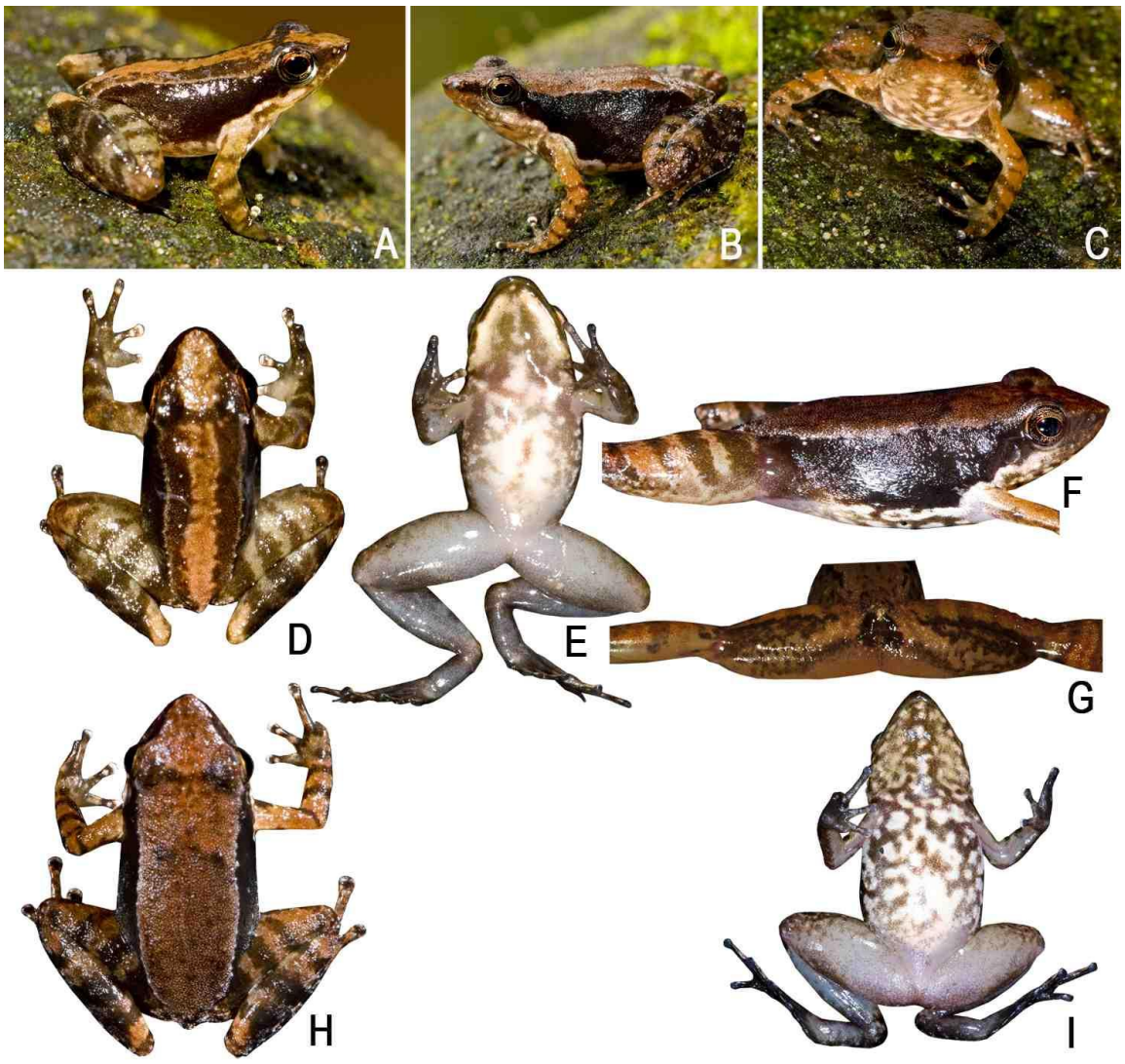

Figure 15. *Micrixalus niluvasei* sp. nov. in life: **A.** dorsolateral view (HT, BNHS 5627, m); **B.** dorsolateral view, **C.** front view (PT, BNHS 5629, f); **D.** dorsal view, **E.** ventral view, **F.** lateral view of thigh and groin, **G.** posterior side of thighs (HT, BNHS 5627, m); **H.** dorsal view, **I.** ventral view (PT, BNHS 5629, f). Photos: SDB.

(fd1 0.3, fw1 0.2; fd2 0.4, fw2 0.2; fd3 0.6, fw3 0.3; fd4 0.5, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present. Thigh length subequal (TL 8.8) to shank (SHL 8.7), and longer than foot (FOL 6.9); toe discs wide compared to toe width (td1 0.4, tw1 0.2; td2 0.5, tw2 0.2; td3 0.6, tw3 0.2; td4 0.6, tw4 0.2; td5 0.5, tw5 0.2); webbing present: I1–2⁻II1–2III1–2IV2–1V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles absent.

Skin of snout, between eyes, upper eyelids and posterior part of back shagreened; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, weakly developed; dorsal parts of forelimb shagreened; thigh, tibia and tarsus shagreened; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened.

Colour in preservation. Dorsum brown with a broad light orangish-brown band from the tip of snout to vent, a brown band connecting the eyes; flanks dark brown; tympanic area brownish-black; forelimbs, dorsal surfaces of thigh, tibia and feet greyish-brown with dark brown cross-bands, posterior parts of thigh light brown with dark greyish-brown reticulations; throat, chest and belly light grey with minute black spots; tibia and feet greyish-brown; webbing blackish-grey. **Colour in life.** Dorsum uniform dark brown with a broad light brown band from the tip of snout to vent; tympanum and surrounding areas dark brown; iris light brown with reddish tinge; anterior parts of flank brownish-black, posterior parts of flank light greyish-brown; groin light brown; dorsal surface of limbs greyish-brown with dark brown cross-bands; throat and margins of throat, chest and belly dark grey; thighs light grey; foot blackish-grey.

Variations. See Table 5 for morphometric characters of two adult males and four adult females. For colour variations see Figure 15.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5629): ova yellowish-white with minute black spots (diameter 0.8–1.0 mm, *N* = 10).

Etymology. The species is named after Niluvase, where the type series was collected. The species name *niluvasei* is a noun in the genitive case.

Distribution. *Micrixalus niluvasei* is known only from its type locality Niluvase (Shimoga dist., Karanataka state), which lies north of Palghat gap in the Western Ghats (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is moist leaf litter or rock surfaces in streams covered with forest canopy. The male specimens were found actively calling and‘foot-flagging’. Collections were made between 13:00–16:00 h.

Micrixalus sairandhri sp. nov.

Sairandhri Dancing Frog

(Figs 3, 11F, 16; Tables 1–5)

Holotype. BNHS 5633, an adult male, Sairandhri, Silent Valley, Palakkad dist., Kerala state, India, collected by SDB and SG, 19 September 2011.

Paratypes. ***Kerala*****:** *Palakkad dist.*, Sairandhri, Silent Valley, BNHS 5634–BNHS 5638, five adult males, and BNHS 5639, an adult female, collected along with holotype.

Comparison. *Micrixalus sairandhri* could be confused with *M. candidus*, *M. elegans*, *M. kurichiyari*, *M. niluvasei*, *M. spelunca* and *M. uttaraghati*. However, *M. sairandhri* differs from *M. spelunca* by its snout rounded in dorsal view (vs. subovoid), head longer than its wide, HW 5.7 ± 0.2 mm, HL 6.6 ± 0.2, *N* = 6, (vs. equal, HW 5.6 ± 0.2 mm, HL 5.6 ± 0.2, *N* = 6), interorbital space equal to upper eyelid, IUE 1.5 ± 0.1 mm, UEW 1.5 ± 0.1 mm, *N* = 6, (vs. longer, IUE 2.0 ± 0.2 mm, UEW 1.2 ± 0.1 mm, *N* = 6), shank longer than foot length, SHL 9.4 ± 0.3 mm, FOL 8.9 ± 0.2 mm, *N* = 6 (vs. equal, SHL 8.4 ± 0.2 mm, FOL 8.4 ± 0.3 mm, *N* = 6,); differs from *M. uttaraghati* by its interorbital space equal to upper eyelid, IUE 1.5 ± 0.1 mm, UEW 1.5 ± 0.1 mm, *N* = 6, (vs. longer, IUE 1.9 ± 0.1 mm, UEW 1.2 ± 0.1 mm, *N* = 7), fourth toe webbing beyond the second subarticular tubercle on either side (vs. fourth toe webbing up to the disc on either side), dermal fringe along toe V smooth in males (vs. dermal fringe along toe V well developed from tip of toe to heel, with glandular projections ending with sharp spinules in males).

For differences with *Micrixalus candidus, M. elegans, M. kurichiyari* and *M. niluvasei* see ‘Comparison’ of those species.

Description of holotype *(measurements in mm)*. Adult male (SVL 17.8); head small (HW 5.5, HL 6.8), longer than wide, flat above; snout round in dorsal view, acute in lateral view, its length (SL 2.9) longer than horizontal diameter of eye (EL 2.4); loreal region vertical, rounded canthus rostralis; interorbital space flat, subequal (IUE 1.6) to upper eyelid (UEW 1.5) and shorter than internarial distance (IN 1.8); distance between back of eye (IBE 4.9) 1.5 times the distance between front of eye (IFE 3.2); nostril oval, nearly as close to eye (EN 1.5) as to tip of snout (NS 1.4); tympanum (TYD 0.6) 50% of eye diameter (EL 1.2); tongue moderately large, emarginate, without median lingual papillae; supratympanic

fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 3.8) shorter than hand length (HAL 4.9); finger discs moderately wide compared to finger width (fd1 0.5, fw1 0.3; fd2 0.6, fw2 0.3; fd3 0.7, fw3 0.3; fd4 0.6, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present. Thigh length (TL 10.3) longer than shank (SHL 9.8), and foot (FOL 8.7); toe discs wide compared to toe width (td1 0.6, tw1 0.3; td2 0.7, tw2 0.3; td3 0.8, tw3 0.3; td4 0.8, tw4 0.3; td5 0.7, tw5 0.3); webbing present: I1–2⁻II1–2III1⁺–2$^{1}/_{2}$IV2$^{1}/_{2}$–1$^{1}/_{5}$V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles absent.

Skin of snout, between eyes, upper eyelids and posterior part of back shagreened to sparsely granular; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, weakly developed; flanks sparsely granular; dorsal parts of forelimb shagreened; thigh, tibia and tarsus shagreened to sparsely granular; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened.

Colour in preservation. Dorsum light brown with irregular grey spots, a brown band connecting the eyes; flanks dark brown; tympanic area brownish-black; forelimbs, dorsal surfaces of thigh, tibia and feet greyish-brown with dark brown cross-bands; throat, chest and belly light grey with minute black spots; tibia and feet greyish-brown, margins light blackish-brown; webbing blackish-grey. **Colour in life.** Dorsum uniform reddish-brown; tympanum and surrounding areas blackish-brown; iris light brown

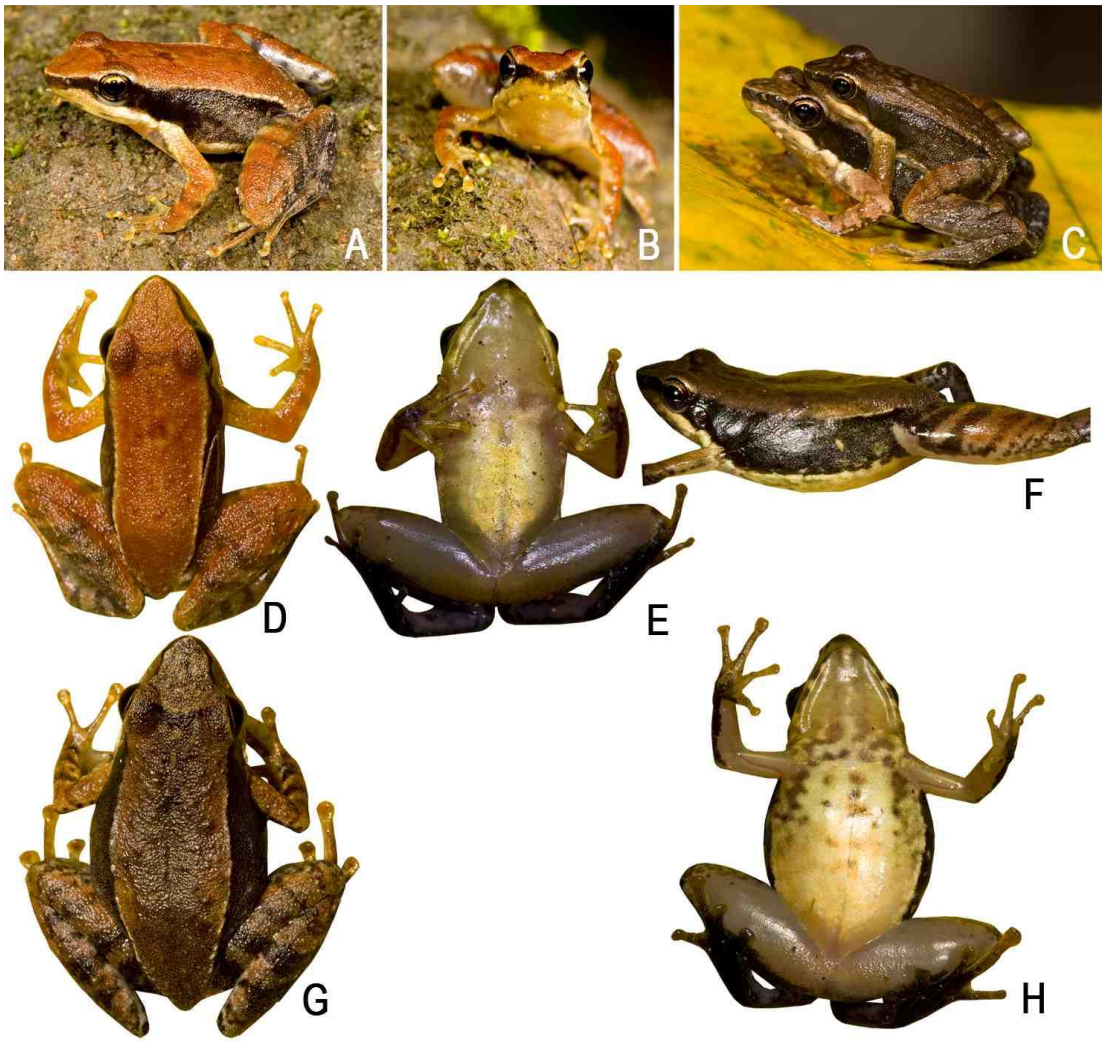

Figure 16. *Micrixalus sairandhri* sp. nov. in life: **A.** dorsolateral view, **B.** front view (HT, BNHS 5633, m); **C.** amplected pair (PT, BNHS 5638, m; PT, BNHS 5639, f); **D.** dorsal view, **E.** ventral view, **F.** lateral view of thigh and groin (HT, BNHS 5633, m); **G.** dorsal view, **H.** ventral view (PT, BNHS 5639, f). Photos: SDB.

with reddish tinge; anterior parts of flank brownish-black, posterior parts of flank light blackish-brown; groin light blackish-brown; dorsal surfaces of limbs reddish-brown with light brown cross-bands; throat and margins of throat, chest and belly dark grey; thighs blackish-brown; foot blackish-grey.

Variations. See Table 5 for morphometric characters of six males and a female. For colour variations see Figure 16.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5639): ova creamy white with minute black spots (diameter 0.9–1.2 mm, *N* = 20).

Etymology. The species is named after Sairandhri, where the type series was collected. The specific name is a noun in apposition to the generic name and therefore invariable.

Distribution. *Micrixalus sairandhri* is known only from its type locality Sairandhri, Silent Valley (Palakkad dist., Kerala state), which lies north of Palghat gap in the Western Ghats (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is damp leaf liiter or rock surfaces close to forest streams. BNHS 5638–BNHS 5639, were observed in amplexus on the surface of a wet rock close to fast flowing water. Specimens were collected between 09:00–12:00 h.

Micrixalus spelunca sp. nov.

Cave Dancing Frog

(Figs 3, 11G, 17; Tables 1–5)

Holotype. BNHS 5640, an adult male, Coonoor, Nilgiris dist., Tamil Nadu state, India, collected by SDB, SG and RS, 21 August 2012.

Paratypes. ***Tamil Nadu*****:** *Nilgiris dist.*, Coonoor, BNHS 5641–BNHS 5643, three adult males, BNHS 5644, an adult female, collected along with holotype, BNHS 5645–BNHS 5646, two adult males, collected by SDB and SG, 9 June 2012.

Other material studied. ***Tamil Nadu*****:** *Nilgiris dist.*, Coonoor, SDBDU 2005.4731, collected by SDB, 12 October 2005.

Comparison. *Micrixalus spelunca* could be confused with *M. candidus*, *M. elegans*, *M. kurichiyari*, *M. niluvasei*, *M. sairandhri* and *M. uttaraghati*. However, *M. spelunca* differs from *M. uttaraghati* by its snout subovoid in dorsal view (vs. rounded), fourth toe webbing not extending beyond the first subarticular tubercle on either side (vs. up to the disc on either side), dermal fringe along toe V smooth in males (vs. dermal fringe along toe V well developed from tip of toe to heel, with glandular projections ending with sharp spinules), dorsum shagreened (vs. prominently spinular).

For differences with *Micrixalus candidus, M. elegans, M. kurichiyari, M. niluvasei* and *M. sairandhri* see 'Comparison' of those species.

Description of holotype *(measurements in mm)*. Adult male (SVL 17.2), head small (HW 5.9, HL 5.9), as long as wide, flat above; snout subovoid in dorsal view, acute in lateral view, its length (SL 2.6) longer than horizontal diameter of eye (EL 2.1); loreal region vertical, rounded canthus rostralis; interorbital space flat, wider (IUE 2.3) than upper eyelid (UEW 1.3) and shorter than internarial distance (IN 2.1); distance between back of eye (IBE 5.1) 1.4 times the distance between front of eye (IFE 3.6); nostril oval, closer to tip of snout (NS 1.1) than eye (EN 1.4); tympanum obscure externally; tongue moderately large, emarginate, without median lingual papillae; supratympanic fold absent. Forelimbs (FAL 3.5) shorter than hand length (HAL 4.5); finger discs moderately wide compared to finger width (fd1 0.4, fw1 0.2; fd2 0.5, fw2 0.2; fd3 0.6, fw3 0.2; fd4 0.6, fw4 0.2); subarticular tubercles weakly developed, oval, single, all present. Thigh longer (TL 9.5) than shank (SHL 8.5), and foot (FOL 8.5); toe discs wide compared to toe width (td1 0.5, tw1 0.3; td2 0.6, tw2 0.2; td3 0.7, tw3 0.2; td4 0.7, tw4 0.2; td5 0.5, tw5 0.2); webbing present: I1–2^{-}II1–2III1–2$^{1}/_{5}$IV2$^{4}/_{5}$–1$^{1}/_{5}$V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles absent.

Skin of snout, between eyes, upper eyelids and posterior part of back shagreened; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, weakly developed; flanks shagreened; dorsal parts of forelimb, thigh, tibia and tarsus shagreened; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened.

Colour in preservation. Dorsum dark grey with irregular light grey spots; flanks dark brown with light grey reticulations; tympanic area brownish-black; forelimbs, dorsal surfaces of thigh, tibia and feet light grey with light brown cross-bands; webbing blackish-grey. **Colour in life.** Dorsum uniform dark brown with light brown reticulations; tympanum and surrounding areas blackish-brown; iris light brown with reddish tinge; anterior parts of flank bluish-black with light brown reticulations, posterior parts of flank light brown; groin light reddish-brown; dorsal surface of limbs greyish-brown with dark brown cross-bands; throat and margins of throat and chest light reddish-brown; belly yellowish-brown

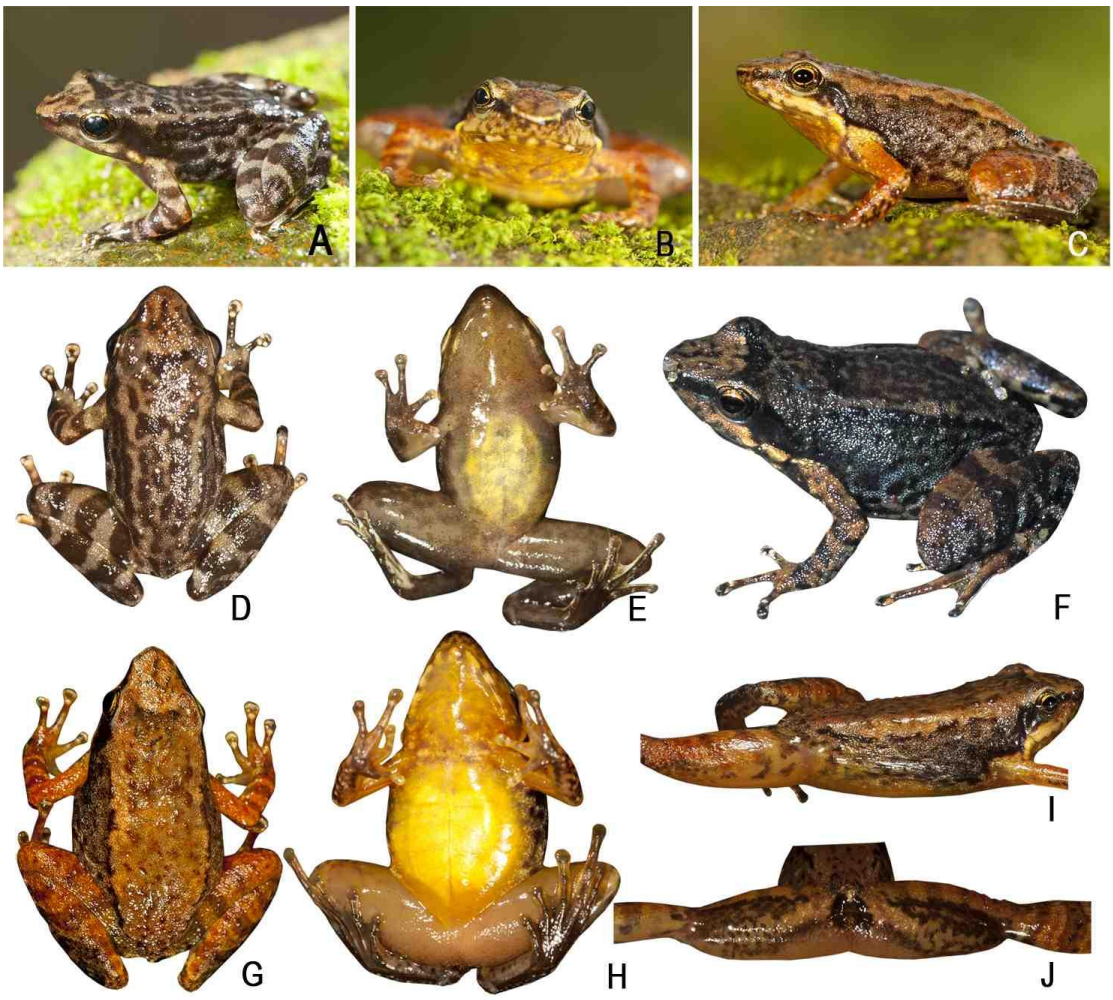

Figure 17. *Micrixalus spelunca* sp. nov. in life: **A.** dorsolateral view (HT, BNHS 5640, m); **B.** front view, **C.** dorsolateral view (PT, BNHS 5644, f); **D.** dorsal view, **E.** ventral view (HT, BNHS 5640, m); **F.** dorsolateral view (not preserved); **G.** dorsal view, **H.** ventral view, **I.** lateral view of thigh and groin, **J.** posterior side of thigh (PT, BNHS 5644, f). Photos: SDB.

with scattered light grey spots; thigh light grey; foot blackish-grey.

Variations. See Table 5 for morphometric characters of six adult males and an adult female. For colour variations see Figure 17.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5644): ova creamy white with minute black spots (diameter 0.9–1.2 mm, *N* = 10).

Etymology. The species epithet is a noun in apposition, therefore invariable, derived from the Latin word *'spelunca'* meaning cave, referring to the damp cave habitat where the type series was collected.

Distribution. *Micrixalus spelunca* is known only from its type locality Coonoor (Nilgiris dist., Tamil Nadu state), which lies north of Palghat gap in the Western Ghats (Fig. 3, Table 1).

Habitat and natural history. The present study found this species is inside a damp cave with a shallow stream of water flowing underneath. The collection site was located in a secondary forest. Male specimens were found actively calling and collections were made between 12:00–16:00 h.

***Micrixalus uttaraghati* sp. nov.**
Northern Dancing Frog
(Figs 3, 11H, 18; Tables 1–5)

Holotype. BNHS 5647, an adult male, Amboli, Sindhudurg dist., Maharashtra state, India, collected by SDB and SG, 21 October 2012.

Paratypes. *Maharashtra*: *Sindhudurg dist.*, Amboli, BNHS 5648– BNHS 5653, six adult males, and BNHS 5654, an adult female, collected along with holotype.

Other material studied. ***Maharashtra*****:** *Sindhudurg dist.*, Amboli, SDBDU 2007.6084, collected SDB, 21 March 2007.

Comparison. *Micrixalus uttaraghati* could not be confused with other members of the *Micrixalus elegans* group due to its toe webbing extending up to the disc on all digits, prominently spinular dorsum and dermal fringe along toe V well developed from tip of toe to heel, with glandular projections ending with sharp spinules in males.

For more specific differences with *Micrixalus candidus*, *M. elegans*, *M. kurichiyari*, *M. niluvasei*, *M. sairandhri* and *M. spelunca* see 'Comparison' of those species.

Description of holotype *(measurements in mm).* Adult male (SVL 17.4); head small (HW 5.8, HL 6.2), longer than wide, flat above; snout rounded in dorsal view, acute in lateral view, its length (SL 2.6) longer than horizontal diameter of eye (EL 1.8); loreal region vertical, rounded canthus rostralis; interorbital space flat, wider (IUE 2.1) than upper eyelid (UEW 1.2) and shorter than internarial distance (IN 1.9); distance between back of eye (IBE 5.0) 1.4 times the distance between front of eye (IFE 3.4); nostril oval, closer to eye (EN 1.1) than tip of snout (NS 1.5); tympanum (TYD 0.8) 44% of eye diameter (EL 1.8); tongue moderately large, emarginate, without median lingual papillae; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 2.7) shorter than hand length (HAL 4.7); finger discs moderately wide compared to finger width (fd1 0.5, fw1 0.3; fd2 0.6, fw2 0.2; fd3 0.8, fw3 0.2; fd4 0.8, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present. Thigh longer (TL 10.2) than shank (SHL 9.7), and foot (FOL 8.0); toe discs wide compared to toe width (td1 0.6, tw1 0.3; td2 0.6, tw2 0.3; td3 0.7, tw30.3; td4 0.8, tw4 0.3; td5 0.6, tw5 0.3); webbing present: I1–1II1–1III1–1IV1–1V; subarticular

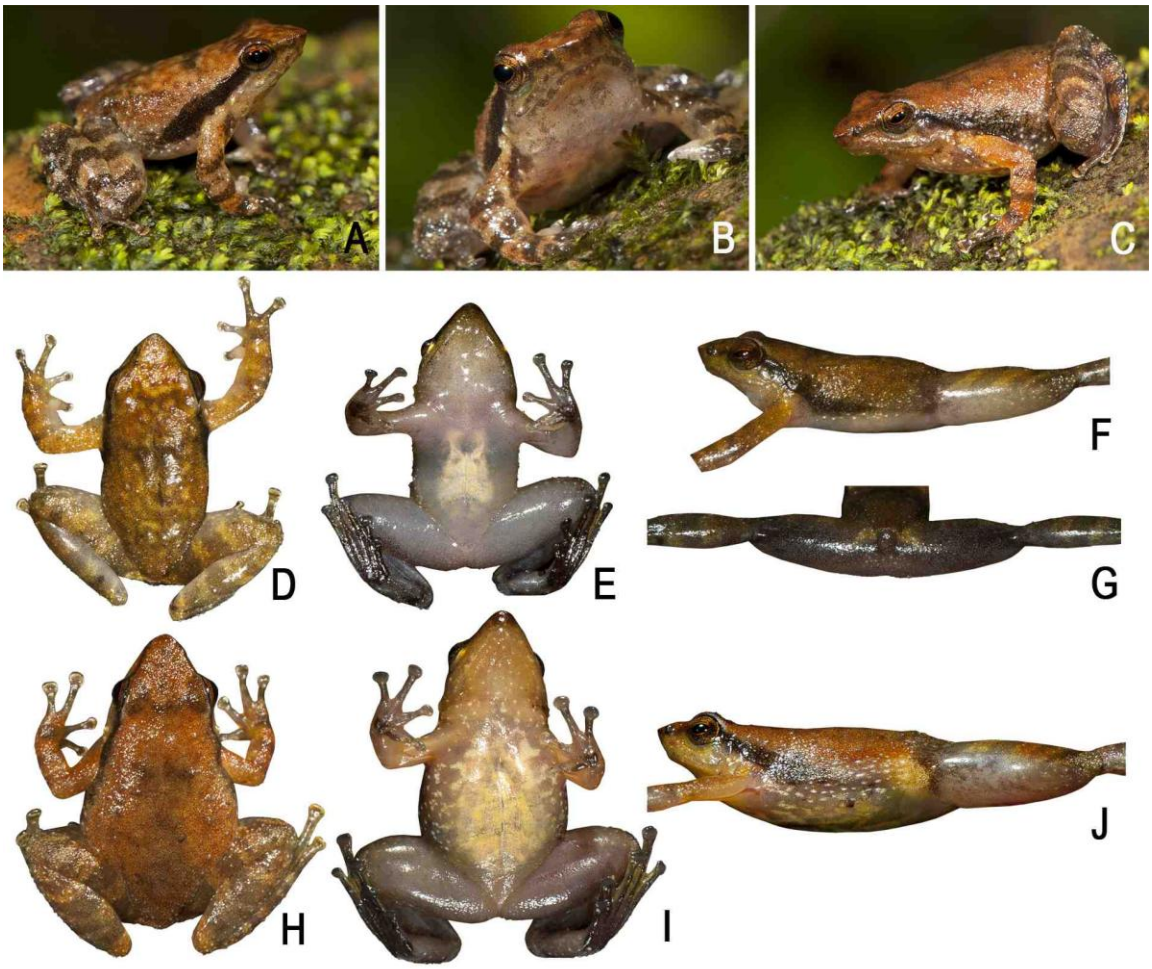

Figure 18. *Micrixalus uttaraghati* sp. nov. in life: **A.** dorsolateral view, **B.** frontal view (HT, BNHS 5647, m); **C.** dorsolateral view (PT, BNHS 5654, f); **D.** dorsal view, **E.** ventral view, **F.** lateral view of thigh and groin, **G.** posterior side of thighs (HT, BNHS 5647, m); **H.** dorsal view, **I.** ventral view, **J.** lateral view of thigh and groin (PT, BNHS 5654, f). Photos: SDB.

tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles absent.

Skin of snout, between eyes, upper eyelids and posterior part of back shagreened with prominent spinular projections; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, weakly developed; flanks prominently spinular; dorsal parts of forelimb shagreened and sparsely spinular; thigh, tibia and tarsus shagreened with scattered granular projections; dermal fringe along toe V well developed from tip of toe to heel, with glandular projections ending with sharp spinules in males; ventral surfaces of throat, chest and abdomen smooth, posterior parts of thigh shagreened.

Colour in preservation. Dorsum dark grey with irregular light grey patches; anterior parts of flank light brown; tympanic area brownish-black; forelimbs, dorsal surfaces of thigh and tibia light grey with dark grey cross-bands; feet grey with dark brown cross-bands; posterior parts of thigh light grey with dark grey reticulations; throat, chest and belly light grey with minute black spots; ventral surfaces of tibia and feet light grey with black spots; webbing light brownish-grey. **Colour in life.** Dorsum uniform brownish-grey with grey patches; tympanum and surrounding areas dark brown; iris light brown with reddish tinge; presence of a dark brownish-black streak that extends from the posterior corner of eye up to near the groin on either side; anterior parts of flank brown, posterior parts of flank light brown; groin light grey; dorsal surface of limbs light brown with blackish-brown cross-bands; throat, chest and belly dark grey; thighs light grey; foot blackish-grey.

Variations. See Table 5 for morphometric characters of seven adult males and an adult female. For colour variations see Figure 18.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5654): ova creamy white with minute black spots (diameter 0.7–0.9 mm, *N* = 10).

Etymology. The species epithet is derived from two Sanskrit words—*'uttara'* meaning north and '*ghat*' meaning mountains—referring to this species forming the extreme limit of *Micrixalus* distribution in the Western Ghats. The species name *uttaraghati* is a noun in the genitive case.

Distribution. *Micrixalus uttaraghati* is known only from its type locality Amboli (Sindhudurg dist., Maharashtra state), which lies north of Goa gap in the Western Ghats (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is flowing streams covered with forest canopy. The majority of male specimens were found actively calling and 'foot-flagging'. A few calling males were observed inside rock crevices in splashy zones of the stream. Collections were made between 10:00–14:00 h.

Micrixalus fuscus group

Members. *Micrixalus adonis* sp. nov., *Micrixalus fuscus, Micrixalus herrei, Micrixalus kodayari* sp. nov., *Micrixalus mallani* sp. nov. and *Micrixalus nelliyampathi* sp. nov.

This group can be distinguished from other *Micrixalus* groups by the combination of following morphological characters: small adult size (male, SVL 16–29 mm; female, SVL 24–33 mm), body slender; dorsolateral folds present; two to four circular glands that start just behind the tympanum and extend towards the posterior axis of mandibles; dorsum with inverted V-shaped glandular ridge on the anterior half; lateral sides of head (snout and tympanic area) lighter in colour than upper parts of flank; distribution restricted to regions south of Palghat gap in the Western Ghats (Fig. 19).

Micrixalus adonis sp. nov.

Beautiful Dancing Frog

(Figs 3, 19A, 20; Tables 1–5)

Holotype. BNHS 5655, an adult male, Sevenmallay, Munnar, Idukki dist., Kerala state, India, collected by SDB and Systematics lab team, 20 September 2011.

Paratypes. ***Kerala*****:** *Idukki dist.*, Sevenmallay, BNHS 5656, an adult male, collected by SDB, 15 March 2002; Kadalar estate, Munnar, BNHS 5657–BNHS 5661, five adult males, and BNHS 5662–BNHS 5665, four adult females, collected by SDB and Systematics lab team, 23 September 2011; Letchmi estate, Munnar, BNHS 5666, an adult male, and BNHS 5667, an adult female, collected by SDB and Systematics lab team, 20 September 2011; Thekkady, BNHS 5668, an adult female, collected by SDB, 8 June 2006.

Comparison. *Micrixalus adonis* could be confused with *M. fuscus, M. herrei, M. kodayari, M. mallani* and *M. nelliyampathi*. However, *M. adonis* differs from *M. fuscus, M. kodayari, M. mallani* and *M. nelliyampathi* by its head rounded in lateral view (vs. acute in *M. fuscus, M. kodayari* and *M. nelliyampathi*; nearly acute in *M. mallani*); differs from *M. fuscus, M. herrei, M. kodayari* and *M. mallani* by its snout subovoid in dorsal view (vs. pointed in *M. fuscus* and *M. herrei;*

subelliptical in *M. kodayari* and *M. mallani*). More specifically differs from *M. kodayari* and *M. mallani* by its fourth toe webbing extending up to the first subarticular tubercle on the outside (vs. below the second subarticular in both species); differs from *M. herrei* and *M. nelliyampathi* by its third toe webbing at the base of first subarticular tubercle (vs. extending above the first subarticular tubercle in both species); and differs from *M. fuscus* by its fourth toe webbing extending up to the first subarticular tubercle on the outside side (vs. upto the disc). Furthermore, *M. adonis* differs from *M. herrei* by its larger snout-vent size, male, SVL 21.1–24.1 mm, *N* = 8, female, SVL 26.5–30.1 mm, *N* = 6 (vs. smaller, *M. herrei*, male, SVL 16.7–19.4 mm, *N* = 9, female, SVL 24.8–26.6 mm, *N* = 3); differs from *M. fuscus* by its smaller snout-vent size, male, SVL 21.1–24.1 mm, *N* = 8, female, SVL 26.5–30.1 mm, *N* = 6 (vs. larger, *M. fuscus*, male, SVL 27.9–28.8 mm, *N* = 3, female, SVL 30.1–33.1 mm, *N* = 8); differs from *M. herrei*, *M. kodayari* and *M. mallani* by its shank longer than thigh length, male, SHL 12.4 ± 0.4 mm, TL 11.4 ± 0.5 mm, *N* = 8, female, SHL 15.1 ± 0.5 mm, TL 13.2 ± 0.3 mm, *N* = 6 (vs. subequal in *M. herrei*, male, SHL 10.1 ± 0.4 mm, TL 10.0 ± 0.4 mm, *N* = 9, female, SHL 13.5 ± 0.6 mm, TL 13.4 ± 0.6 mm, *N* = 3; subequal in *M. kodayari*, male, SHL 10.3 ± 0.9 mm, TL 10.2 ± 1.0 mm, *N* = 2, female, SHL 13.0 ± 0.2 mm, TL 13.0 ± 0.1 mm, *N* = 3; equal in *M. mallani*, male, SHL 10.5 ± 0.3 mm, TL 10.5 ± 0.2 mm, *N* = 4, female, SHL 13.7 ± 0.5 mm, TL 13.7 ± 0.6 mm, *N* = 4); differs from *M. nelliyampathi* by its thigh longer than foot length, male, TL 11.4 ± 0.5 mm, FOL 10.3 ± 0.3 mm, *N* = 8; female, TL 13.2 ± 0.3 mm, FOL 11.7 ± 0.4 mm, *N* = 6 (vs. subequal, *M. nelliyampathi*, male, TL 10.7 ± 0.9 mm, FOL 10.6 ± 0.9 mm, *N* = 7, female, TL 12.7 ± 0.6 mm, FOL 12.7 ± 0.5 mm, *N* = 5).

Description of holotype *(measurements in mm)*. Adult male (SVL 22.6); head small (HW 6.7, HL 8.0), longer than wide, flat above; snout subovoid in dorsal view, rounded in lateral view, its length (SL 3.8) longer than horizontal diameter of eye (EL 2.8); loreal region vertical and concave with rounded canthus rostralis; interorbital space flat, wider (IUE 2.3) than upper eyelid (UEW 1.8), and equal to internarial distance (IN 2.3); distance between back of eye (IBE 6.1) 1.6 times the distance between front of eye (IFE 3.7); nostril oval, closer to eye (EN 1.4) than tip of snout (NS 1.7); tympanum (TYD 1.0) 36% of eye diameter (EL 2.8); tongue moderately large, emarginate, without lingual papilla; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 4.7) shorter than hand length (HAL 5.8);

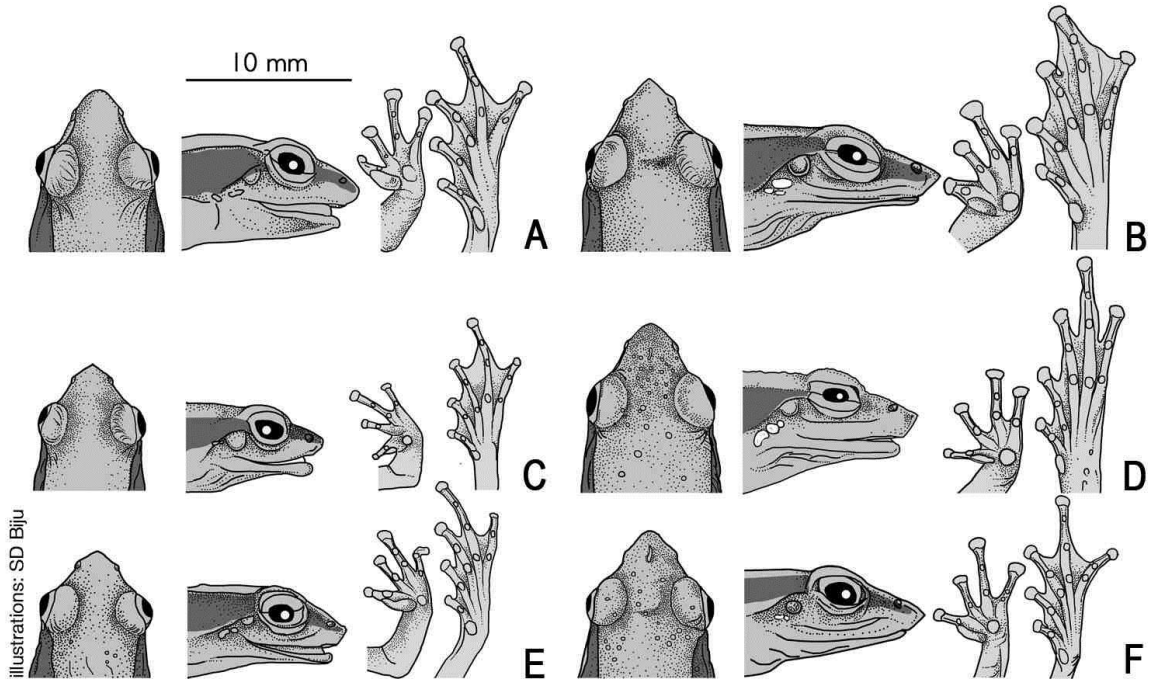

Figure 19. From left to right, dorsal view of head, lateral view of head, ventral view of hand and ventral view of foot of *Micrixalus fuscus* group: **A.** *Micrixalus adonis* sp. nov. (HT, BNHS 5655, m); **B.** *M. fuscus* (LT, NHM 74.4.29.258, f); **C.** *M. herrei* (TT, BNHS 5677, m); **D.** *Micrixalus kodayari* sp. nov. (HT, BNHS 5689, f); **E.** *Micrixalus mallani* sp. nov. (HT, BNHS 5694, m); **F.** *Micrixalus nelliyampathi* sp. nov. (HT, BNHS 5702, m).

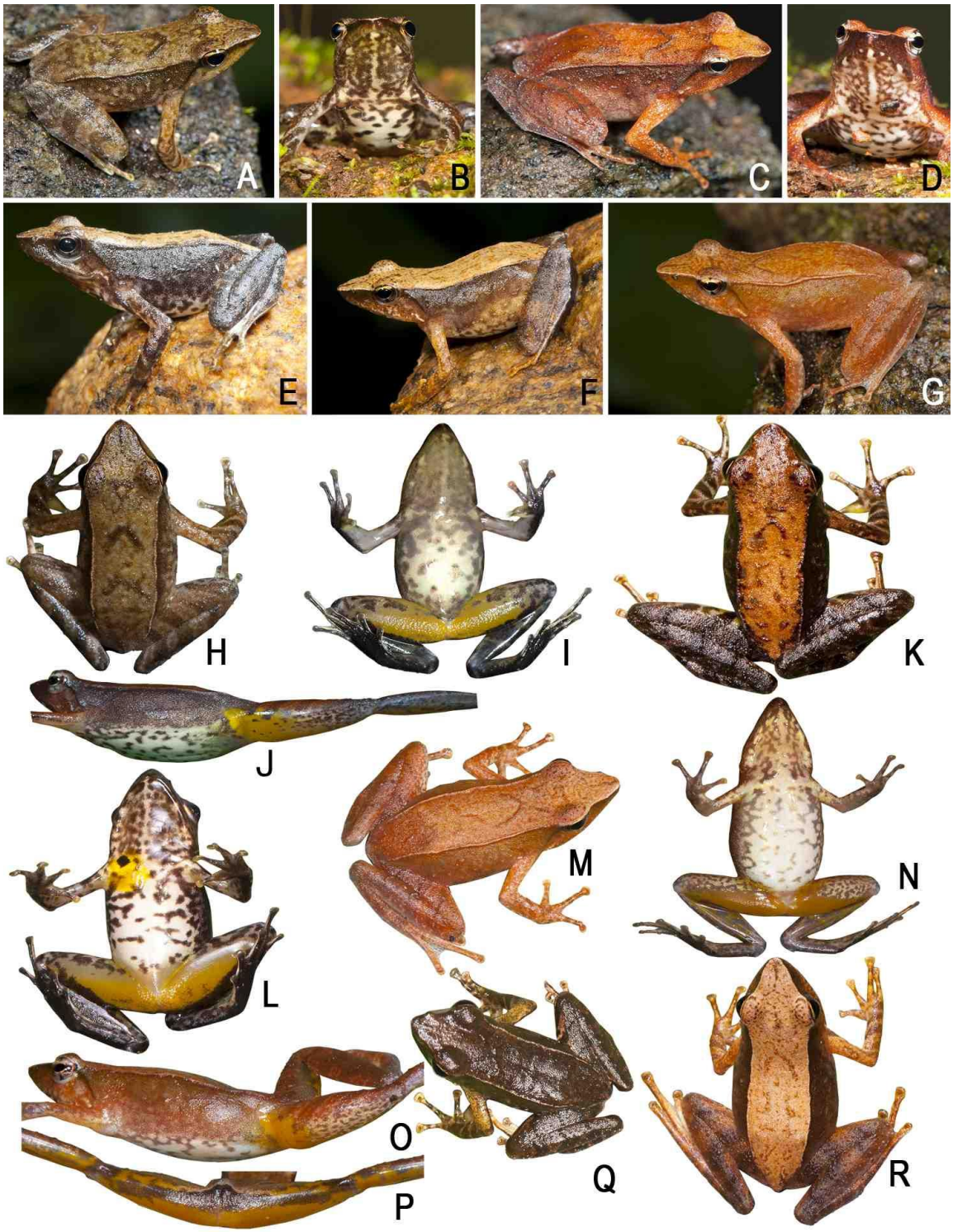

Figure 20. *Micrixalus adonis* sp. nov. in life: **A.** dorsolateral view, **B.** front view (HT, BNHS 5655, m); **C.** dorsolateral view, **D.** front view (PT, BNHS 5667, f); **E.** dorsolateral view (PT, SDB BNHS 5657, m); **F.** dorsolateral view (PT, BNHS 5662, f); **G.** dorsolateral view (PT, BNHS 5663, f); **H.** dorsal view, **I.** ventral view, **J.** lateral view of thigh and groin (HT, BNHS 5655, m); **K.** dorsal view, **L.** ventral view (PT, BNHS 5657, m); **M.** dorsal view, **N.** ventral view, **O.** lateral view of thigh and groin, **P.** posterior side of thighs (PT, BNHS 5663, f); **Q.** dorsal view (PT, BNHS 5661, m); **R.** dorsal view (PT, BNHS 5662, f). Photos: SDB.

finger discs moderately wide compared to finger width (fd1 0.5, fw1 0.2; fd2 0.7, fw2 0.2; fd3 0.8, fw3 0.3; fd4 0.8, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present. Thigh length (TL 11.5) shorter than shank (SHL 12.3), and longer than foot (FOL 10.2); toe discs wide compared to toe width (td1 0.6, tw1 0.2; td2 0.8, tw2 0.3; td3 0.9, tw3 0.2; td4 0.9, tw4 0.3; td5 0.7, tw5 0.2); webbing present: I1–1½II1–2III1–2IV2–1V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes and upper eyelids shagreened to finely glandular; posterior part of back shagreened to sparsely granular; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, well developed; dorsal parts of forelimb shagreened; thigh, tibia and tarsus with weakly developed glandular projections; ventral surface of throat, chest and abdomen smooth; posterior parts of thigh shagreened to sparsely granular.

Colour in preservation. Dorsum greyish-brown; lower flanks dark grey with black speckles; dorsolateral folds light grey; forelimbs, dorsal surfaces of thigh, tibia and feet light greyish-brown with dark brown cross-bands, ventral surfaces of thigh light grey with scattered dark grey spots, tibia and feet brownish-black, posterior parts of thigh light grey with dark greyish-brown reticulations; webbing blackish-grey; throat, chest and belly greyish-white with black reticulations. **Colour in life.** Dorsum uniform greyish-brown with black specks; tympanum and surrounding areas light brown; iris light brown with reddish tinge; flanks light yellowish-grey with light grey reticulations; groin yellow with light spots; dorsal surface of limbs greyish-brown with light brown cross-bands; throat and margins of throat, chest and belly greyish-white with prominent brownish reticulations.

Variations. See Table 5 for morphometric characters of eight adult males and six adult females. For colour variations see Figure 20.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5662): ova creamy white with minute black spots (diameter 1.0–1.5 mm, *N* = 20).

Etymology. The species name *adonis* refers to the mythic character Adonis, a demigod of beauty and desire in Greek mythology. The name reflects the vividly rich and contrasting colouration observed on this species. The specific name is an invariable noun in the nominative singular standing in apposition to the generic name.

Distribution. *Micrixalus adonis* is known only from the Western Ghats state of Kerala, with its distribution restricted between the Palghat gap and Shencottah gap. The present study found this species in Sevenmallay; Letchmi estate, Munnar; Kadalar estate, Munnar; and Thekkady in Idukki district (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species was streams covered with forest canopy at Sevenmallay, Letchmi estate and Thekkady. Collections from Kadalar estate were predominately from streams near cardamom plantations. BNHS 5657 and BNHS 5660 were collected from leaf litter close to forest streams, while all other collections were from boulders emerging from streams. *Micrixalus adonis* was found to be relatively abundant at all the collection localities. The majority of male specimens were found actively calling and collected between 08:00–18:00 h.

***Micrixalus fuscus* (Boulenger, 1882)**

Kalakkad Dancing Frog

(Figs 3, 19B, 21A–B, 22; Tables 1–5)

Original name and description. *Ixalus fuscus* Boulenger, 1882. *Catalogue of the Batrachia Salientia s. Ecaudata in the Collection of the British Museum,* ed. 2: 96. **Lectotype.** NHM 74.4.29.258, an adult female, SVL 32.1 mm, by present designation. **Type locality.** "Travancore". **Current status of specific name.** Valid name, as *Micrixalus fuscus* (Boulenger, 1882).

Referred specimens. *Tamil Nadu*: *Tirunelveli dist.*, Kakkachi, BNHS 5669–BNHS 5670, SDBDU 2006.2296, three adult males, collected by SDB, 28 May 2006, and BNHS 5671–BNHS 5672, two adult females, collected by SDB, 31 August 2002; Sengaltheri, BNHS 5673–BNHS 5674, two adult females, collected by SDB, 15 August 2003; ***Kerala*:** *Thiruvananthapuram dist.*, Athirimala, BNHS 5675, an adult female, collected by SDB, 8 Augsut 2002; Pandipath, BNHS 5676, an adult female, collected by SDB and Systematics lab team, 21 September 2012; Paralectotype, "Travancore", NHM 74.4.29.259, an adult female, collected by Beddome.

Other material studied. *Tamil Nadu*: *Tirunelveli dist.*, Kakkachi, SDBDU 2002.2047, collected by SDB, 31 August 2002, Kakkachi, SDBDU 2006.2299, collected by SDB, 28 May 2006; Sengaltheri, SDBDU 2002.874, collected by SDB, 12 January 2002.

Comments. Boulenger (1882) described this species based on several specimens from six localities: "Travancore", NHM 74.4.29.258–265,

eight specimens (five females and three males); "Torocata", NHM 74.4.29.1401–4, four specimens (three females and a male); "Anamallays", NHM 14.4.29.1506–8, three male specimens; "Sevagherry", NHM 74.4.29.1459–68, eight specimens (three females and five males); "Malabar", NHM 74.4.29.927–930, four specimens according to the NHM catalogue but a total of six specimens (three females and three male) found in the jar; and "N. Canara", NHM 72.4.17.256, three male specimens. We examined all the available syntypes at NHM (without individual specimen numbers) and found them to be heterogeneous in identity, composing of at least four different *Micrixalus* species. Since collection localities of these historical specimens are mentioned as broad colonial regions (Biju, 2001), it was difficult for us to provide accurate identification of specimens in the syntype series. However, we find NHM 74.4.29.258–265 (from "Travancore") and NHM 74.4.29.1459–64 (from "Sevagherry") to be comparable with the original description and accompanying illustration. More specifically, specimens from "Travancore" agree with the original description in their snout-vent size ("from snout to vent 32 millim"), snout shape ("snout pointed") and toe webbing ("toes entirely webbed"). Therefore, in order to avoid any possible doubt or confusion, we hereby designate NHM 74.4.29.258 (from "Travancore", SVL 32.1 mm) as lectotype of *Micrixalus fuscus* (Figs 21A–B).

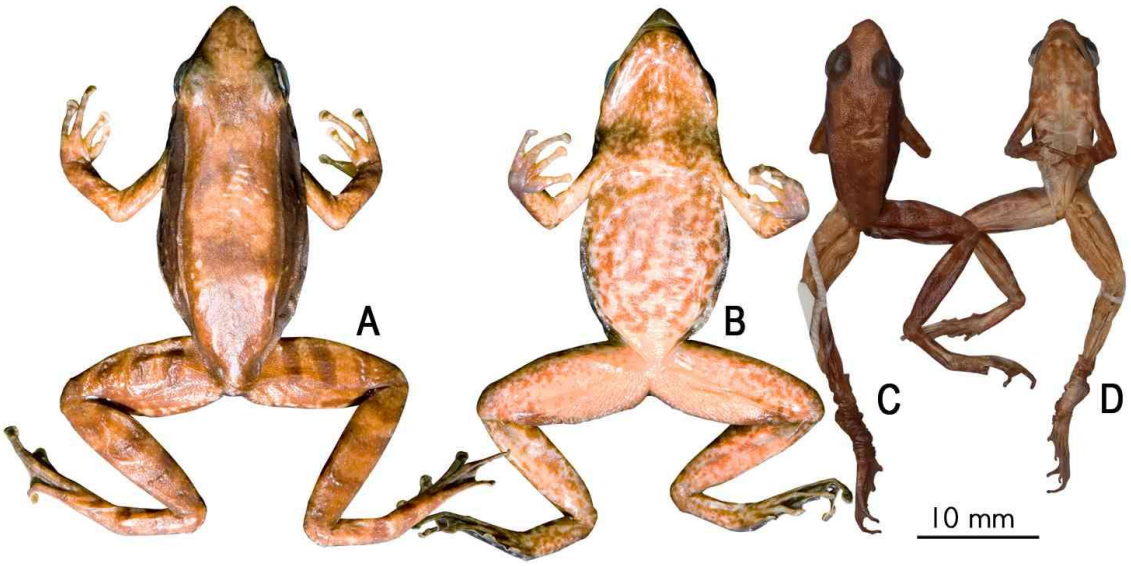

Figure 21. A–B. Lectotype of *Ixalus fuscus* Boulenger, 1882 (NHM 74.4.29.258, f), from "Travancore": **A.** dorsal view, **B.** ventral view; **C–D.** Holotype of *Micrixalus herrei* Myers, 1942 (CAS-SU 7265, m), from "Kallar": **C.** dorsal view, **D.** ventral view.

Comparison. *Micrixalus fuscus* could not be confused with any of the allied taxa within *Micrixalus fuscus* group due its larger snout-vent adult size, male, SVL 27.9–28.8 mm, *N* = 3, female, SVL 30.0–33.1 mm, *N* = 8 (vs. smaller in *M. adonis*: male, SVL 21.1–24.1 mm, *N* = 8, female, SVL 26.5–30.1 mm, *N* = 6; *M. herrei*: male, SVL 16.7–19.4 mm, *N* = 9, female, SVL 24.8–26.6 mm, *N* = 3; *M. kodayari*: male, SVL 17.7–18.7 mm, *N* = 2, female, SVL 24.6–25.6 mm, *N* = 3; *M. mallani*: male, SVL 19.5–22.4 mm, *N* = 4, female, SVL 25.1–27.7 mm, *N* = 4; and *M. nelliyampathi*: male, SVL 21.3–23.7 mm, *N* = 7, female, SVL 25.6–29.5 mm, *N* = 5), presence of median lingual papillae on tongue (vs. absent in all other species) and webbing between toes extending up to the tip of the disc on all toes (vs. well below the disc on either side of toe IV in all other species). More specifically, differs from *M. adonis*, *M. herrei*, and *M. mallani* by its head acute in lateral view (vs. rounded in all three species); differs from *M. kodayari* and *M. nelliyampathi* by its head pointed in dorsal view (vs. subelliptical in *M. kodayari*; subovoid in *M. nelliyampathi*).

Description of lectotype *(measurements in mm)*. Adult female (SVL 32.1); head small (HW 8.3, HL 10.5) longer than wide, flat above; snout pointed in dorsal view, acute in lateral view, its length (SL 5.1) longer than horizontal diameter of eye (EL 3.5); loreal region vertical with sharp canthus rostralis; interorbital space flat, wider (IUE 2.7) than upper eyelid (UEW 2.5), and narrower than internarial distance (IN 3.8); distance between back of eye (IBE 10.1) 1.3 times the distance between front of eye (IFE 7.9); nostril oval, nearly as close to eye (EN 2.1) as to tip of

snout (NS 2.2); tympanum (TYD 1.2) 34% of eye diameter (EL 3.5); tongue moderately large, emarginate, with median lingual papillae; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 5.2) shorter than hand length (HAL 7.9); finger discs moderately wide compared to finger width (fd1 1.0, fw1 0.4; fd2 1.2, fw2 0.4; fd3 1.5, fw3 0.4; fd4 1.3, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present. Thigh length (TL 14.9) shorter than shank (SHL 16.0), and longer than foot (FOL

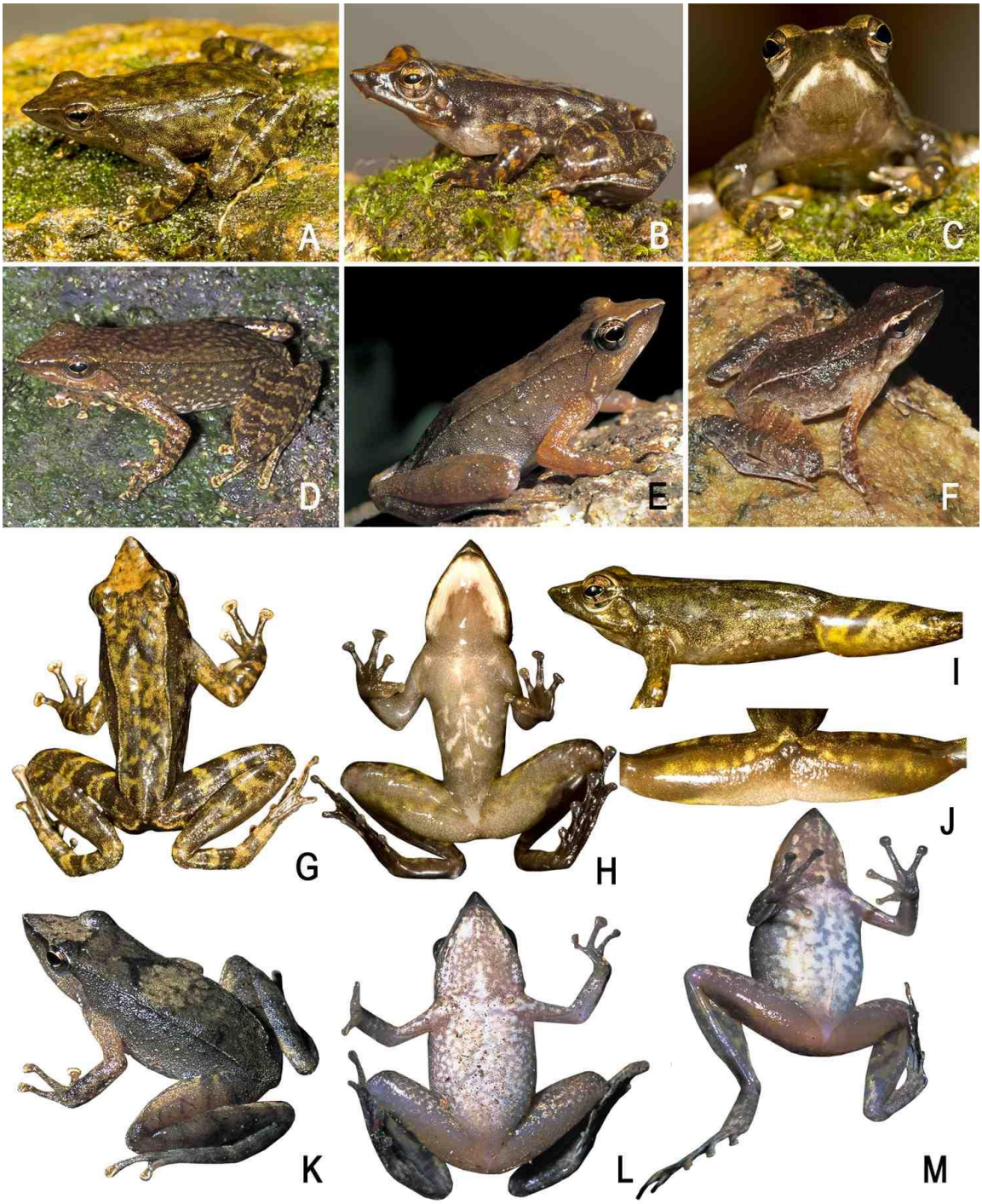

Figure 22. *Micrixalus fuscus* in life: **A.** dorsolateral view, **B.** lateral view, **C.** front view (RS, BNHS 5669, m); **D.** dorsolateral view (RS, BNHS 5671, f); **E.** dorsolateral view (RS, BNHS 5674, f); **F.** dorsolateral view (RS, BNHS 5676, f); **G.** dorsal view, **H.** ventral view, **I.** lateral view of thigh and groin, **J.** posterior side of thighs (RS, BNHS 5669, m); **K.** dorsolateral view, **L.** ventral view (RS, BNHS 5674, f); **M.** ventral view (RS, BNHS 5671, f). Photos: SDB.

13.6); toe discs wide compared to toe width (td1 0.9, tw1 0.3; td2 1.4, tw2 0.3; td3 1.4, tw3 0.3; td4 1.6, tw4 0.4; td5 1.2, tw5 0.4); webbing complete: I0–0II0–0III0–0IV0–0V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes and upper eyelids shagreened to sparsely granular; posterior part of back shagreened; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides; a faintly developed inverted V-shaped glandular projection on the middle of dorsum; dorsal parts of forelimb shagreened; thigh, tibia and tarsus shagreened with weakly developed granular projections; shanks shagreened with prominent glandular projections; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened to sparsely granular.

Colour in preservation. Dorsum light reddish-brown with faint light grey reticulations; lower flanks dark grey; tympanic area light grey; dorsolateral folds light greyish-brown; forelimbs, dorsal surfaces of thigh, tibia and feet light greyish-brown with faint brown cross-bands, posterior parts of thigh light grey with dark greyish-brown reticulations; throat, chest and belly, ventral parts of thigh and tibia greyish-white with black reticulations; webbing blackish-grey. **Colour in life** (BNHS 5674, female). Dorsum uniform dark grey with black specks; tympanum and surrounding areas light grey; iris light brown with reddish tinge; flanks light greenish-grey; groin light grey; dorsal surface of limbs greyish-brown with light brown cross-bands; throat and margins of throat, chest and belly greyish-white with prominent light brown reticulations.

Variations. See Table 5 for morphometric characters of three adult males and eight adult females. For colour variations see Figure 22.

Secondary sexual characters. Male (BNHS 5669): Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling, white patch on lower jaw. Female (NHM 74.4.29.258): ova creamy white with minute black spots (diameter 1.2–1.6 mm, *N* = 20).

Distribution. *Micrixalus fuscus* is known only from the Western Ghats state of Kerala and Tamil Nadu, with its distribution restricted to south of Shencottah gap. The present study found this species in Kakkachi and Sengaltheri (Tirunelveli dist.) in Tamil Nadu state, and Athirimala and Pandipath (Thiruvananthapuram dist.) in Kerala state (Fig. 3, Table 1). It is possible that Beddome collected the type series from Kalakkad-Mundanthurai or Pandipath area, since many of Beddome's plant collections from "Travancore" mentioned these locality names (Biju, 2001).

Habitat and natural history. The preferred habitat of this species is fast flowing streams covered with forest canopy. *Micrixalus fuscus* was found to be relatively abundant at all the collection localities. The majority of male specimens were found actively calling and 'foot-flagging'. Collections were made between 07:00–16:00 h.

Micrixalus herrei Myers, 1942

Kallar Dancing Frog

(Figs 3, 19C, 21C–D, 23; Tables 1–5)

Original name and description. *Micrixalus herrei* Myers, 1942. A new frog of the genus *Micrixalus* from Travancore, *Proceedings of the Biological Society of Washington*, 55: 71–74. **Holotype.** CAS-SU 7265, an adult male, by original designation. **Type locality.** "Kallar, 30 miles northeast of Trivandrum, Travancore, South India", Thiruvananthapuram (= Trivandrum) dist., Kerala state. **Current status of specific name.** Valid name, as *Micrixalus herrei* Myers, 1942.

Referred specimens. *Kerala*: *Thiruvananthapuram dist.*, Kallar, BNHS 5677–BNHS 5678, two adult males, collected by SDB, 24 May 2006; Chathankod, BNHS 5679, an adult male, and BNHS 5680, an adult female, collected by SDB, 20 July 2002, BNHS 5681–BNHS 5682, two adult males, and BNHS 5683, an adult female, collected by SDB and Systematics lab team, 11 September 2011, BNHS 5684, an adult male, collected by SDB and SG, 31 May 2012; Ponmudi, BNHS 5685, an adult male, collected by SDB, 20 March 2001; *Kollam dist.*, Kovachal, BNHS 5686, an adult male, collected by SDB and Systematics lab team, 15 September 2011; ***Tamil Nadu*:** *Kanyakumari dist.*, Glenback estate, Kiriparai, BNHS 5687, an adult male, collected by SDB, 19 November 2008; *Tirunelveli dist.*, Putherichariu m, BNHS 5688, an adult female, collected by SDB, 17 November 2002.

Other material studied. *Kerala*: *Thiruvananthapuram dist.*, Attayar, SDBDU 2012.2314, collected by SDB, 1 June 2012; Chathankod, SDBDU 2006.4766, collected by SDB, 23 May 2006, SDBDU 2009.106, collected by SDB and Systematics lab team, 20 July 2009; *Kollam dist.*, Kovachal, SDBDU 2011.918, collected by SDB and Systematics lab team, 15 September 2011; ***Tamil Nadu*:** *Tirunelveli dist.*, Putherichariu m, SDBDU 2002.4054, collected by SDB, 17 November 2002.

Comments. Inger *et al.* (1985 "1984") proposed synonymy of *Micrixalus herrei* with

Micrixalus fuscus, and subsequently Dutta (1997) and Dinesh *et al.* (2009) did not consider it as a valid species. We studied both the taxa and find *M. herrei* to be morphologically dissimilar from *M. fuscus*, the most conspicuous difference being the webbing between its toes that does not extend up to the tip of the disc on either side of toe IV (vs. extends up to the tip of the disc on all toes) and head rounded in lateral view (vs. acute). For detailed comparison see *M. fuscus*. Furthermore, our study finds *M. herrei* to differ from *M. fuscus* by considerable mean genetic divergence of 5.6% for 16S and 12.6% for COI. The molecular and morphological differences allow us to remove the former from synonymy of *M. fuscus*.

Myers (1942) described *Micrixalus herrei* based on a sole specimen that is currently present in the California Academy of Sciences, Herpetological collection. However, the original publication does not provide a description of the holotype (museum number CAS-SU 7265) apart from a few basic measurements including the snout-vent size (SVL 17.5 mm). Though we could not physically study the type specimen, we studied photographs of the holotype (Figs 21C–D), and new collections from the type locality (Kallar) that correspond to the snout-vent size of the holotype. A detailed description of the topotype is provided below.

Comparison. *Micrixalus herrei* could be confused with *M. adonis, M. fuscus, M. kodayari, M. mallani* and *M. nelliyampathi*. However, *M. herrei* differs from *M. adonis, M. fuscus, M. mallani* and *M. nelliyampathi* by its smaller snout-vent size, male, SVL 16.7–19.4 mm, *N* = 9, female, SVL 24.8–26.6 mm, *N* = 3 (vs. *M. adonis:* male, SVL 21.1–24.1 mm, *N* = 8, female, SVL 26.5–30.1 mm, *N* = 6; *M. fuscus:* male, SVL 27.9–

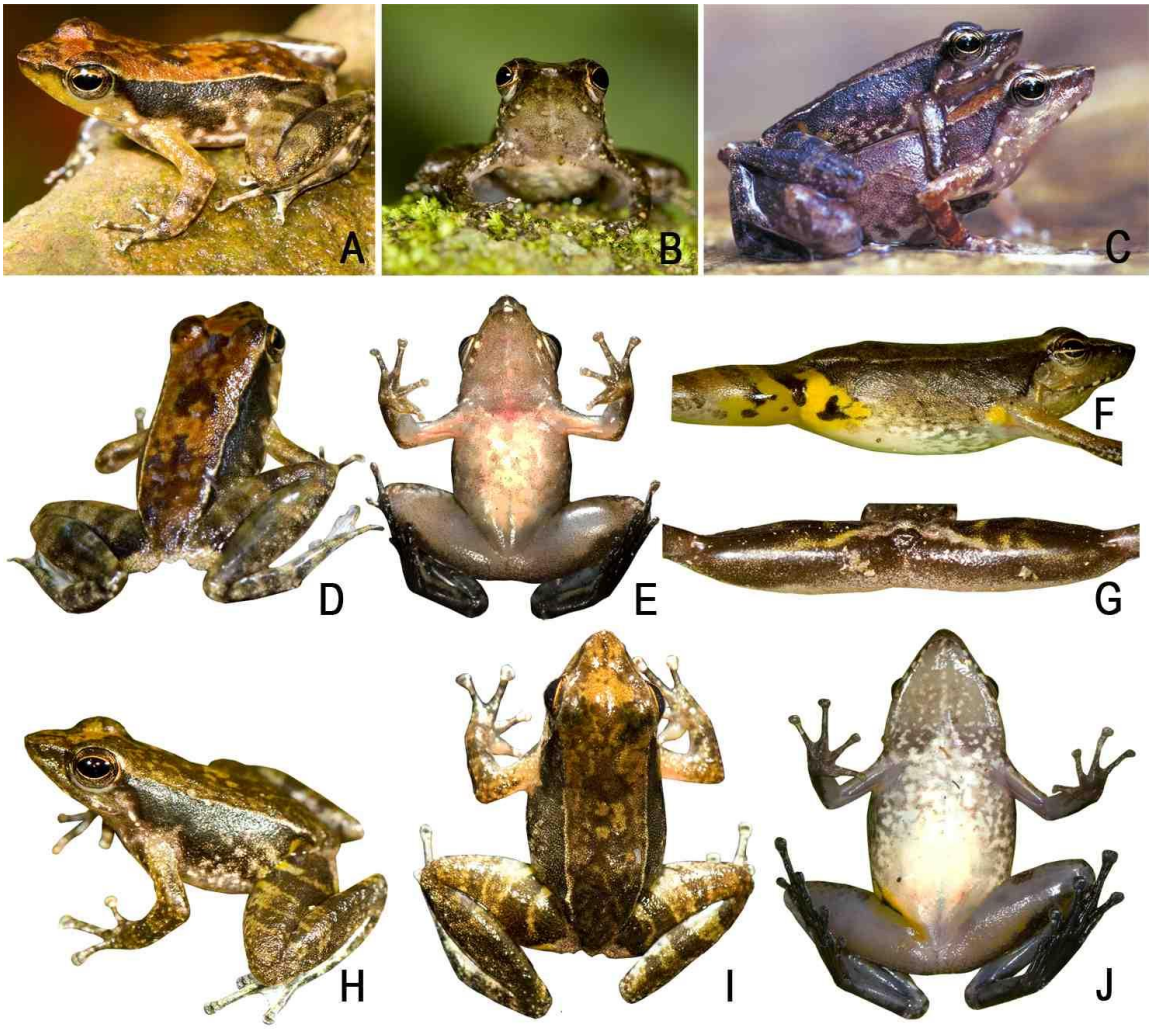

Figure 23. *Micrixalus herrei* in life: **A**. dorsolateral view, **B.** front view (TT, BNHS 5677, m); **C.** dorsolateral view, amplected pair (RS, BNHS 5679, m, and RS, BNHS 5680, f); **D.** dorsal view, **E.** ventral view, **F.** lateral view of thigh and groin, **G.** posterior side of thighs (TT, BNHS 5677, m); **H.** dorsolateral view (RS, BNHS 5687, m); **I.** dorsal view, **J.** ventral view (RS, BNHS 5681, m). Photos: SDB.

28.8 mm, *N* = 3, female, SVL 30.0–33.1 mm, *N* = 8; *M. mallani:* male, SVL 19.5–22.4 mm, *N* = 4, female, SVL 25.1–27.7 mm, *N* = 4; *M. nelliyampathi*: male, SVL 21.3–23.7 mm, *N* = 7, female, SVL 25.6–29.5 mm, *N* = 5). More specifically, *M. herrei* differs from *M. kodayari*, *M. mallani* and *M. nelliyampathi* by its snout pointed in dorsal view (vs. subelliptical in *M. kodayari* and *M. mallani*; subovoid in *M. nelliyampathi*) and rounded in lateral view (vs. nearly acute in *M. mallani*; acute in *M. kodayari* and *M. nelliyampathi*).

For more differences with *Micrixalus adonis* and *M. fuscus* see 'Comparison' of those species.

Description of topotype *(measurements in mm)*. Adult male (SVL 17.7); head small, as long as its width (HW 6.0, HL 6.0), flat above; snout pointed in dorsal view, rounded in lateral view, its length (SL 2.8) longer than horizontal diameter of eye (EL 2.3); loreal region vertical with rounded canthus rostralis; interorbital space flat, wider (IUE 1.7) than upper eyelid (UEW 1.3) and narrower than internarial distance (IN 2.2); distance between back of eye (IBE 5.1) 1.4 times the distance between front of eye (IFE 3.6); nostril oval, subequal to eye (EN 1.2) and tip of snout (NS 1.1); tympanum (TYD 0.9) 39% of eye diameter (EL 2.3); tongue moderately large, emarginate, without median lingual papillae; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 3.6) shorter than hand length (HAL 4.8); finger discs moderately wide compared to finger width (fd1 0.4, fw1 0.2; fd2 0.6, fw2 0.3; fd3 0.7, fw3 0.3; fd4 0.7, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present. Thigh length (TL 10.4) subequal to shank (SHL 10.5), and longer than foot (FOL 8.9); toe discs wide compared to toe width (td1 0.6, tw1 0.3; td2 0.7, tw2 0.3; td3 0.7, tw3 0.3; td4 0.9, tw4 0.3; td5 0.8, tw5 0.3); webbing present: I1–1$^{1}/_{2}$II1–2^{-}III1–2IV2–1V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes and upper eyelids, and posterior part of back shagreened to sparsely granular; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, well developed; lateral side of head shagreened; dorsal parts of forelimb, thigh, tibia and tarsus shagreened; weakly developed inverted V-shaped glandular projection on the middle of dorsum; ventral surface of throat, chest and abdomen smooth; posterior parts of thigh shagreened.

Colour in preservation. Dorsum light brown; lower flanks greyish-brown; tympanic area light grey; dorsolateral folds light greyish-brown; forelimbs, dorsal surfaces of thigh, tibia and feet greyish-brown with brown cross-bands, posterior parts of thigh light grey with dark greyish-brown reticulations; throat, chest and belly, ventral parts of thigh and tibia greyish-white; webbing blackish-grey. **Colour in life**. Dorsum reddish-orange with irregular light brown patches; tympanum and surrounding areas dark grey; iris light brown with reddish tinge; flanks light grey; groin light yellow with brown patches; dorsal surface of limbs light brown with dark brown cross-bands; throat and margins of throat, chest and belly greyish-white with scattered light greyish-yellow reticulations on belly.

Variations. See Table 5 for morphometric characters of nine adult males and three adult females. For colour variations see Figure 23.

Secondary sexual characters. Male (BNHS 5677): Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5680): ova creamy white with minute black spots, (diameter 0.7–1.0 mm, *N* = 20).

Distribution. *Micrixalus herrei* is known only from the Western Ghats states of Kerala and Tamil Nadu, with its distribution restricted to south of Shencottah gap. The present study found this species in Attayar, Chathankod, Kallar and Ponmudi (Thiruvananthapuram dist.) and Kovachal (Kollam dist.) in Kerala state, and Kiriparai (Kanyakumari dist.) and Putherichariu (Tirunelveli dist.) in Tamil Nadu state (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is fast flowing streams and rivulets in primary and secondary forests. *Micrixalus herrei* was found to be relatively abundant at all the collection localities. The majority of male specimens were found actively calling and 'foot-flagging'. Collections were made between 10:00–15:00 h.

***Micrixalus kodayari* sp. nov.**

Kodayar Dancing Frog

(Figs 3, 19D, 24; Tables 1–5)

Holotype. BNHS 5689, an adult female, Kodayar, Tirunelveli dist., Tamil Nadu state, India, collected by SDB, 16 November 2008.

Paratypes. ***Tamil Nadu*****:** *Tirunelveli dist.*, Kodayar, BNHS 5690, an adult male, collected by SDB, 31 August 2002, BNHS 5691, an adult male, collected by SDB, 26 November 2002; Kakkachi, SDB BNHS 5692–BNHS 5693, two adult females, collected by SDB, 25 November 2002.

Comparison. *Micrixalus kodayari* could be

confused with *M. adonis*, *M. fuscus*, *M. herrei*, *M. mallani* and *M. nelliyampathi*. However, *M. kodayari* differs from *M. mallani* by its head acute in lateral view (vs. nearly acute) and *M. nelliyampathi* by its head subelliptical in dorsal view (vs. subovoid). Furthermore, *M. kodayari* differs from *M. nelliyampathi* by its shank subequal to thigh length, male, SHL 10.3 ± 0.9 mm, TL 10.2 ± 1.0 mm, *N* = 2, female, SHL 13.0 ± 0.2 mm, TL 13.0 ± 0.1 mm, *N* = 3 (vs. longer, male, SHL 12.0 ± 0.6 mm, TL 10.7 ± 0.9 mm, *N* = 7, female, SHL 14.8 ± 0.4 mm, TL 12.7 ± 0.6 mm, *N* = 5).

For more differences with *Micrixalus adonis*, *M. fuscus* and *M. herrei* see 'Comparison' of those species.

Description of holotype *(measurements in mm)*. Adult male (SVL 24.6); head small (HW 8.0, HL 8.8), longer than wide, flat above; snout subelliptical in dorsal view, acute in lateral view, its length (SL 3.6) longer than horizontal diameter of eye (EL 2.3); loreal region acute and concave with rounded canthus rostralis; interorbital space flat, subequal (IUE 2.0) to upper eyelid (UEW 1.9) and narrower than internarial distance (IN 2.6); distance between back of eye (IBE 6.9) 1.8 times the distance between front of eye (IFE 3.8); nostril oval, as close to eye (EN 1.6) as to tip of snout (NS 1.7); tympanum (TYD 0.9) 39% of eye diameter (EL 2.3); tongue moderately large, emarginate, without median lingual papillae; supratympanic fold that extends from posterior corner of eye to near the shoulder, well developed. Forelimbs (FAL 4.9) shorter than hand length (HAL 6.1); finger discs moderately wide compared to finger width (fd1 0.5, fw1 0.2; fd2 0.6, fw2 0.3; fd3 1.0, fw3 0.3; fd4 0.8, fw4 0.3); subarticular tubercles well developed, oval, single, all present. Thigh length (TL 12.9) equal to shank (SHL 12.9), and longer than foot (FOL 11.2); toe discs wide compared to toe width (td1 0.6, tw1 0.3; td2 0.9, tw2 0.3; td3 1.0, tw3 0.3; td4 1.0, tw4 0.3; td5 0.8, tw5 0.3); webbing present: I1–2II1–$2^{1}/_{3}$III1–$2^{2}/_{3}$IV3–$1^{1}/_{5}$V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

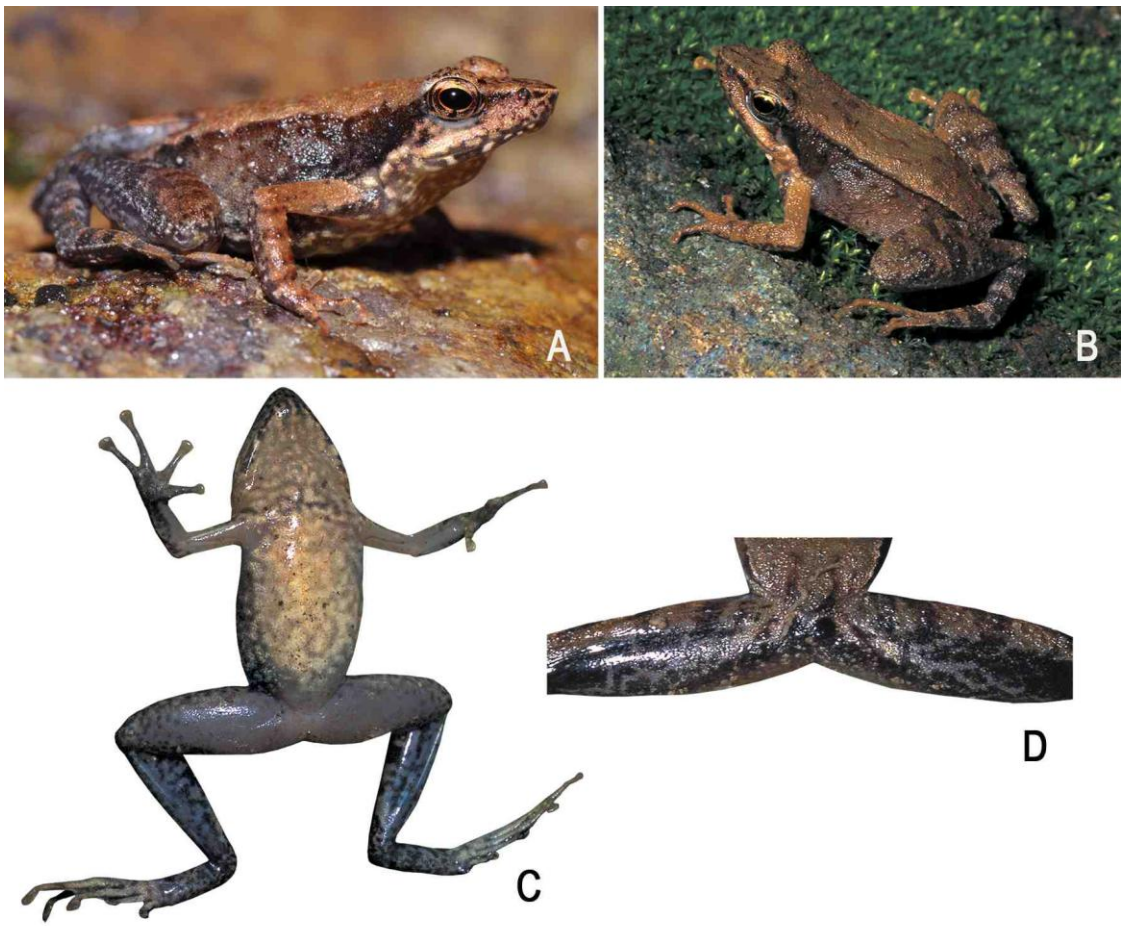

Figure 24. *Micrixalus kodayari* sp. nov. in life: **A.** dorsolateral view (HT, BNHS 5689, f); **B.** dorsolateral view, **C.** ventral view, **D.** posterior side of thighs (PT, BNHS 5692, f). Photos: SDB.

Skin of snout, between eyes and upper eyelids shagreened with prominently glandular

projections; posterior part of back shagreened with sparsely glandular projections; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, well developed; dorsal part of forelimbs shagreened to sparsely granular; thigh, tibia and tarsus shagreened with glandular projections and scattered glandular warts; weakly developed inverted V-shaped glandular projection on the middle of dorsum; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened to sparsely granular.

Colour in preservation. Dorsum uniform light greyish-brown; anterior part of flanks light brown with dark grey speckles; tympanic area dark brown; forelimbs, dorsal surfaces of thigh, tibia and feet light greyish-brown with dark brown cross-bands, posterior parts of thigh dark brownish-grey with light greyish-brown reticulations; throat, chest and belly light grey with prominent black reticulations; ventral parts of thigh light grey with scattered dark spots, tibia and feet brownish-black with grey reticulations; groin light brown with brown reticulations; webbing light grey with minute black spots. **Colour in life.** Dorsum uniform greyish-brown with metallic tinge; tympanum and surrounding areas light brown; iris light brown with reddish tinge; anterior parts of flank dark blackish-brown, posterior parts of flank light greyish-brown; groin light grey with minute black spots; dorsal surface of limbs greyish-brown with light brown cross-bands; posterior parts of thigh greyish-blue with light black reticulations; throat and margins of throat, chest and belly greyish-white with prominent grey reticulations; thigh light grey, shank and feet bluish-grey; webbing dark greyish-black.

Variations. See Table 5 for morphometric characters of an adult male and three adult females. For colour variations see Figure 24.

Secondary sexual characters. Female (BNHS 5689): ova creamy white with black reticulations (diameter 0.9–1.1 mm, *N* = 20).

Etymology. The species is named after Kodayar, where the holotype was collected. The specific name is a noun in apposition to the generic name and therefore invariable.

Distribution. *Micrixalus kodayari* is known only from the Western Ghats state of Tamil Nadu, with its distribution restricted to the south of Shencottah gap. The present study found this species in Kodayar and Kakkachi, (Tirunelveli dist.) (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is shallow waters on the sides of flowing streams covered with forest canopy. *Micrixalus kodayari* was found to be rare at both the collection localities. Specimens were collected between 10:00–17:00 h.

***Micrixalus mallani* sp. nov.**

Mallan's Dancing Frog

(Figs 3, 19E, 25; Tables 1–5)

Holotype. BNHS 5694, an adult male, Pandimotta, Shendurney WLS, Kollam dist., Kerala state, India, collected by SDB and Systematics lab team, 13 September 2011.

Paratypes. ***Kerala*****:** *Kollam dist.*, Pandimotta, BNHS 5695, an adult female, collected along with the holotype; *Pathanamthitta dist.*, Sabarimala, BNHS 5696–BNHS 5698, three adult males, collected by SDB, 11 June 2006; *Thiruvananthapuram dist.*, Athirimala, BNHS 5699–BNHS 5700, two adult females, collected by SDB, 13 March 2003; Ponkalappara, BNHS 5701, an adult female, collected by SDB, 23 December 2007.

Other material studied. ***Kerala*****:** *Thiruvananthapuram dist.*, Athirimala, SDBDU 2002.495, collected by SDB, 9 June 2002.

Comparison. *Micrixalus mallani* could be confused with *M. adonis, M. fuscus, M. herrei, M. kodayari* and *M. nelliyampathi*. However, *M. mallani* differs from *M. nelliyampathi* by its snout subelliptical in dorsal view (vs. subovoid) and its shank equal to thigh length, male, SHL 10.5 ± 0.3 mm, TL 10.5 ± 0.2 mm, *N* = 4, female, SHL 13.7 ± 0.5 mm, TL 13.7 ± 0.6 mm, *N* = 4 (vs. longer than thigh, male, SHL 12.0 ± 0.6 mm, TL 10.7 ± 0.9 mm, *N* = 7, female, SHL 14.8 ± 0.4 mm, TL 12.7 ± 0.6 mm, *N* = 5).

For differences with *Micrixalus adonis, M. fuscus, M. herrei* and *M. kodayari* see 'Comparison' of those species.

Description of holotype *(measurements in mm)*. Adult male (SVL 19.5); head small (HW 6.1, HL 7.2), longer than wide, flat above; snout subelliptical in dorsal view, nearly acute in lateral view, its length (SL 3.1) longer than horizontal diameter of eye (EL 2.3); loreal region vertical with rounded canthus rostralis; interorbital space flat, wider (IUE 1.7) than upper eyelid (UEW 1.2) and narrower than internarial distance (IN 2.4); distance between back of eye (IBE 5.8) 1.5 times the distance between front of eye (IFE 4.0); nostril oval, closer to eye (EN 1.1) than tip of snout (NS 1.3); tympanum (TYD 0.9) 39% of eye diameter (EL 2.3); tongue moderately large, emarginate, without median lingual papillae; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 3.8) shorter than hand length (HAL 5.1); finger discs moderately wide compared to finger width (fd1 0.7, fw1 0.3; fd2 0.8, fw2 0.3; fd3 0.9, fw3 0.2; fd4 0.9, fw4 0.2); subarticular tubercles weakly developed, oval, single, all present. Thigh

length (TL 10.5) longer than shank (SHL 10.1), and longer than foot (FOL 9.2); toe discs wide compared to toe width (td1 0.6, tw1 0.3; td2 0.9, tw2 0.3; td3 0.9, tw3 0.3; td4 0.9, tw4 0.3; td5 0.6, tw5 0.2); webbing present: I1–1$^{1}/_{2}$II1–2III1–3IV3–1V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes and upper eyelids shagreened to finely granular; posterior part of back shagreened to sparsely granular; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, well developed; thigh, tibia and tarsus shagreened with weakly developed glandular projections; an inverted V-shaped glandular projection on the middle of dorsum; dorsal parts

Figure 25. *Micrixalus mallani* sp. nov. in life: **A.** dorsolateral view, **B.** front view (HT, BNHS 5694, m); **C.** dorsolateral view, **D.** front view (PT, BNHS 5695, f); **E.** dorsolateral view (PT, BNHS 5700, f); **F.** dorsal view, **G.** ventral view, **H.** lateral view of thigh and groin, **I.** posterior side of thighs (HT, BNHS 5694, m); **J.** ventral view, **K.** lateral view of thigh and groin, **L.** posterior side of thigh (PT, BNHS 5695, f); **M.** dorsal view, **N.** lateral view of thigh and groin, **O.** posterior side of thighs (PT, BNHS 5700, f). Photos: SDB.

forelimb shagreened; ventral surface of throat, chest and abdomen smooth; posterior parts of thigh shagreened to sparsely granular.

Colour in preservation. Dorsum brown

with light grey reticulations; posterior parts of flank grey with dark grey speckles; tympanic area grey; dorsolateral folds light brown; forelimbs, dorsal surfaces of thigh, tibia and feet light greyish-brown with dark brown cross-bands; throat, chest and belly greyish-white with grey reticulations; ventral parts of thigh light grey with scattered dark spots, tibia and feet brownish-black; webbing blackish-grey. **Colour in life.** Dorsum uniform greyish-brown with light grey specks; iris light brown with reddish tinge; flanks light brownish-grey with brown reticulations; groin yellow with light grey spots; dorsal surface of limbs greyish-brown with light brown cross-bands; throat and margins of throat, chest and belly grey with prominent brownish-grey reticulations; ventral surface of thighs light orange.

Variations. See Table 5 for morphometric characters of four adult males and four adult females. For colour variations see Figure 25.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5695): ova creamy white with black spots or reticulations (diameter 0.8–1.0 mm, $N = 20$).

Etymology. This species is named after Mr. Mallan Kani, in appreciation of his tremendous support and companionship to SDB in field, since 1998. The species name *mallani* is a noun in the genitive case.

Distribution. *Micrixalus mallani* is known only from the Western Ghats state of Kerala, with its distribution restricted to the south of Palghat gap. The present study found this species in Pandimotta (Kollam dist.), Sabarimala (Pathanamthitta dist.), Athirimala and Ponkalapara (Thiruvananthapuram dist.) (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is streams covered with forest canopy. The majority of male specimens were found actively calling and 'foot-flagging'. Collections were made between 09:00–17:00 h.

***Micrixalus nelliyampathi* sp. nov.**
Nelliyampathi Dancing Frog
(Figs 3, 19F, 26; Tables 1–5)

Holotype. BNHS 5702, an adult male, Kesavapara, Nelliyampathy, Palakkad dist., Kerala state, India, collected by SDB and Systematics lab team, 14 October 2011.

Paratypes. ***Kerala*:** *Palakkad dist.*, Kesavapara, Nelliyampathy, BNHS 5703–BNHS 5704, two adult males, and BNHS 5705–BNHS 5706, two adult females, collected along with holotype; Poopara, BNHS 5707, an adult male, collected by SDB and Systematics lab team, 13 August 2011; ***Tamil Nadu*:** *Coimbatore dist.*, Andiparai shola, BNHS 5708–BNHS 5709, two adult males, and BNHS 5710, an adult female, collected by SDB, 15 August 2002, BNHS 5711, an adult male, collected by SDB, 8 January 2004; Grass hills, BNHS 5712–BNHS 5713, two adult females, collected by SDB, 12 July 2005.

Other material studied. ***Kerala*:** *Palakkad dist.*, Kesavapara, Nelliyampathy, SDBDU 2011.1154, collected along with holotype; Poopara, SDBDU 2011.562, collected by SDB and Systematics lab team, 13 August 2011; ***Tamil Nadu*:** *Coimbatore dist.*, Puthuthottam, SDBDU 2001.785, collected by SDB, 28 July 2001.

Comparison. *Micrixalus nelliyampathi* could be confused with *M. adonis*, *M. fuscus*, *M. herrei*, *M. kodayari* and *M. mallani*. For differences with *Micrixalus adonis*, *M. fuscus*, *M. herrei*, *M. kodayari* and *M. mallani* see 'Comparison' of those species.

Description of holotype *(measurements in mm)*. Adult male (SVL 23.7); head small (HW 7.2, HL 8.4), longer than wide, flat above; snout subovoid in dorsal view, acute in lateral view, its length (SL 4.1) longer than horizontal diameter of eye (EL 3.0); loreal region vertical and concave with rounded canthus rostralis; interorbital space flat, wider (IUE 2.1) than upper eyelid (UEW 1.8) and narrower than internarial distance (IN 2.6); distance between back of eye (IBE 6.3) 1.7 times the distance between front of eye (IFE 3.8); nostril oval, closer to eye (EN 1.3) than tip of snout (NS 1.7); tympanum (TYD 0.8) 27% of eye diameter (EL 3.0); tongue moderately large, emarginate, without median lingual papillae; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 5.1) shorter than hand length (HAL 6.2); finger discs moderately wide compared to finger width (fd1 0.7, fw1 0.3; fd2 0.7, fw2 0.3; fd3 1.0, fw3 0.3; fd4 0.9, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present. Thigh length (TL 11.9) shorter than shank (SHL 12.1), and subequal to foot (FOL 11.8); toe discs wide compared to toe width (td1 0.6, tw1 0.2; td2 0.9, tw2 0.3; td3 0.9, tw3 0.3; td4 0.9, tw4 0.3; td5 0.9, tw5 0.3); webbing present: I1–1$^{1}/_{2}$II1–2^{-}III1–2IV2–1V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes and upper eyelids, posterior part of back shagreened to sparsely granular; dorsolateral folds that extend

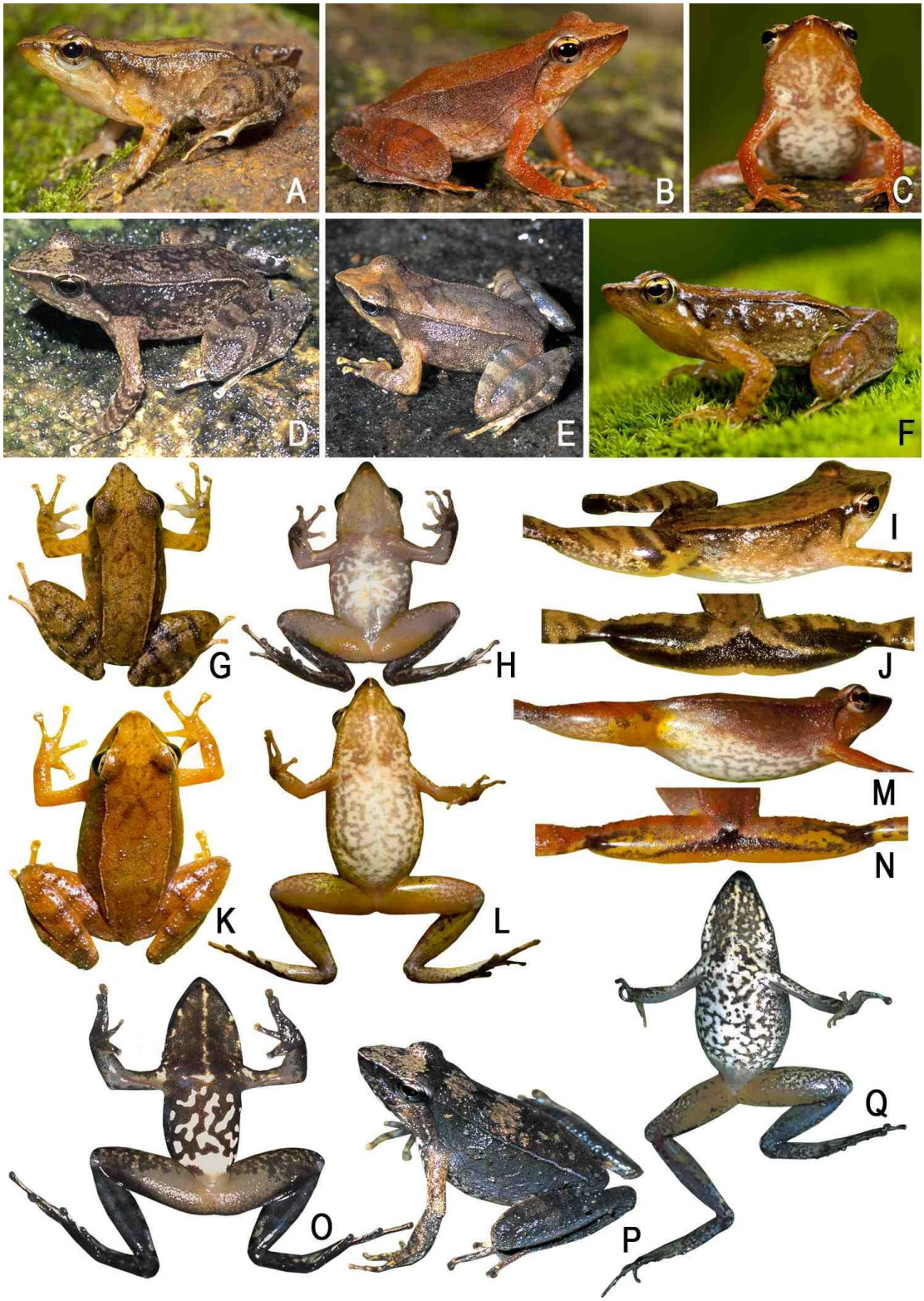

Figure 26. *Micrixalus nelliyampathi* sp. nov. in life: **A.** dorsolateral view (HT, BNHS 5702, m); **B.** dorsolateral view, **C.** front view (PT, BNHS 5705, f); **D.** dorsolateral view (PT, BNHS 5711, m); **E.** dorsolateral view (PT, BNHS 5708, m); **F.** dorsolateral view (PT, BNHS 5707, m); **G.** dorsal view, **H.** ventral view, **I.** lateral view of thigh and groin, **J.** posterior side of thighs (HT, BNHS 5702, m); **K.** dorsal view, **L.** ventral view, **M.** lateral view of thigh and groin, **N.** posterior side of thighs (PT, BNHS 5705, f); **O.** ventral view (PT, BNHS 5711, m); **P.** dorsolateral view, **Q.** ventral view (PT, BNHS 5712, f). Photos: SDB.

from the posterior corner of the eye to the entire body length on both sides, well developed; dorsal part of forelimbs shagreened to sparsely granular; thigh, tibia and tarsus with weakly developed glandular projections; an inverted V-shaped glandular projection on the middle of dorsum; ventral surface of throat, chest and abdomen smooth; posterior parts of thigh shagreened to sparsely granular.

Colour in preservation. Dorsum light grey; flanks brown with dark grey speckles; tympanic area light grey; dorsolateral folds light grey; forelimbs, dorsal surfaces of thigh, tibia and feet light greyish-brown with dark brown cross-bands, posterior parts of thigh dark brown with greyish-brown reticulations; throat, chest and belly greyish-white with black reticulations; ventral parts of thigh light grey with scattered dark spots, tibia and feet brownish-black; webbing blackish-grey. **Colour in life.** Dorsum uniform greyish-brown with minute brown spots; flanks light yellowish-grey with brown spots; tympanum and surrounding areas light brownish-grey; iris light brown with minute reddish tinge; groin light yellow with light brown spots; posterior parts of thigh dark brownish-black; dorsal surface of limbs yellowish-brown with brown cross-bands; throat, chest and belly greyish-white with prominent white reticulations.

Variations. See Table 5 for morphometric characters of seven adult males and five adult females. For colour variations see Figure 26.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5705): ova creamy white with black spots (diameter 1.0–1.3 mm, *N* = 20).

Etymology. The species is named after Nelliyampathi, where the holotype was collected. The specific name is a noun in apposition to the generic name and therefore invariable.

Distribution. *Micrixalus nelliyampathi* is known from the Western Ghats states of Kerala and Tamil Nadu, with its distribution restricted between the Palghat gap and Shencottah gap. The present study found this species in Kesavapara and Poopara (Palakkad dist.) in Kerala state, and Andiparai shola, Grass hills and Puthuthottam (Coimbatore dist.) in Tamil Nadu state (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is fast flowing streams covered with forest canopy at Kesavapara, Poopara and Grass hills. However the collections from Andiparai shola were predominantly from streams near plantations. *Micrixalus nelliyampathi* was found to be relatively abundant at all the collection localities. The majority of male specimens were found actively calling and 'foot-flagging'. Collections were made between 10:00–17:00 h.

Micrixalus nudis group

Members. *Micrixalus gadgili, Micrixalus nudis, Micrixalus sali* sp. nov. and *Micrixalus thampii*

This group can be distinguished from other *Micrixalus* groups by the combination of following morphological characters: small adult size (male, SVL 13.0–17.0 mm; female, SVL 17.0–22.0 mm); absence or presence of dorsolateral folds; fourth toe webbing does not extend beyond the second subarticular tubercle on either side; presence of outer metatarsal tubercle; absence of glands behind the tympanum or near posterior axis of the mandibles; and presence of a dark brownish-black band that extends from posterior corner of the eye up to the groin, where it ends in to a thin line. It is also one of the more widely distributed *Micrixalus* groups that is found on both sides of the Palghat gap and Shencottah gap in the Western Ghats, but with individual species having narrow geographical ranges (Fig. 27).

Micrixalus gadgili Pillai and Pattabiraman, 1990

Gadgil's Dancing Frog

(Figs 3, 27A, 28, 29; Tables 1–5)

Original name and description. *Micrixalus gadgili* Pillai and Pattabiraman, 1990. Amphibians from Sabagiri forest, Western Ghats, Kerala, including a new species of *Micrixalus. Records of the Zoological Survey of India* 86: 386–388. **Holotype.** ZSI-SRS VA/780 according to Chanda *et al.*, 2001 "2000". **Type locality.** "Dynamite House, Pamba, Sabarigiri, S. India". **Current status of specific name.** Valid name, as *Micrixalus gadgili* Pillai and Pattabiraman, 1990.

Referred specimens. *Kerala*: *Pathanamthitta dist.*, Sabarimala, BNHS 5714, an adult male, collected by SDB, 9 June 2006; Gavi, BNHS 5715, an adult male, and BNHS 5716, an adult female, collected by SDB, 10 June 2006; *Idukki dist.*, Thekkady, BNHS 5717–BNHS 5718, two adult males, collected by SDB, 8 June 2006, BNHS 5719, an adult male, collected by SDB and SG, 28 January 2012; *Palakkad dist*., Kesavapara, Nelliyampathy, BNHS 5720–BNHS 5722, three adult males, collected by SDB and Systematics lab team, 14 October 2011.

Other material studied. *Kerala*: *Idukki dist.*, Thekkady, SDBDU 2006.4801, collected by SDB, 8 June 2006, SDBDU 2012.1842–1843, collected by SDB and SG, 28 January 2012; *Palakkad dist.*, Kesavapara, Nelliyampathy,

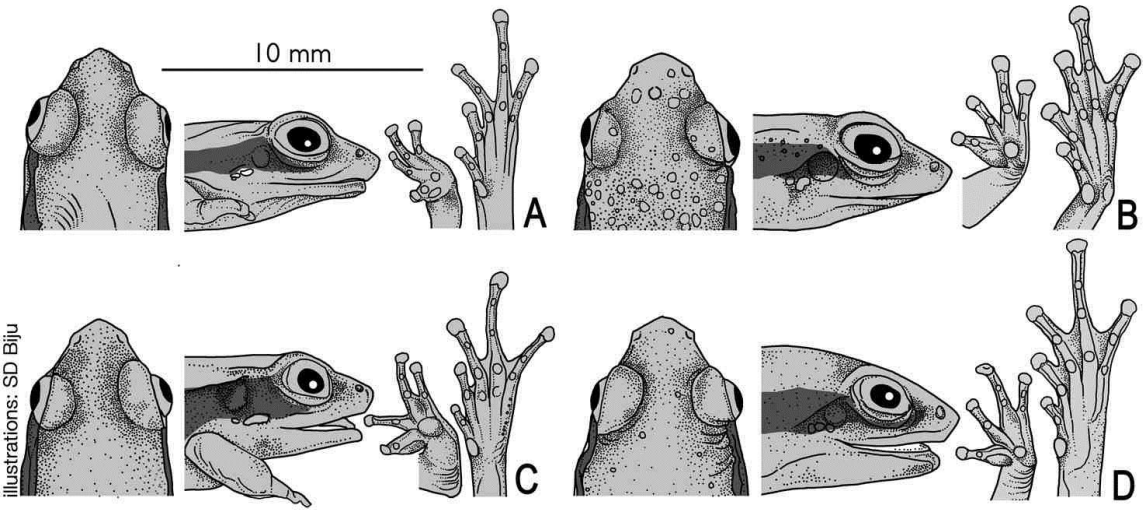

Figure 27. From left to right, dorsal view of head, lateral view of head, ventral view of hand and ventral view of foot of *Micrixalus nudis* group: **A.** *M. gadgili* (RS, BNHS 5715, m); **B.** *M. nudis* (RS, BNHS 5725, m); **C.** *Micrixalus sali* sp. nov. (HT, BNHS 5731, m); **D.** *M. thampii* (RS, BNHS 5742, m).

SDBDU 2011.1148–1149, collected by SDB and Systematics lab team, 15 October 2011.

Comments. Pillai and Pattabiraman (1990) described this species based on seven specimens (the holotype along with six paratypes). However, the original description does not cite any specimen numbers. Chanda *et al.* (2001 "2000") stated ZSI/SRS Chennai VA/780 to be the holotype (Fig. 28) and ZSI/SRS Chennai VA/781 (unregistered) as paratypes. We studied the type series in ZSI/SRS, and found four specimens (one male and three females), including the holotype. SDB first studied the holotype in 2002, and later in 2011 found it severely damaged.

Comparison. *Micrixalus gadgili* could be confused with *M. nudis*, *M. sali* and *M. thampii*. However, *M. gadgili* differs from *M. nudis* and *M. thampii* by its first toe webbing basal on the inside (vs. extending up to base of the disc, in both species) and nostril closer to eye than tip of snout, male, EN 0.8 ± 0.1 mm, NS 1.3 ± 0.1 mm, *N* = 8, female, EN 1.2 ± 0.1 mm, NS 1.6 ± 0.1 mm, *N* = 2 (vs. closer to tip of snout than eye in *M. nudis*: male, EN 1.5 ± 0.1 mm, NS 1.0 ± 0.1 mm, *N*= 5, female, EN 1.7 ± 0.1 mm, NS 1.2 ± 0.0 mm, *N* = 3; as close to eye as to tip of snout in *M. thampii*: male, EN 1.1 ± 0.2 mm, NS 1.1 ± 0.1 mm, *N*= 6, female, EN 1.4 ± 0.2 mm, NS 1.3 ± 0.1 mm, *N*= 3); differs from *M. sali* by its larger adult size, male, SVL 15.1–16.2 mm, *N* = 8, female, SVL 17.0–18.2 mm, *N* = 2 (vs. small, male, SVL 13.8–14.9 mm, *N* = 6, female, SVL 16.2 mm, *N* = 1), second toe webbing extending beyond the subarticular tubercle on the outside (vs. basal) and nostril closer to eye than tip of snout, male, EN 0.8 ± 0.1 mm, NS 1.3 ± 0.1 mm, *N* = 8, female, EN 1.2 ± 0.1 mm, NS 1.6 ± 0.1 mm, *N* = 2 (vs. as close to eye as to tip of snout, male, EN 1.1 ± 0.1 mm, NS 1.1 ± 0.1 mm, *N* = 6, female, EN 1.3 mm, NS 1.3 mm, *N* = 1).

Description of holotype. A general description was published by Pillai and Pattabiraman (1990).

Figure 28. Holotype of *Micrixalus gadgili* (ZSI-SRS VA/780, f).

Distribution. *Micrixalus gadgili* is known only from the Western Ghats state of Kerala, with its distribution restricted between the Palghat and Shencottah gap. The present study found this species in Sabarimala, Gavi (Pathanamthitta dist.), Thekkady (Idukki dist.) and Kesavapara (Palakkad dist.) (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is mostly damp leaf litter on the sides of streams covered with forest canopy. The majority of male specimens were found actively calling and collected between 12:00–16:00 h.

Figure 29. *Micrixalus gadgili* in life: **A.** dorsolateral view, **B.** front view, **C.** dorsolateral view (RS, BNHS 5722, m); **D.** dorsolateral view, **E.** dorsolateral view (RS, BNHS 5719, m); **F.** amplected pair (RS, BNHS 5715, m, and BNHS 5716, f); **G.** dorsal view, **H.** ventral view, **I.** lateral view of thigh and groin, **J.** posterior side of thighs (RS, BNHS 5722, m); **K.** lateral view of thigh and groin, **L.** posterior side of thighs (RS, BNHS 5719, m); **M.** dorsal view (RS, BNHS 5715, m). Photos: SDB.

***Micrixalus nudis* Pillai, 1978**
Naked Dancing Frog
(Figs 3, 27B, 30, 31; Tables 1–5)

Original name and description. *Micrixalus nudis* Pillai, 1978. A new frog of the genus *Micrixalus* Boul. from Wynad, S. India. *Proceedings of the Indian Academy of Sciences*, *Section B* 87: 173. **Holotype.** ZSI-SRS VA/771, an adult female, according to Chanda *et al*., 2001 "2000". **Type locality.** "forest brook, 8 km north of Forest Rest House, Chedleth, Kurichiat Reserve Forest", Wayanad dist., Kerala state. **Current status of specific name.** Valid name, as *Micrixalus nudis* Pillai, 1978.

Referred specimens. ***Kerala*:** *Wayanad dist.*, Chethalayam falls, Kurichiat, BNHS 5723, an adult male, and BNHS 5724, an adult female, collected by SDB, 20 September 2002, BNHS 5725–BNHS 5728, four adult males, and BNHS 5729–BNHS 5730, two adult females, collected by SDB and SG, 6 June 2012.

Comments. This species has been reported from Ponmudi (Inger *et al.*, 1984), Siruvani (Biju *et al.*, 2004) and Nagarahole (Aravind, 2002). However, the populations from Ponmudi belong to a different species, described herein as a new species (*Micrixalus sali*), whereas population from Siruvani and surrounding regions belong to *Micrixalus thampii*.

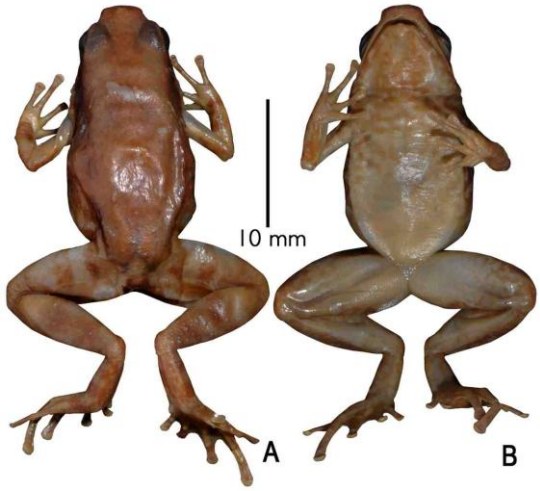

Figure 30. Holotype of *Micrixalus nudis* (ZSI-SRS VA/771): **A.** Dorsal view, **B.** ventral view.

Comparison. *Micrixalus nudis* could be confused with *M. gadgili*, *M. sali* and *M. thampii*. However, *M. nudis* differs from *M. sali* by its larger adult size, male, SVL 15.2–16.3 mm, *N* = 5, female, SVL 20.3–20.7 mm, *N* = 3 (vs. small, male, SVL 13.8–14.9 mm, *N* = 6, female, SVL 16.2 mm, *N* = 1), second toe webbing extending up to the base of disc on the outside (vs. basal) and nostril closer to tip of snout than eye, male, EN 1.5 ± 0.1 mm, NS 1.0 ± 0.1 mm, *N* = 5, female, EN 1.7 ± 0.1 mm, NS 1.2 ± 0.0 mm, *N* = 3 (vs. as close to tip of snout as eye, male, EN 1.1 ± 0.1 mm, NS 1.1 ± 0.1 mm, *N* = 6, female, EN 1.3 mm, NS 1.3 mm, *N* = 1); differs from *M. thampii* by its nostril closer to tip of snout than eye, male, EN 1.5 ± 0.1 mm, NS 1.0 ± 0.1 mm, *N* = 5, female, EN 1.7 ± 0.1 mm, NS 1.2 ± 0.0 mm, *N* = 3 (vs. as close to tip of snout as eye, male, EN 1.1 ±

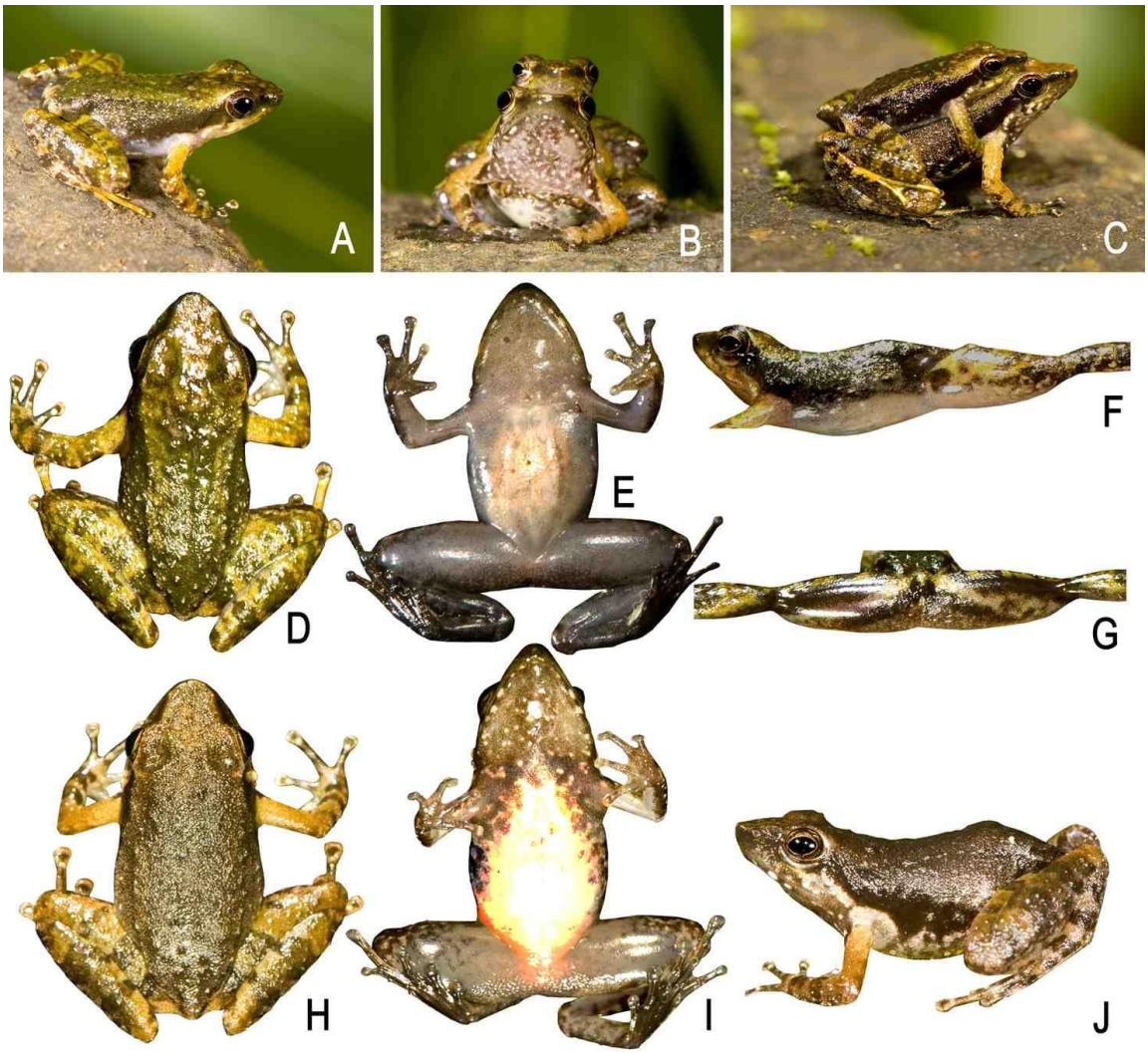

Figure 31. *Micrixalus nudis* in life: **A.** dorsolateral view (RS, BNHS 5726, m); **B.** front view of amplected pair, **C.** dorsolateral view of amplected pair (RS, BNHS 5727, m, and RS, BNHS 5730, f); **D.** dorsal view, **E.** ventral view, **F.** lateral view of thigh and groin, **G.** posterior side of thighs (RS, BNHS 5726, m); **H.** dorsal view, **I.** ventral view (RS, BNHS 5729, f); **J.** dorsolateral view (RS, BNHS 5725, m). Photos: SDB.

0.2 mm, NS 1.1 ± 0.1 mm, *N* = 6, female, EN 1.4 ± 0.2 mm, NS 1.3 ± 0.1 mm, *N* = 3), third toe webbing extending up to the first subarticular tubercle on the inside (vs. up to the second subarticular tubercle).

For more differences with *Micrixalus gadgili* see 'Comparison' of that species.

Description of holotype. A general original description was published by Pillai (1978).

Distribution. *Micrixalus nudis* is known only from the Western Ghats state of Kerala, with its distribution restricted to the north of Palghat gap. The present study found this species in Chethalayam falls in Kurichiat and surrounding regions in Wayanad dist. of Kerala state (Fig. 3, Table 1).

Habitat and natural history. This species was mostly found on damp leaf litter or in shallow waters on the sides of streams covered with forest canopy. The majority of male specimens were found actively calling and collected between 09:00–16:00 h.

***Micrixalus sali* sp. nov.**
Sali's Dancing Frog
(Figs 3, 27C, 32; Tables 1–5)

Holotype. BNHS 5731, an adult male, Ponmudi, Thiruvananthapuram dist., Kerala state, India, collected by SDB, SG and Sali Palode, 30 May 2012.

Paratypes. ***Kerala*:** *Thiruvananthapuram dist.*, Ponmudi, BNHS 5732–BNHS 5734, three adult males, collected along with holotype, BNHS 5735–BNHS 5736, two adult males, collected by SDB, 22 November 2002, BNHS 5737, an adult female, collected by SDB and Systematics lab team, 11 September 2011.

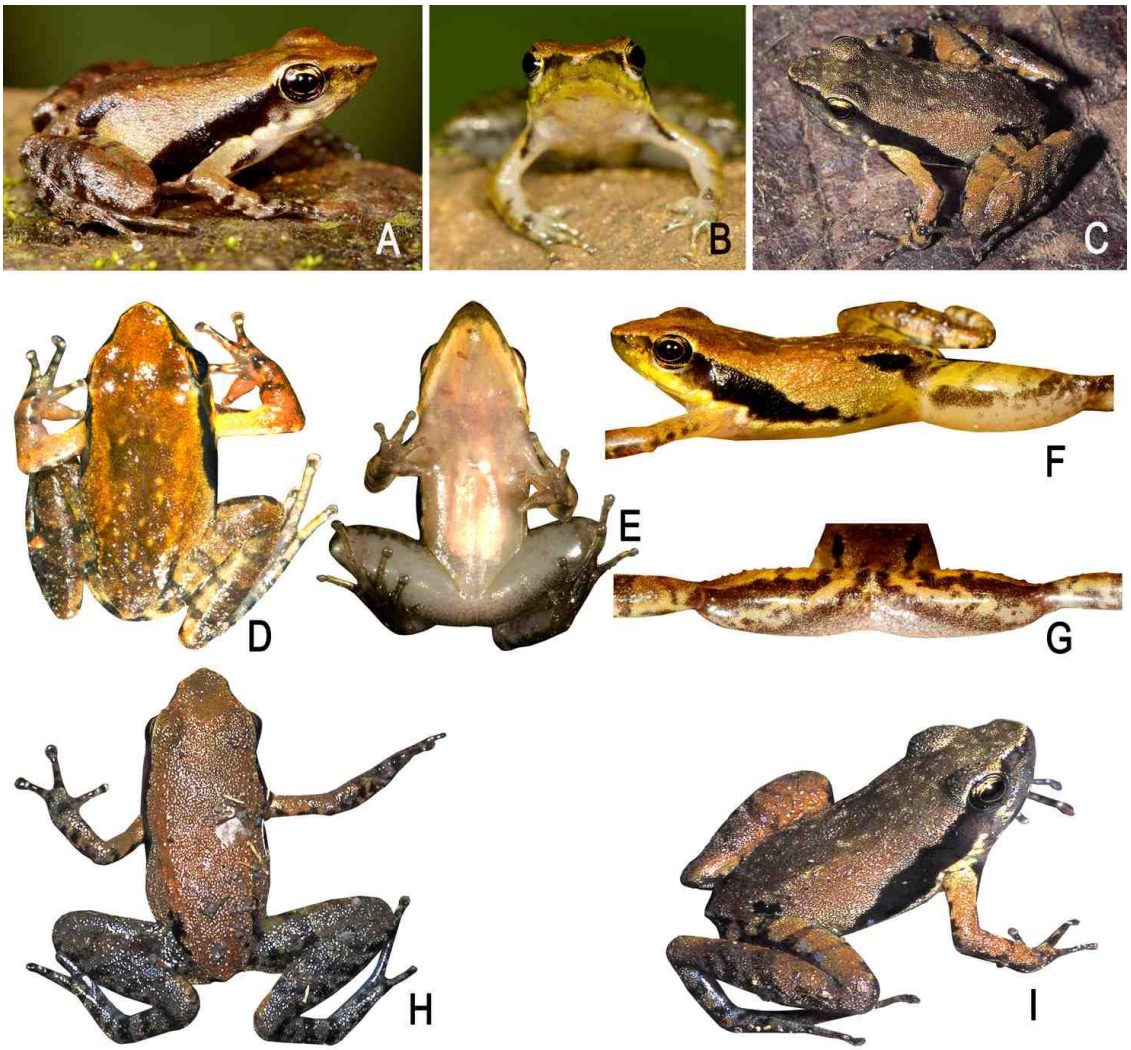

Figure 32. *Micrixalus sali* sp. nov. in life: **A.** dorsolateral view, **B.** front view (HT, BNHS 5731, m); **C.** dorsolateral view (PT, BNHS 5736, m); **D.** dorsal view, **E.** ventral view, **F.** lateral view of thigh and groin, **G.** posterior side of thighs (HT, BNHS 5731, m); **H.** dorsal view, **I.** dorsolateral view (PT, BNHS 5735, m). Photos: SDB.

Comparison. *Micrixalus sali* could be confused with *M. gadgili*, *M. nudis* and *M. thampii*. However, *M. sali* differs from other members of *Micrixalus nudis* group by its smaller adult size, male, SVL 13.8–14.9 mm, *N* = 6, female, SVL 16.2 mm, *N* = 1 (vs. larger, *M. gadgili*: male, SVL 15.1–16.2 mm, *N* = 8, female, SVL 17.0–18.2 mm, *N* = 2; *M. nudis*: male, SVL 15.2–16.3 mm, *N* = 5, female, SVL 20.3–20.7 mm, *N* = 3; *M. thampii*: male, SVL 14.4–16.2 mm, *N* = 6, female, SVL 18.4–21.1 mm, *N* = 3) and second toe webbing basal on the outside (vs. well beyond the subarticular tubercle on the outside in *M. gadgili*; up to the base of disc on the outside in *M. nudis* and *M. thampii*).

For more differences with *Micrixalus gadgili* and *M. nudis* see 'Comparison' of those species.

Description of holotype *(measurements in mm)*. Adult male (SVL 14.8); head small (HW 4.6, HL 5.5), longer than wide, flat above; snout subelliptical in dorsal view, nearly acute in lateral view, its length (SL 2.4) longer than horizontal diameter of eye (EL 1.8); loreal region acute and concave with rounded canthus rostralis; interorbital space flat, wider (IUE 1.7) than upper eyelid (UEW 1.2) and subequal to internarial distance (IN 1.8); distance between back of eye (IBE 4.6) 1.6 times the distance between front of eye (IFE 2.9); nostril oval, as close to eye (EN 1.0) as to tip of snout (NS 1.0); tympanum (TYD 0.4) 22% of eye diameter (EL 1.8); tongue moderately large, emarginate, without lingual papilla; supratympanic fold that extends from posterior corner of eye to near the shoulder, well developed. Forelimbs (FAL 3.1) shorter than hand length (HAL 3.9); finger discs moderately wide compared to finger width (fd1 0.4, fw1 0.2; fd2 0.5, fw2 0.3; fd3 0.5, fw3 0.2; fd4 0.5, fw4 0.2); subarticular tubercles weakly developed, oval, single, all present; round palmar tubercles. Thigh length (TL 7.8) subequal to shank (SHL 7.7), and longer than foot (FOL 6.9); toe discs wide compared to toe width (td1 0.5, tw1 0.2; td2 0.6, tw2 0.2; td3 0.6, tw3 0.2; td4 0.6, tw4 0.2; td5 0.5, tw5 0.2); webbing reduced: I2–2II2–3III2^{+}–3^{+}IV3$^{1}/_{5}$–2V; subarticular tubercles well developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes and upper eyelids shagreened; posterior part of back shagreened; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, weakly developed; upper and lower parts of flank shagreened and sparsely granular; dorsal parts of forelimb shagreened; thigh, tibia and tarsus with weakly developed granular projections; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened.

Colour in preservation. Dorsum light brown; lateral sides of head (snout and tympanic area) distinctly light grey; a dark brownish-black band that extends from posterior corner of the eye up to the groin, where it ends in to a thin line; posterior parts of flank dark brownish-black; dorsal surfaces of thigh, tibia and feet light greyish-brown with dark brown cross-bands; throat, chest and belly grey with dark grey reticulations. **Colour in life.** Anterior part of dorsum brownish-orange; a dark brownish-black band that extends from posterior corner of the eye up to the groin, where it ends in to a thin line; iris brown with reddish tinge; flanks light brown with orange tinge; groin yellowish-brown; dorsal surface of limbs brownish-orange with light brown cross-bands; throat light yellowish-red; chest, belly, thighs and shank light grey; foot dark brownish-black.

Variations. See Table 5 for morphometric characters of six adult males and an adult female. For colour variations see Figure 32.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling.

Etymology. The species is named after Mr. Sali Palode, as a token of appreciation for his constant support to SDB during field studies in the Western Ghats over the past two decades. The species name *sali* is used as a noun in apposition to the generic name and therefore invariable.

Distribution. *Micrixalus sali* is known only from its type locality Ponmudi (Thiruvananthapuram dist., Kerala state), which is located south of Shencottah gap in the Western Ghats (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is brooks or damp leaf litter on exposed streambeds, inside wet evergreen forests. The majority of male specimens were found calling and collected between 11:00–15:00 h.

***Micrixalus thampii* Pillai, 1981**

Silent Valley Dancing Frog

(Figs 3, 27D, 33; Tables 1–5)

Original name and description. *Micrixalus thampii* Pillai, 1981. Two new species of Amphibia from Silent Valley, S. India. *Bulletin of the Zoological Survey of India* 3: 153. **Holotype.** ZSI-SRS VA/778, an adult female, according to Chanda *et al.*, 2001 "2000". **Type locality.** "Silent Valley", Palakkad dist., Kerala state. **Current**

status of specific name. Valid name, as *Micrixalus thampii* Pillai, 1981.

Referred specimens. ***Kerala*****:** *Palakkad dist.*, Sairandhri, Silent Valley, BNHS 5738, an adult male, and BNHS 5739, an adult female, collected by SDB and team, 6 November 2010, BNHS 5740–BNHS 5742, three adult males, and BNHS 5743, an adult female, collected by SDB and SG, 19 September 2011; Kuddam, Siruvani, BNHS 5744–BNHS 5745, two adult males, and BNHS 5746, an adult female, collected by SDB and Systematics lab team, 18 October 2011.

Figure 33. *Micrixalus thampii* in life: **A.** dorsolateral view, **B.** front view (RS, BNHS 5738, m); **C.** dorsolateral view (RS, BNHS 5739, f); **D.** dorsolateral view, **E.** front view (RS, BNHS 5745, m); **F.** dorsolateral view, **G.** ventral view, **H.** lateral view of thigh and groin, **I.** posterior side of thighs (RS, BNHS 5744, m); **J.** dorsal view (RS, BNHS 5742, m); **K.** dorsal view (RS, BNHS 5743, f); **L.** dorsal view, **M.** ventral view (RS, BNHS 5746, f). Photos: SDB.

Other material studied. ***Kerala*****:** *Palakkad dist.*, Sairandhri, Silent Valley, SDBDU 2010.131, collected by SDB and team, 6 November 2010, SDBDU 2011.963, collected by SDB and SG, 19 September 2011; Singappara, Siruvani, SDBDU 2011.1226, and SDBDU 2011.1271, collected by SDB and Systematics lab team, 18 October 2011.

Comparison. *Micrixalus thampii* could be confused with *Micrixalus gadgili, M. nudis and M. sali*. For differences with *M. gadgili, M. nudis and M. sali* see 'Comparison' of those species.

Description of holotype. A general original description was published by Pillai (1981).

Distribution. *Micrixalus thampii* is known only from the Western Ghats state of Kerala, with its distribution restricted to north of the Palghat gap. The present study found this species in Sairandhri, Silent Valley and Kuddam, Siruvani in Palakkad dist. (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is banks of shallow streams inside wet evergreen forests. The majority of male specimens were found actively calling and collected between 10:00–16:00 h.

Micrixalus saxicola Group

Members. *Micrixalus kottigeharensis, Micrixalus saxicola* and *Micrixalus specca* sp. nov.

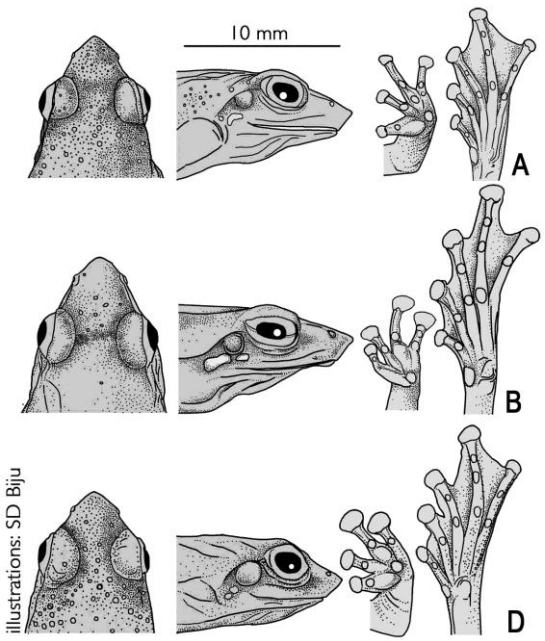

Figure 34. From left to right, dorsal view of head, lateral view of head, ventral view of hand and ventral view of foot of *Micrixalus saxicola* group: **A.** *M. kottigeharensis* (NT, BNHS 5747, m); **B.** *M. saxicola* (RS, BNHS 5764, f); **C.** *Micrixalus specca* sp. nov. (HT, BNHS 5778, m).

This group can be distinguished from other *Micrixalus* groups by the combination of following morphological characters: small adult size (male, SVL 19.0–24.0 mm; female, SVL 24.0–33.0 mm); absence of dorsolateral folds; tongue with lingual papilla; and fully webbed toes (Fig. 34).

Micrixalus kottigeharensis (Rao, 1937)

Kottigehar Dancing Frog

(Figs 3, 34A, 35, 36; Tables 1–5)

Original name and description. *Philautus kottigeharensis* Rao, 1937. On some new forms of Batrachia from S. India. *Proceedings of Indian Academy Science (B)*, 6: 157. **Neotype.** By present designation, BNHS 5747, an adult male (SVL 22.1 mm), collected by SDB, 17 November 2010. **Neotype locality.** Kottigehara, Chikmagalur dist., Karnataka state. **Current status of specific name.** Valid name, as *Micrixalus kottigeharensis* (Rao, 1937) (Bossuyt and Dubois, 2001). **Synonyms.** *Philautus narainensis* Rao, 1937 ***Syn. nov.*** (= *Micrixalus narainensis* [Rao, 1937]) and *Philautus swamianus* Rao, 1937 ***Syn. nov.*** (= *Micrixalus narainensis* [Rao, 1937]).

Referred specimens. ***Karnataka*****:** *Chikmagalur dist.*, Kottigehara, BNHS 5748, an adult male, collected along with neotype; Kemmanagundi, BNHS 5749, an adult female, collected by SDB, 29 June 2010; *Dakshina Kannada dist.*, Charmadi Ghats, BNHS 5750, an adult female, collected by SDB and Systematics lab team, 23 October 2011; *Hassan dist.*, Maranhalli, Sakleshpur, BNHS 5751–BNHS 5752, two adult males, and BNHS 5753–BNHS 5754, two adult females, collected by SDB and Systematics lab team, 30 September 2012; *Uttara Kannada dist.*, Kathlekan, BNHS 5755–BNHS 5757, three adult males, and BNHS 5758, an adult female, collected by SDB and team, 22 October 2011; Waddighat, Yana, BNHS 5759, an adult male, and BNHS 5760– BNHS 5761, two adult females, collected by SDB and team, 21 October 2011; Unchalli falls, BNHS 5762, an adult female, collected by KVG and GS, 28 September 2012.

Other material studied. ***Karnataka*****:** *Chikmagalur dist.*, Kottigehara, SDBDU 2010.124, collected along with neotype, SDBDU 2012.55 and SDBDU 2012.62, collected by SDB and team, 11 June 2012; Kemmanagundi, SDBDU 2003.40268, collected by SDB, 23 August 2003, SDBDU 2010.005, collected by SDB, 29 June 2010; Muthodi, SDBDU 2003.40215, collected by SDB, 2 July 2003; *Uttara Kannada dist.*, Waddighat, Yana, SDBDU 2011.1347, collected by SDB and team, 21 October 2011.

Comments. Rao (1937) described *Philautus kottigeharensis* from "Kottigehar,

Kadur" based on a sole specimen (SVL "23.00 mm"), and Bossuyt and Dubois (2001) subsequently transferred this species to *Micrixalus*. Like several other species that were described by Rao (1937) and the types for which were deposited in Central College Bangalore (CCB), the type of *Philautus kottigeharensis* is also lost (Dubois 1987 "1986"; SDB personal

Figure 35. *Micrixalus kottigeharensis* in life: **A.** dorsolateral view (NT, BNHS 5747, m); **B.** front view, **C.** dorsolateral view (RS, BNHS 5758, f); **D.** dorsolateral view, **E.** front view (RS, BNHS 5755, m); **F.** dorsolateral view (RS, BNHS 5757, m); **G.** dorsolateral view (from Kathlekan, not preserved); **H.** dorsolateral view (RS, BNHS 5749, f); **I.** dorsolateral view (RS, BNHS 5750, f); **J.** dorsolateral view (RS, BNHS 5754, f); **K.** dorsolateral view of amplected pair, **L.** front view of amplected pair (RS, BNHS 5753, f, and RS, BNHS 5751, m); **M.** dorsolateral view (RS, BNHS 5760, f); **N.** dorsolateral view (not preserved, on left), and dorsal view (RS, BNHS 5756, m, on right); **O.** front view (RS, BNHS 5751, m). Photos: SDB.

observation). We collected several specimens, comparable with Rao's description of *Philautus kottigeharensis*, from the type locality Kottigehara and its vicinity. However, due to the availability of three names—*Micrixalus kottigeharensis* (Rao, 1937), *Micrixalus narainensis* (Rao, 1937) and *Micrixalus swamianus* (Rao, 1937)—from exactly the same type locality "Kottigehar, Kadur", a species could not be confidently assigned to our recent collections. A critical study of the original descriptions of these three species (Rao 1937) shows that majority of the mentioned characters (*M. kottigeharensis:* SVL "23.00 mm" [presumably a male with "the sac with tumid lips"], "snout acutely pointed", "tongue with a papilla", "thigh as long as the tibium"; *M. swamianus*: SVL "29.00 mm" [presumably a female], "snout pointed", "conical papilla nearer to the anterior end", "tibia about as long as thigh"; *M. narainensis*: SVL "29.00 mm" [presumably a female], "snout acutely pointed", tongue "with a conical papilla", "tibia longer than the thigh"), are nearly the same in all the three species, and therefore not helpful in distinguishing them from each other.

We presume that the three taxa were described in the same publication by Rao (1937), based on members of the same population without any diagnostic characters. In our study, we found slight variations in metric and meristic characters among individuals of our new collections. These were mostly observed for some feeble characters (like skin texture, and finger and toe width), which cannot be considered diagnostic for species that were described based on a single specimen each. Our morphological analysis corroborates the molecular evidences, which showed genetic variations that are not sufficient to consider these populations as distinct species.

Therefore, on the basis of evidence provided in this study, we consider *Philautus* (= *Micrixalus*) *narainensis* and *Philautus* (= *Micrixalus*) *swamianus* to be junior subjective synonyms of *Philautus* (= *Micrixalus*) *kottigeharensis* Rao, 1937, which is prioritized by alphabetical appearance of its name in the original description. To stabilize this name, we herein designate a specimen that is most comparable with the original description as the neotype of *Philautus* (= *Micrixalus*) *kottigeharensis* Rao, 1937.

This species was identified as *Micrixalus saxicola* by Gururaja (2010) and Preininger *et al*. (2013a, 2013b), and as *Micrixalus* aff. *saxicola* by Preininger *et al*. (2013c).

Comparison. *Micrixalus kottigeharensis* could be confused with *M. saxicola* and *M. specca*. However, *M. kottigeharensis* differs from *M. saxicola* and *M. specca* by its snout pointed in dorsal view (vs. subovoid in both species) and third finger much longer, male, $F_{III}L$ 3.7 ± 0.2 mm, *N* = 8, female, $F_{III}L$ 5.1 ± 0.5 mm, *N* = 8 (vs. short in both species, *M. saxicola*: male, $F_{III}L$ 3.3 ± 0.2 mm, *N* = 9, female, $F_{III}L$ 4.3 ± 0.2 mm, *N* = 7; *M. specca*: male, $F_{III}L$ 3.1 ± 0.2 mm, *N* = 4, female, $F_{III}L$ 3.9 ± 0.3 mm, *N* = 4). More specifically differs from *M. specca* by its non-speckled dorsum in life and preservation (vs. prominently speckled) and discs of fingers proportionally smaller in comparison to finger width, male, FD_{III} 1.0 ± 0.1 mm vs. FW_{III} 0.7 ± 0.1 mm, *N* = 8; female, FD_{III} 1.2 ± 0.1 mm vs. FW_{III} 0.4 ± 0.1 mm, *N* = 8 (vs. much enlarged, male, FD_{III} 1.2 ± 0.2 mm vs. FW_{III} 0.3 ± 0.0 mm, *N* = 4; female, FD_{III} 1.6 ± 0.1 mm vs. FW_{III} 0.4 ± 0.1 mm, *N* = 4).

Description of neotype (*all measurements in mm*). Adult female (SVL 22.1); head small (HW 6.5, HL 7.6), longer than wide, flat above; snout pointed in dorsal view, acute in lateral view, its length (SL 3.5) longer than horizontal diameter of eye (EL 1.9); loreal region vertical with sharp canthus rostralis; interorbital space flat, wider (IUE 2.0) than upper eyelid (UEW 1.5); distance between back of eye (IBE 5.8) 1.6 times the distance between front of eye (IFE 3.7); nostril oval, closer to tip of snout (NS 1.6) than eye **(**EN 1.8); tympanum (TYD 0.8) 42% of eye diameter (EL 1.9); tongue moderately large, emarginate, with lingual papilla; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 4.4) shorter than hand length (HAL 5.6); finger discs moderately wide compared to finger width (fd1 0.8, fw1 0.4; fd2 1.0, fw2 0.3; fd3 1.0, fw3 0.3; fd4 0.9, fw4 0.3); subarticular tubercles well developed, oval, single, all present; prepollex weakly developed; round palmar tubercles present. Thigh length (TL 11.4) shorter to shank (SHL 12.7), and longer than foot (FOL 10.6); toe discs wide compared to toe width (td1 0.8, tw1 0.3; td2 1.1, tw2 0.3; td3 1.0, tw3 0.4; td4 1.2, tw4 0.3; td5 0.9, tw5 0.3); webbing complete: I0–0II0–0III0–0IV0–0V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles absent.

Skin of snout, between eyes and upper eyelids shagreened with scattered granular projections, minute spinular projections throughout the dorsal skin; flanks shagreened with scattered granular projections; thigh, tibia and tarsus shagreened; dermal fringe along toe V well developed from tip of toe to heel, with glandular projections ending with sharp spinules in males; ventral surface of throat and margins granular; throat, chest and abdomen smooth; posterior parts

of thigh shagreened.

Colour in preservation. Dorsum dark brown with scattered light grey spots; lateral sides of head (snout and tympanic area) light grey; flanks light brown; forelimbs, dorsal surfaces of thigh, tibia and feet light brown with light grey cross-bands, posterior parts of thigh grey with dark grey reticulations; throat, chest and belly light greyish-brown with light grey spots; hands and posterior sides of thigh light brown, feet dark brown, webbing light grey with minute black spots. **Colour in life.** Dorsum uniform reddish-brown with scattered yellowish-grey spots; lateral sides of head (snout and tympanic area) light reddish-brown; iris light golden brown with reddish tinge; flanks light reddish-brown; groin light grey with scattered dark grey spots; dorsal surface of limbs greyish-brown with dark brown cross-bands; throat and chest greyish-white; belly grey; thigh and shank grey with light brown spots; foot dark grey.

Variations. See Table 5 for morphometric characters of eight adult males (including neotype) and eight adult females. For colour variations see Figures 35 and 36.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured. Female (BNHS 5760): ova yellowish-white with minute black spots (diameter 1.7–2.0 mm, $N = 10$).

Distribution. *Micrixalus kottigeharensis* is known only from the Western Ghats state of Karnataka. This species is wide-ranging throughout the state, but its distribution is restricted to the north of Palghat gap and south of Goa gap. The present study found this species in Kemmanagundi, Kottigehara and Muthodi (Chikmagalur dist.), Charmadi Ghats (Dakshina Kannada dist.), Sakleshpur (Hassan dist.), Kathlekan, Unchalli falls and Waddighat (Uttara Kannada dist.) (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is fast flowing streams and rivulets in primary and secondary forests. *Micrixalus kottigeharensis* was found to be relatively abundant at all the collection localities. The majority of male specimens were found actively calling and 'foot-flagging'. Collections were made between 08:00–18:00 h.

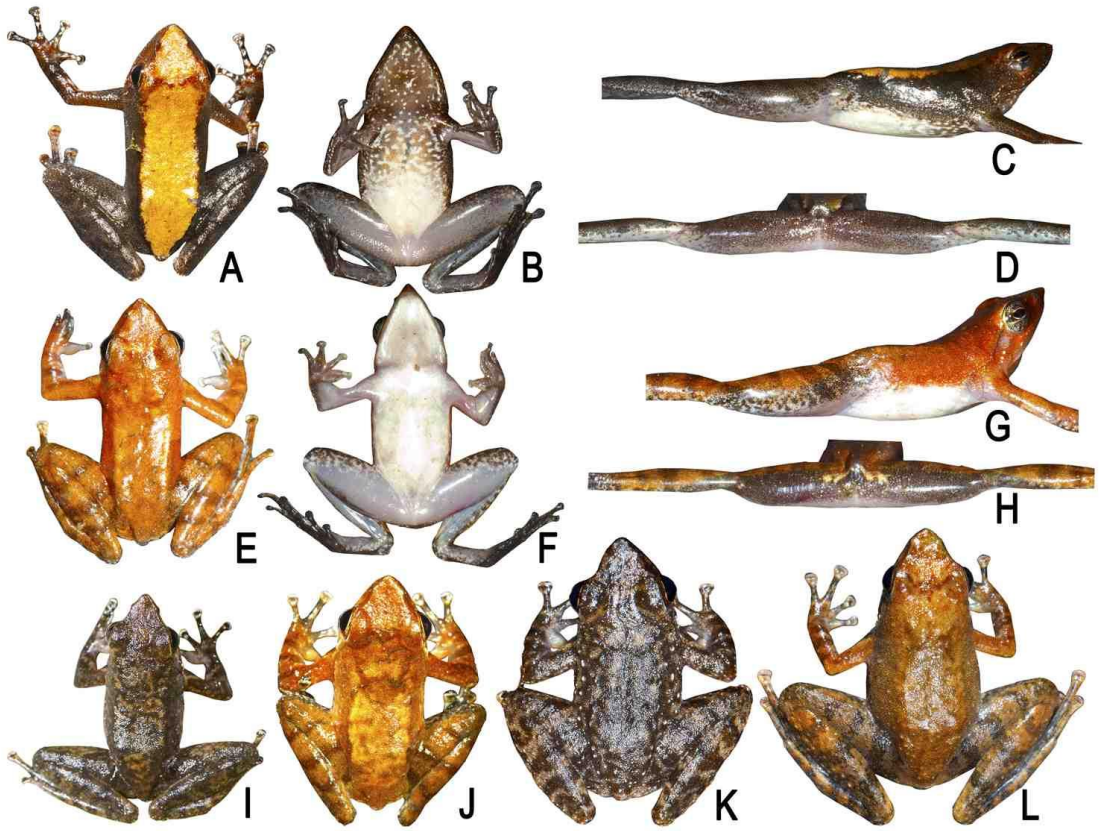

Figure 36. *Micrixalus kottigeharensis* in life: **A.** dorsal view, **B.** ventral view, **C.** lateral view of thigh and groin, **D.** posterior side of thighs (RS, BNHS 5758, f); **E.** dorsal view, **F.** ventral view, **G.** lateral view of thigh and groin, **H.** posterior side of thighs (RS, BNHS 5755, m); **I.** dorsal view (RS, BNHS 5756, m); **J.** dorsal view (RS, BNHS 5752, m); **K.** dorsal view (not preserved); **L.** dorsal view (RS, BNHS 5762, f). Photos: SDB.

***Micrixalus saxicola* (Jerdon, 1854)**
Wayanad Dancing Frog
(Figs 3, 34B, 37, 38; Tables 1–5)

Original name and description. *Polypedates ? saxicola* Jerdon, 1854 "1853". Catalogue of reptiles inhabiting the Peninsula of India, *Journal of the Asiatic Society of Bengal* 22: 533. **Lectotype.** BMNH 72.4.17.203, an adult female (SVL 28.8 mm), by present designation. **Lectotype locality.**"Malabar". **Current status of specific name.** Valid name, as *Micrixalus saxicola* (Jerdon, 1854).

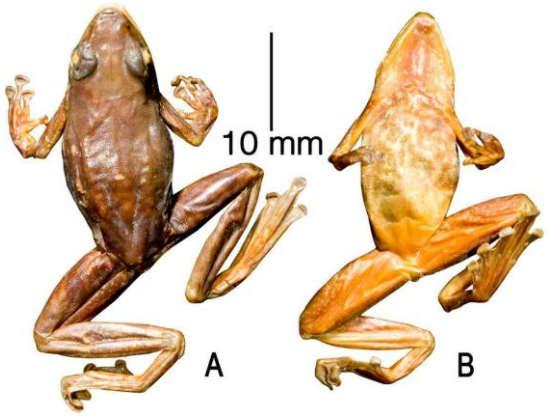

Figure 37. Lectotype of *Micrixalus saxicola*, NHM 72.4.17.203 (SVL 28.8 mm), from "Malabar": **A.** dorsal view, **B.** ventral view.

Referred specimens. *Kerala*: *Wayanad dist.*, Periya, BNHS 5763, an adult male, collected by SDB and Systematics lab team, 20 July 2012, and BNHS 5764, an adult female, collected by SDB, 15 September 2002; Banasura, BNHS 5765, an adult female, collected by SDB, 14 September 2002; Kurichiyarmala, BNHS 5766, an adult male, BNHS 5767, an adult female, collected by SDB and SG, 5 June 2012; Settukunnu, BNHS 5768, an adult female, collected by SDB and Systematics lab team, 15 August 2011; *Kannur dist.*, Aralam, BNHS 5769–BNHS 5770, two adult males, collected by SDB and Systematics lab team, 25 September 2011; ***Karnataka*:** *Chikmagalur dist.*, Kottigehara, BNHS 5771, an adult male, collected by SDB, 17 November 2010; *Dakshina Kannada dist.*, Charmadi Ghats, BNHS 5772, an adult female, collected by SDB and Systematic lab team, 23 October 2011; *Hassan dist.* Maranhalli, BNHS 5773, an adult male, collected by SDB and Systematic lab team, 30 September 2012; Kempholay, BNHS 5774, an adult male, collected by SDB, 16 November 2010; *Kodagu dist.*, Yavakapady, Coorg, BNHS 5775, an adult male, and BNHS 5776, an adult female, collected by SDB and Systematics lab team, 4 October 2012; *Uttara Kannada dist.*, Unchalli falls, BNHS 5777, an adult male, collected by KVG and GS, 28 September 2012.

Other material studied. *Kerala*: *Wayanad dist.*, Banasura, SDBDU 2002.3021, an adult female, collected by SDB, 14 September 2002; Periya, SDBDU 2012.911, collected by SDB and Systematics lab team, 20 July 2012; Settukunnu, SDBDU 2011.854, collected by SDB and Systematics lab team, 15 August 2011; Suganthagiri, SDBDU 2005.4736, collected by SDB 15 October 2005, and SDBDU 2007.5092, collected by SDB, 14 August 2007; *Kannur dist.*, Aralam, SDBDU 2011.1084, collected by SDB and Systematics lab team, 25 September 2011; Meenmutty, Aralam, SDBDU 2008.427, collected by SDB, 5 June 2008; ***Karnataka:** Hassan dist.*, Kempholay, SDBDU 2010.010, collected by SDB, 16 November 2010; Sakleshpur, SDBDU 2005.4599 and SDBDU 2005.4661, collected by SDB, 2 October 2005.

Comments. Jerdon (1854 "1853") described *Polypedates? saxicola* with a very short description and mentioned its 'type locality' as "found on rocks in shady mountain streams in Malabar and Wynaad". Jerdon's collections were presumably in ZSIC but later Jerdon (1870) himself reported them as lost. Subsequent workers (Dutta, 1997; Chanda *et al.*, 2000) confirmed this, and our study also could not find any specimens of *Polypedates? saxicola* Jerdon 1853 in ZSIC. However, we examined the 'syntype' series (NHM 72.4.17.203–7, 72.4.17.221–222) currently available in NHM, with a bottle label "N. canara" as the locality. According to Boulenger (1882) and the NHM catalogue, these specimens were 'purchased' from Jerdon and are collections from "Malabar". Therefore we consider these as the syntypes. We also studied new collections from Periya (Wayanad dist.), which is also mentioned in the original description, and found them comparable to the syntype series in NHM. In order to avoid further confusion and for nomenclatural stability, we hereby designate the largest female specimen, NHM 72.4.17.203 (SVL 28.8 mm), as lectotype of this species (Fig. 37).

Comparison. *Micrixalus saxicola* could be confused with *M. kottigeharensis* and *M. specca.* However, *M. saxicola* differs from *M. specca* by its thigh equal to shank length, male, TL 12.2 ± 0.4 mm, SHL 12.2 ± 0.4 mm, *N* = 9, female, TL 14.7 ± 0.3 mm, SHL 14.7 ± 0.4 mm, *N* = 7 (vs. shorter, male, TL 11.3 ± 1.5 mm, SHL 12.9 ± 0.5 mm, *N* = 4, female, TL 14.7 ± 0.5 mm, SHL 15.7 ± 0.6 mm, *N* = 4), third finger longer, male, $F_{III}L$ 3.3 ± 0.2 mm, *N* = 9, female, $F_{III}L$ 4.3 ± 0.2 mm, *N* = 7 (vs. short, male, $F_{III}L$ 3.1 ± 0.2 mm, *N* = 4, female, $F_{III}L$ 3.9 ± 0.3 mm, *N* = 4) (Fig. 34).

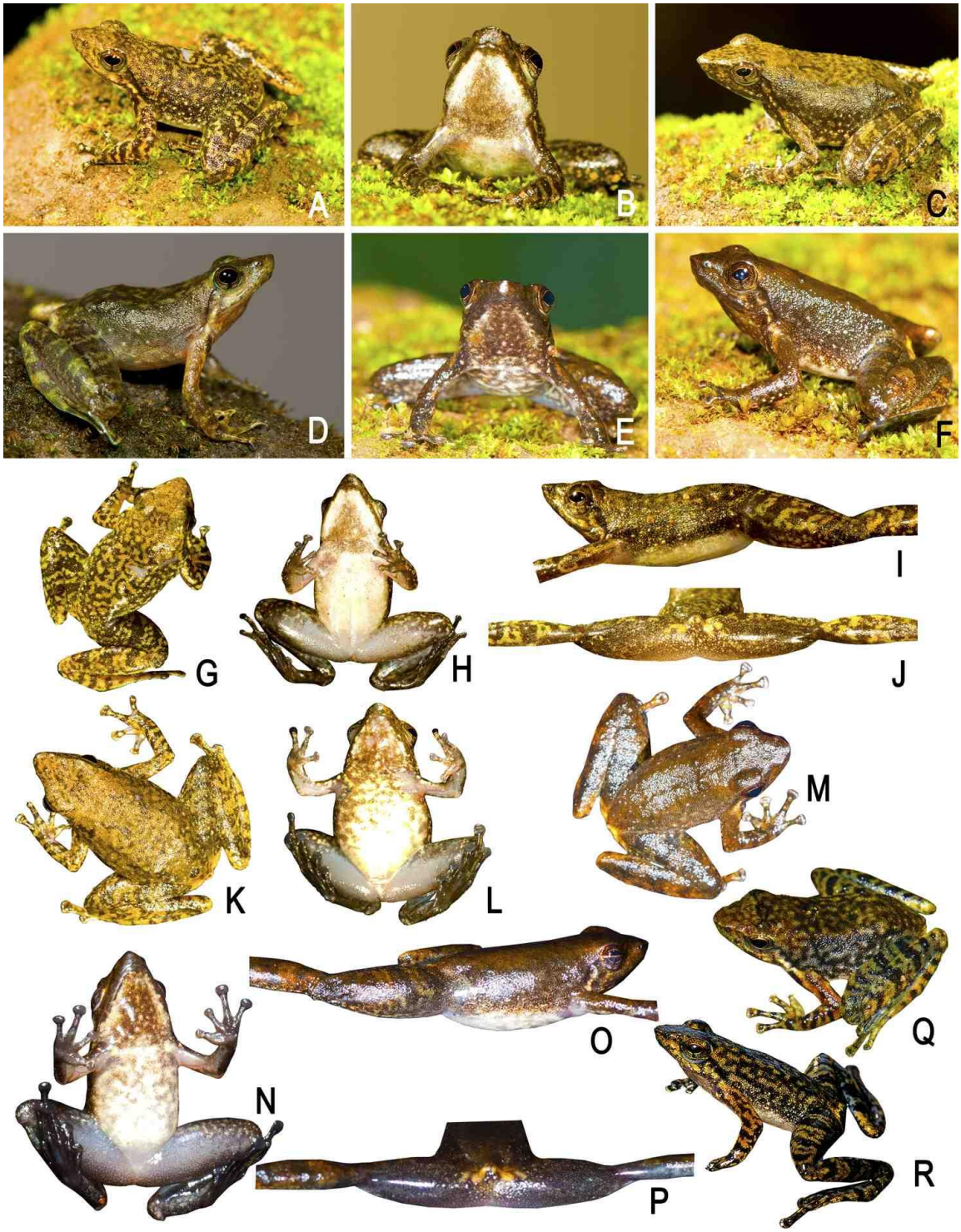

Figure 38. *Micrixalus saxicola* in life: **A.** dorsolateral view, **B.** front view (RS, BNHS 5766, m); **C.** dorsolateral view (RS, BNHS 5767, f); **D.** dorsolateral view (RS, BNHS 5772, f); **E.** front view (RS, BNHS 5775, m); **F.** dorsolateral view (RS, BNHS 5764, f); **G.** dorsal view, **H.** ventral view, **I.** lateral view of thigh and groin, **J.** posterior side of thighs (RS, BNHS 5766, m); **K.** dorsal view, **L.** ventral view (RS, BNHS 5767, f); **M.** dorsal view (RS, BNHS 5776, f); **N.** ventral view, **O.** lateral view of thigh and groin, **P.** posterior side of thighs (RS, BNHS 5775, m); **Q.** dorsolateral view (RS, BNHS 5763, m); **R.** dorsolateral view (RS, BNHS 5773, m). Photos: SDB.

For differences with *Micrixalus kottigeharensis*, see 'Comparison' of that species.

Description of lectotype (*all measurements in mm*). Adult female (SVL 28.8); head small (HW 7.6, HL 9.7), longer than wide, flat above; snout appears subovoid in dorsal view (due to specimen damage an accurate judgment of snout shape cannot be made), its length (SL 4.1) longer than horizontal diameter of eye (EL 3.5); loreal region vertical; interorbital space flat, wider (IUE 2.5) than upper eyelid (UEW 1.9); nostril oval, closer to eye (EN 1.8) than tip of snout (NS 2.1); tympanum (TYD 1.4) 40% of eye diameter (EL 3.5); tongue moderately large, emarginate, with lingual papilla; supratympanic fold that extends from posterior corner of eye to near the shoulder, weakly developed. Forelimbs (FAL 5.2) shorter than hand length (HAL 6.2); finger discs moderately wide compared to finger width (fd1 1.0, fw1 0.4; fd2 1.0, fw2 0.4; fd3 1.1, fw3 0.4; fd4 1.1, fw4 0.5); subarticular tubercles well developed, oval, single, all present; prepollex weakly developed; weakly developed round palmar tubercles present. Thigh length (TL 14.7) subequal to shank (SHL14.8), and longer than foot (FOL 13.3); toe discs wide compared to toe width (td1 1.0, tw1 0.4; td2 1.1, tw2 0.4; td3 1.3, tw3 0.4; td4 1.3, tw4 0.4; td5 1.1, tw5 0.4); webbing complete: I0–0II0–0III0–0IV0–0V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles weakly developed.

Skin of snout, between eyes and upper eyelids shagreened; flanks shagreened with scattered granular projections; thigh, tibia and tarsus shagreened; ventral surface of throat and margins shagreened; throat, chest and abdomen smooth; posterior parts of thigh shagreened.

Colour in preservation. Dorsum dark brown; lateral sides of head (snout and tympanic area) light grey; flanks light brown; forelimbs, dorsal surfaces of thigh, tibia and feet light greyish-brown with dark grey cross-bands, posterior parts of thigh dark greyish-brown with light grey marbling; throat, chest and belly light greyish-yellow with minute black spots; hands and posterior sides of thigh light brown; feet dark brown; webbing light grey with minute black spots.

Variations. See Table 5 for morphometric characters of nine adult males and seven adult females (including lectotype). For colour variations see Figure 38.

Secondary sexual characters. Female: ova yellowish-white with minute black spots (diameter 1.7–1.9 mm, *N* = 10). Males (BNHS 5771): Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; dermal fringe along toe V well developed from tip of toe to heel, with glandular projections ending with sharp spinules in males.

Distribution. *Micrixalus saxicola* has a wide distribution in Karnataka and adjoining regions in Kerala, but its range is restricted to the north of Palghat gap and south of Goa gap in the Western Ghats. The present study found this species in Banasura, Periya, Kurichiyarmala, Settukunnu and Suganthagiri (Wayanad dist.), Aralam and Meenmutty (Kannur dist.) in Kerala; Kottigehara (Chikmagalur dist.), Charmadi Ghats (Dakshina Kannada dist.), Kempholay, Maranhalli and Sakleshpur (Hassan dist.), Yavakapady, Coorg (Kodagu dist.), and Unchalli falls (Uttara Kannada dist.) in Karnataka (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is fast flowing streams and rivulets in primary and secondary forests. *Micrixalus saxicola* was very commonly found at all the collection localities. The majority of male specimens were found actively calling from rocks emerging near the splash zones of streams. 'Foot-flagging' was observed in males and collections were made between 08:00–18:00 h.

***Micrixalus specca* sp. nov.**

Spotted Dancing Frog

(Figs 3, 34C, 39; Tables 1–5)

Holotype. BNHS 5778, an adult male, Charmadi Ghats, Dakshina Kannada dist., Karnataka state, India, collected by SDB and Systematics lab team, 23 October 2011.

Paratypes. *Karnataka*: *Dakshina Kannada dist.*, Charmadi Ghats, BNHS 5779–BNHS 5781, three adult males, and BNHS 5782–BNHS 5785, four adult females, collected along with holotype.

Comparison. *Micrixalus specca* could be confused with *M. kottigeharensis* and *M. saxicola*. For more differences with *M. kottigeharensis* and *M. saxicola* see 'Comparison' of those species.

Description of holotype *(measurements in mm)*. Adult male (SVL 22.8); head small (HW 6.8, HL 8.6), longer than wide, flat above; snout subovoid in dorsal view, acute in lateral view, its length (SL 3.6) longer than horizontal diameter of eye (EL 2.7); loreal region vertical, sharp canthus rostralis; interorbital space flat, wider (IUE 2.0) than upper eyelid (UEW 1.6) and narrower than internarial distance (IN 2.4); distance between back of eye (IBE 5.9) 1.6 times the distance between front of eye (IFE 3.8); nostril oval, nearly as close to eye (EN 1.7) as to tip of snout (NS 1.6); tympanum (TYD 0.9) 33% of eye diameter (EL 2.7); tongue moderately large, emarginate, with median lingual papillae; supratympanic fold that extends from posterior corner of eye to near

the shoulder, weakly developed. Forelimbs (FAL 4.7) shorter than hand length (HAL 5.0); finger discs moderately wide compared to finger width (fd1 1.1, fw1 0.3; fd2 1.1, fw2 0.3; fd3 1.2, fw3 0.3; fd4 1.2, fw4 0.3); subarticular tubercles well developed, oval, single, all present. Thigh shorter (TL 11.9) than shank (SHL 13.0), and longer than foot (FOL 11.4); toe discs wide compared to toe width (td1 1.0, tw1 0.3; td2 1.4, tw2 0.3; td3 1.3, tw3 0.3; td4 1.5, tw4 0.2; td5 1.0, tw5 0.2); webbing complete: I0–0II0–0III0–0IV0–0V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles absent.

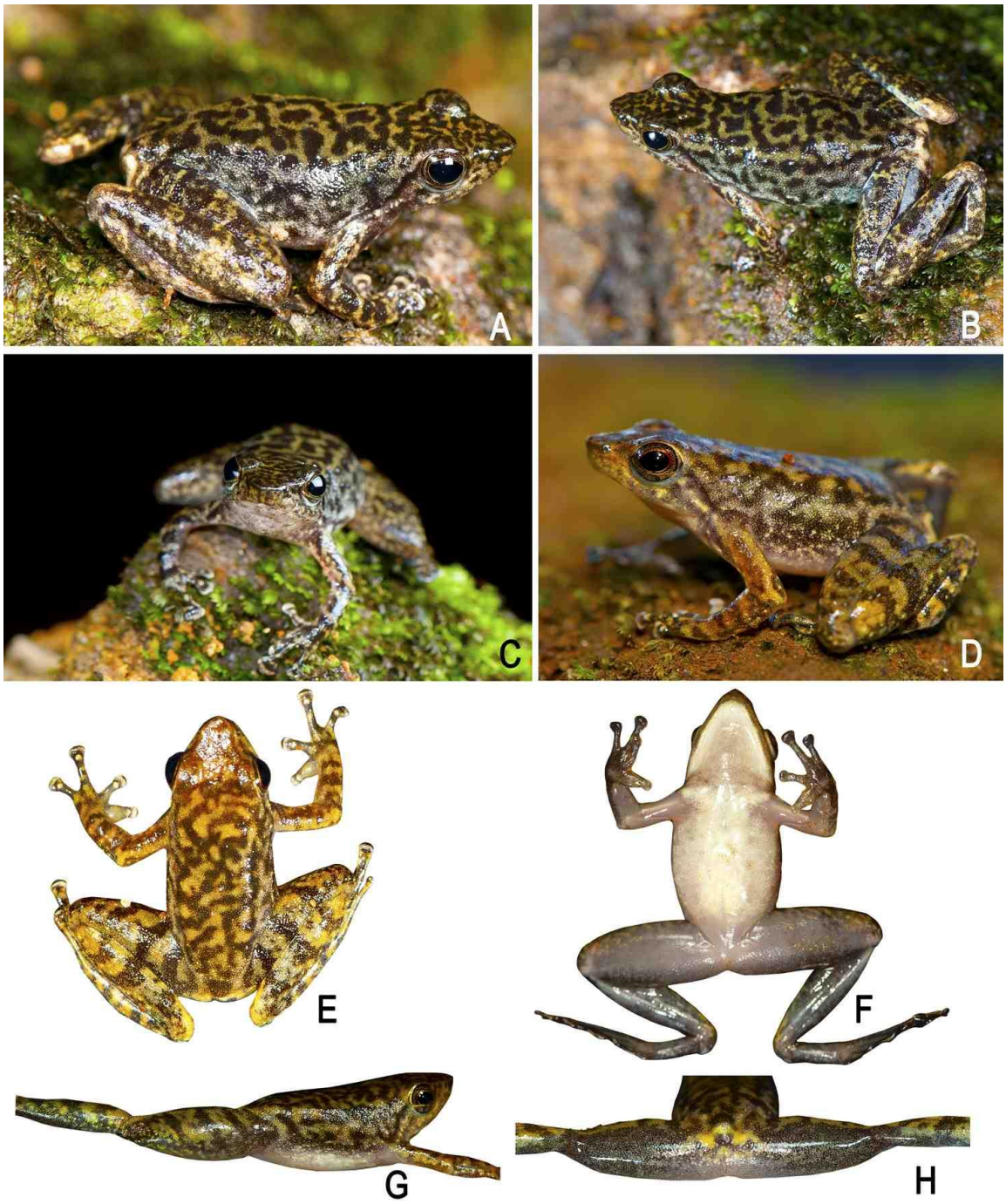

Figure 39. *Micrixalus specca* sp.nov. in life: **A.** dorsolateral view (HT, BNHS 5778, m); **B.** dorsolateral view, **C.** front view (PT, BNHS 5782, f); **D.** dorsolateral view (PT, BNHS 5779, m); **E.** dorsal view, **F.** ventral view, **G.** lateral view of thigh and groin, **H.** posterior side of thigh (PT, BNHS 5781, m). Photos: SDB.

Skin of snout, between eyes, upper eyelids and posterior part of back shagreened with prominent sharp spinules intermitted by scattered granular projections; flanks shagreened with scattered granular projections; dorsal parts of forelimb, thigh, tibia and tarsus shagreened with glandular projections; dermal fringe along toe V well developed from tip of toe to heel, with glandular projections ending with sharp spinules in males; ventral surfaces of throat, chest and abdomen smooth; posterior parts of thigh shagreened.

Colour in preservation. Dorsum blackish-brown with grey reticulations; flanks dark brown with grey reticulations extending from the dorsal surface; tympanic area greyish-brown; forelimbs, dorsal surfaces of thigh, tibia and feet blackish-brown with dark brown cross-bands, posterior parts of thigh light brown with dark grey reticulations; throat, chest and belly light grey with minute black spots; margins of shank light brown; feet light brown; webbing blackish-grey. **Colour in life.** Dorsum and flanks blackish-brown with uniform greyish-yellow reticulations; tympanum and surrounding areas blackish-brown; iris light brown; groin light bluish-brown; dorsal surface of limbs greyish-brown with dark brown cross-bands; throat, chest and belly light greyish-white; foot blackish-grey.

Variations. See Table 5 for morphometric characters of four adult males and four adult females. For colour variations see Figure 39.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5782): ova creamy white with black reticulations (diameter 1.1–1.4 mm, *N* = 20).

Etymology. The species epithet is a noun in apposition, therefore invariable, derived from the Latin word *'specca'* meaning speckled, referring to the prominent reticulations or spots on dorsal surface of this species.

Distribution. *Micrixalus specca* is known only from its type locality Charmadi Ghats (Dakshina Kannada dist., Karanataka state), which lies north of Palghat gap and south of Goa gap in the Western Ghats (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is flowing streams covered with forest canopy. The male specimens were found actively calling and 'foot-flagging'. Collections were made between 08:00–16:00 h.

Micrixalus silvaticus group

Members. *Micrixalus frigidus* sp. nov., *Micrixalus nigraventris* sp. nov., *Micrixalus phyllophilus* and *Micrixalus silvaticus.*

This group can be distinguished from other *Micrixalus* groups by the combination of following morphological characters: small adult size (male, SVL 18.0–26.0 mm; female, SVL 23.0–33.0 mm); dorsolateral folds well developed; fourth toe webbing does not extend beyond the second subarticular tubercle on either side; a white streak that starts from the tip of snout, extends over the eyes and tympanum, and ends near the shoulder; lateral sides of head (snout and tympanic area) distinctly blackish-brown; one of the more widely distributed groups that is found on both sides of the Palghat gap in the Western Ghats (but neither south of Shencottah gap, nor north of Goa gap), with narrow and restricted geographical range of individual species (Fig. 40).

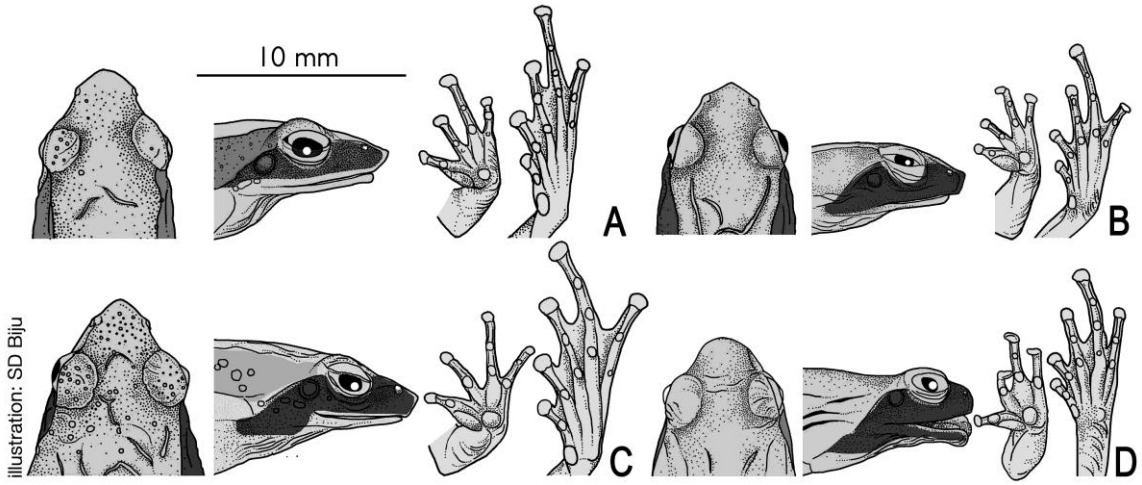

Figure 40. From left to right: dorsal view of head, lateral view of head, ventral view of hand and ventral view of foot of *Micrixalus silavticus* group: **A.** *Micrixalus frigidus* sp. nov. (HT, BNHS 5786, m); **B.** *Micrixalus nigraventris* sp. nov. (HT, BNHS 5793, m); **C.** *M. phyllophilus* (NT, NHM 1947.2.29.87, m); **D.** *M. silvaticus* (LT, NHM 82.2.10.52, f).

***Micrixalus frigidus* sp. nov.**
Cold Stream Dancing Frog
(Figs 3, 40A, 41; Tables 1–5)

Holotype. BNHS 5786, an adult male, Eravikulam National Park, Idukki dist., Kerala state, India, collected by SDB, 14 March 2001.

Paratypes. ***Kerala*****:** *Idukki dist.*, Eravikulam National Park, BNHS 5787, an adult female, collected along with the holotype, BNHS 5788, an adult female, collected by SDB, 22 July 2002; ***Tamil Nadu*****:** *Coimbatore dist.*, Grass hills, BNHS 5789, an adult male, and BNHS 5790–BNHS 5792, three adult females, collected by SDB, 12 July 2005.

Comparison. *Micrixalus frigidus* could be confused with *M. nigraventris*, *M. phyllophilus* and *M. silvaticus*. However, *M. frigidus* differs from *M. nigraventris* by its larger adult size, male, SVL 24.0–25.9 mm, *N* = 2, female, SVL 29.6–32.7 mm, *N* = 5 (vs. small, male, SVL 20.7–20.9 mm, *N* = 2, female, SVL 23.0–26.6 mm, *N* = 3), snout acute in lateral view (vs. vertical), third toe webbing extending up to the disc on the outside (vs. below the first subarticular tubercle), ventral surface brownish-yellow with prominent light yellow reticulations (vs. dark brownish-black with prominent creamy white irregular patches); differs from *M. phyllophilus* by its snout subelliptical in dorsal view (vs. subovoid), tongue without lingual papilla (vs. with lingual papilla), groin yellow with light grey tinge (vs. red); differs from *M. silvaticus* by its larger adult size, male, SVL 24.0–25.9 mm, *N* = 2, female, SVL 29.6–32.7 mm, *N* = 5 (vs. small, male, SVL 18.5–19.8 mm, *N* = 3, female, SVL 25.4–26.0 mm, *N* = 3), body slender (vs. robust), snout subelliptical in dorsal view (vs. rounded), acute in lateral view (vs. rounded).

Description of holotype *(measurements in mm)*. Adult male (SVL 24.0); head small (HW 7.7, HL 8.8), longer than wide, flat above; snout subelliptical in dorsal view, acute in lateral view, its length (SL 3.6) longer than horizontal diameter of eye (EL 2.6); loreal region vertical and concave with rounded canthus rostralis; interorbital space flat, wider (IUE 2.7) than upper eyelid (UEW 1.5) and narraower than internarial distance (IN 3.2); distance between back of eye (IBE 6.5) 1.6 times the distance between front of eye (IFE 4.0); nostril oval, closer to tip of snout (NS 1.6) than eye (EN 1.9); tympanum (TYD 1.1) 42% of eye diameter (EL 2.6); tongue moderately large, emarginate, without lingual papilla; supratympanic fold that extends from posterior corner of eye to near the shoulder, well developed. Forelimbs (FAL 4.4) shorter than hand length (HAL 7.0); finger discs moderately wide compared to finger width (fd1 0.7, fw1 0.3; fd2 0.8, fw2 0.3; fd3 1.1, fw3 0.2; fd4 0.8, fw4 0.3); subarticular tubercles weakly developed, oval, single, all present; prepollex weakly developed; round palmar tubercles; a distinct supernumerary tubercle at the base of each finger. Thigh length (TL 12.3) shorter than shank (SHL 12.8), and longer than foot (FOL 11.9); toe discs wide compared to toe width (td1 0.8, tw1 0.3; td2 1.0, tw2 0.3; td3 1.0, tw3 0.4; td4 1.1, tw4 0.3; td5 0.8, tw5 0.3); webbing present: I1–$1^{2}/_{3}$II1–2III1–3IV3–1V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes shagreened, upper eyelids shagreened to finely granular; posterior part of back shagreened to sparsely granular; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, well developed; scattered glandular ridge on dorsum; anterior and posterior parts of flanks shagreened and sparsely granular with scattered tubercles; dorsal parts of forelimb shagreened to finely granular; thigh, tibia and tarsus with weakly developed granular projections and glandular ridge; ventral surface of throat, chest and abdomen smooth; posterior parts of thigh sparsely granular.

Colour in preservation. Dorsum light brown; a grey streak starting from the tip of snout, extending over the eyes and tympanum, ending near the shoulder; lateral sides of head (snout and tympanic area) distinctly dark grey; flanks dark grey with black speckles; dorsolateral folds light brown; forelimbs, dorsal surfaces of thigh, tibia and feet light brown with dark brown cross-bands, posterior parts of thigh light grey with dark greyish-brown reticulations; throat, chest and belly greyish-white with dark grey reticulations; ventral parts of thigh light grey with scattered dark grey spots, tibia and feet brownish-black; webbing blackish-grey. **Colour in life.** Dorsum uniform reddish-brown; a white streak starting from the tip of snout, extending over the eyes and tympanum, ending near the shoulder; lateral sides of head (snout and tympanic area) distinctly blackish-brown; iris light brown with reddish tinge; flanks light yellowish-grey; groin yellow with light grey tinge; dorsal surface of limbs reddish-brown with dark brown cross-bands; throat, chest and belly light greyish-brown with minute black spots; thigh brownish-yellow with prominent light yellow reticulations; shank and foot dark grey with light bluish-grey spots.

Variations. See Table 5 for morphometric characters of two adult males and five adult females. For colour variations see Figure 41.

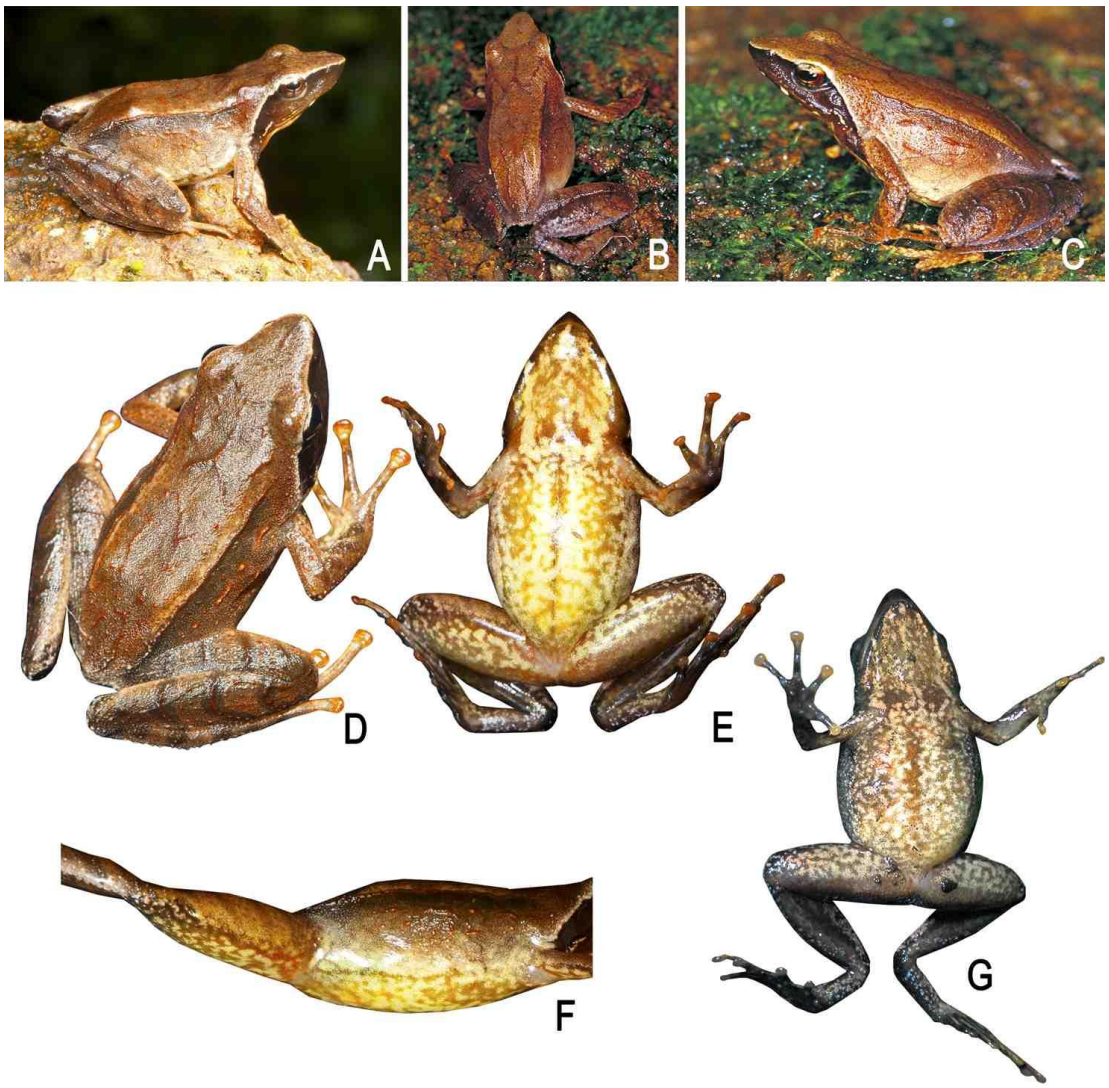

Figure 41. *Micrixalus frigidus* sp. nov. in life: **A.** dorsolateral view, **B.** dorsal view (PT, BNHS 5791, f); **C.** dorsolateral view, **D.** dorsal view, **E.** ventral view, **F.** lateral view of thigh and groin (PT, BNHS 5788, f); **G.** dorsal view (PT, BNHS 5792, f). Photos: SDB.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5788): ova creamy white with minute black spots (diameter 1.0–1.4 mm, *N* = 20).

Etymology. The species epithet is a noun in apposition, therefore invariable, derived from the Latin word '*frigidus*'meaning cold, referring to high altitude cold streams that are the predominant habitat of this species.

Distribution. *Micrixalus frigidus* is known only from the Western Ghats states of Kerala and Tamil Nadu, with its distribution restricted between the Palghat gap and Shencottah gap. The present study found this species in Eravikulam National Park (Idukki dist.) in Kerala state, and Grass hills (Coimbatore dist.) in Tamil Nadu state (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is shallow waters on the sides of streams covered with forest canopy. However, BNHS 5791–BNHS 5792 (Grass hills) were collected from a marshy area located away from streams inside a shola forest. *Micrixalus frigidus* was found in high altitude cold streams above the elevations of 1800 m asl. The majority of male specimens were found actively calling and collected between 08:00–14:00 h.

***Micrixalus nigraventris* sp. nov.**
Black-Bellied Dancing Frog
(Figs 3, 40B, 42; Tables 1–5)

Holotype. BNHS 5793, an adult male, Kodaikanal, Dindigul dist., Tamil Nadu state, India, collected by SDB, 17 March 2002.

Paratypes. ***Tamil Nadu*:** *Dindigul dist.*, Kodaikanal, BNHS 5794, an adult male, and

BNHS 5795, an adult female, collected along with holotype; ***Kerala*****:** *Idukki dist.*, Eravikulam National Park, BNHS 5796–BNHS 5797, two adult females, collected by SDB and Systematics lab team, 21 September 2011.

Comparison. *Micrixalus nigraventris* could be confused with *M. frigidus*, *M. phyllophilus* and *M. silvaticus*. However, *M. nigraventris* differs from *M. phyllophilus* by its smaller size, male, SVL 20.7–20.9 mm, *N* = 2, female, SVL 23.0–26.6 mm, *N* = 3 (vs. larger, male, SVL 22.5–25.9 mm, *N* = 7, female, SVL 28.9–32.5 mm, *N* = 3), snout subelliptical in dorsal view (vs. subovoid), snout vertical in lateral view (vs. acute), fourth toe webbing below the second subarticular tubercle on either side (vs. beyond the second subarticular tubercle on either side), tongue without lingual papilla (vs. with lingual papilla), groin yellowish-brown with creamy white patches (vs. red), ventral surface brownish-black with prominent creamy white irregular patches (vs. brownish-yellow with prominent light yellow reticulations); differs from *M. silvaticus* by its snout subelliptical in dorsal view (vs. rounded), snout vertical in lateral view (vs. rounded), third toe webbing extending up to the first subarticular tubercle on either side (vs. just beyond the second subarticular tubercle on either side), ventral surface brownish-black with prominent creamy white irregular patches (vs. creamy white with orange reticulations).

For more differences with *Micrixalus frigidus* see 'Comparison' of that species.

Description of holotype *(measurements in mm)*. Adult male (SVL 20.7); head small (HW 6.8, HL 6.4), longer than wide, flat above; snout subelliptical in dorsal view, vertical in lateral view, its length (SL 3.3) longer than horizontal diameter of eye (EL 2.3); loreal region acute and concave with rounded canthus rostralis; interorbital space flat, wider (IUE 2.6) than upper eyelid (UEW 1.6) and narrower than internarial distance (IN 3.0); distance between back of eye (IBE 6.2) 1.7 times the distance between

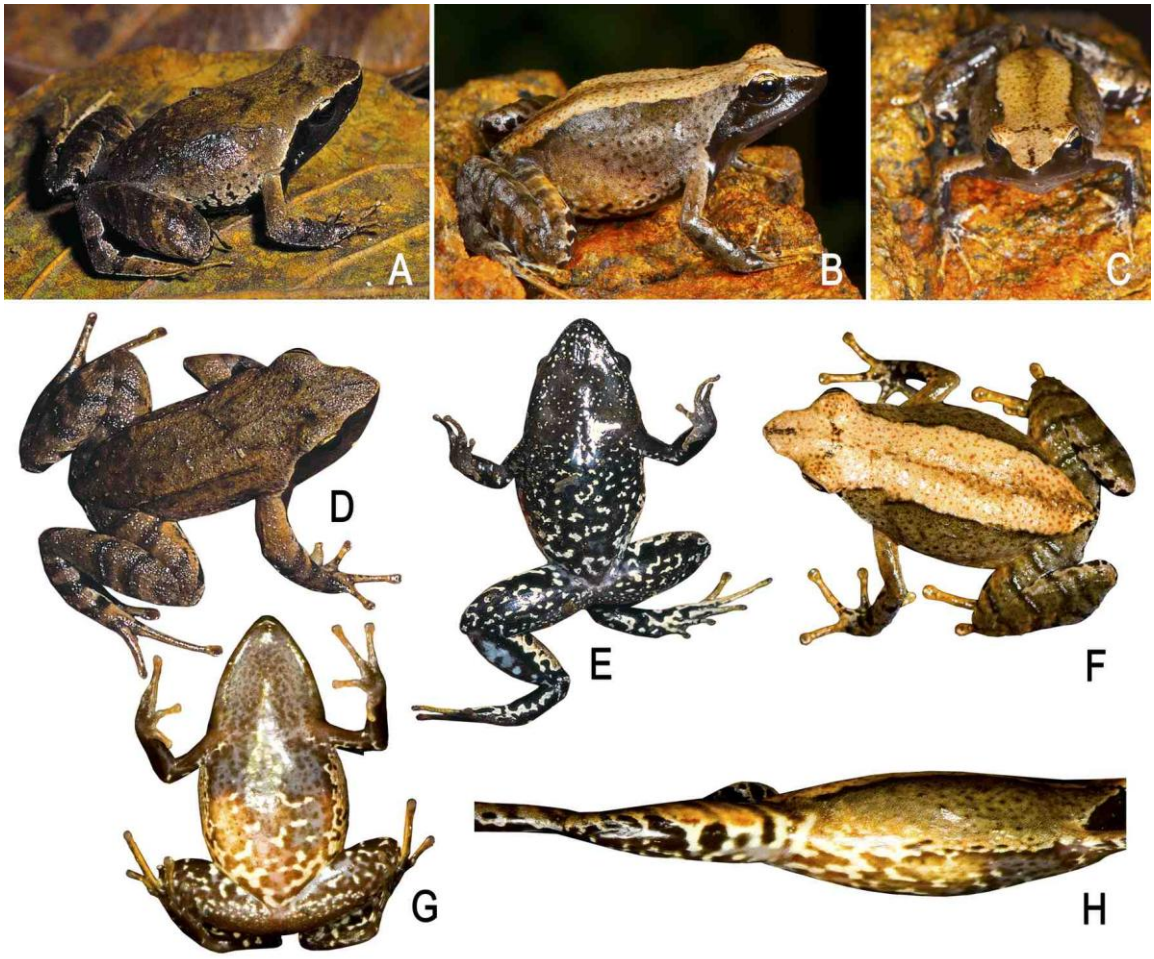

Figure 42. *Micrixalus nigraventris* sp. nov. in life: **A.** dorsolateral view (HT, BNHS 5793, m); **B.** dorsolateral view, **C.** front view (PT, BNHS 5797, f); **D.** dorsal view, **E.** ventral view (PT, BNHS 5794, m); **F.** dorsal view, **G** ventral view, **H.** lateral view of thigh and groin (PT, BNHS 5797, f). Photos: SDB.

front of eye (IFE 3.6); nostril oval, closer to eye (EN 1.4) than tip of snout (NS 1.6); tympanum (TYD 0.7) 30% of eye diameter (EL 2.3); tongue moderately large, emarginate, without lingual papilla; supratympanic fold that extends from posterior corner of eye to near the shoulder, well developed. Forelimbs (FAL 4.3) shorter than hand length (HAL 5.3); finger discs moderately wide compared to finger width (fd1 0.5, fw1 0.3; fd2 0.6, fw2 0.2; fd3 0.7, fw3 0.3; fd4 0.6, fw4 0.2); subarticular tubercles weakly developed, oval, single, all present; prepollex weakly developed; round palmar tubercles. Thigh length (TL 10.1) equal to shank (SHL 10.1), and longer than foot (FOL 9.5); toe discs wide compared to toe width (td1 0.6, tw1 0.3; td2 0.6, tw2 0.3; td3 0.7, tw3 0.3; td4 0.6, tw4 0.2; td5 0.7, tw5 0.2); webbing present: I1–2II1–2III2–3IV3–2V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes and upper eyelids shagreened; posterior part of back shagreened to sparsely granular; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, well developed; scattered glandular ridge on dorsum; flanks shagreened and sparsely granular; dorsal parts of forelimb shagreened; thigh, tibia and tarsus with weakly developed granular projections and glandular ridge; ventral surface of throat, chest and abdomen smooth; posterior parts of thigh shagreened to sparsely granular.

Colour in preservation. Dorsum light brown; a light grey streak starting from the tip of snout, extending over the eyes and tympanum and ending near the shoulder; lateral sides of head (snout and tympanic area) distinctly dark grey; posterior parts of flank dark brownish-grey with black speckles; forelimbs, dorsal surfaces of thigh, tibia and feet light greyish-brown with dark brown cross-bands, posterior parts of thigh light grey with dark greyish-brown reticulations; throat, chest and belly grey with reticulations. **Colour in life.** Anterior part of dorsum greyish-brown with dark grey specks, posterior part of dorsum blackish-brown with black patches; a white streak starting from the tip of snout, extending over the eyes and tympanum, and ending near the shoulder; lateral sides of head (snout and tympanic area) distinctly black; iris brown with reddish tinge; flanks light brownish-grey with light grey reticulations; groin yellowish-brown with creamy white patches; dorsal surface of limbs greyish-brown with light brown cross-bands; throat, chest, belly, thigh, shank and foot dark brownish-black with prominent creamy white irregular patches.

Variations. See Table 5 for morphometric characters of two adult males and three adult females. For colour variations see Figure 42.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5797): ova creamy white with minute black spots (diameter 1.0–1.6 mm, *N* = 20).

Etymology. The species epithet is a noun in apposition, therefore invariable, derived from two Latin words—'*nigra*' meaning black and '*ventris*' meaning belly—referring to the prominent black ventral surface of this species.

Distribution. *Micrixalus nigraventris* is known only from the Western Ghats states of Kerala and Tamil Nadu, with its distribution restricted between the Palghat gap and Shencottah gap. The present study found this species in Eravikulam National Park (Idukki dist.) in Kerala state, and Kodaikanal (Dindigul dist.) in Tamil Nadu state (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is shallow and slow moving streams in shola forests of Eravikulam National Park. Animals from Kodaikanal were collected from moist leaf litter inside a shola forest. *Micrixalus nigraventris* was found at high altitudes (above 1780 m asl). The majority of male specimens were found actively calling and collected between 08:00–14:00 h.

*Micrixalus phyllophilus (*Jerdon, 1854)

Nilgiri Dancing Frog

(Figs 3, 40C, 43A–B, 44; Tables 1–5)

Original name and description. *Limnodytes ? phyllophila* Jerdon, 1854 "1853". Catalogue of reptiles inhabiting the Peninsula of India. *Journal of the Asiatic Society of Bengal* 22:532. **Neotype.** BMNH 1947.2.29.87, an adult male, by Dubois (1987 "1986"). **Neotype locality.** "Nilgherries [= Nilgiri Hills]". **Synonym.** *Micrixalus opisthorhodus* (Günther, 1869 "1868"). **Current status of specific name.** Valid name, as *Micrixalus phyllophilus* (Jerdon, 1854).

Referred specimens. *Tamil Nadu*: *Nilgiris dist.*, Avalanche, BNHS 5798, an adult male, and BNHS 5799, an adult female, collected by SDB, 6 October 2001; Longwood Shola, Kotagiri, BNHS 5800, an adult female, collected by SDB, 9 November 2002, BNHS 5801–BNHS 5804, four adult males, and BNHS 5805, an adult female, collected by SDB, 8 June 2005; Naduvattam, BNHS 5806, an adult male, collected by SDB, 8 November 2002.

Other material studied. *Tamil Nadu*: *Nilgiris dist.*, Avalanche, SDBDU 2001.504, collected by SDB, 6 October 2001; Mukkurthi

National Park, SDBDUD 2008.4407, collected by SDB, 23 March 2008.

Comparison. *Micrixalus phyllophilus* could be confused with *M. frigidus*, *M. nigraventris* and *M. silvaticus*. However, *M. phyllophilus* differs from *M. silvaticus* by its larger adult size, male, SVL 22.5–25.9 mm, *N* = 7, female, SVL 28.9–32.5 mm, *N* = 3 (vs. smaller size, male, SVL 18.5–19.8 mm, *N* = 3, female, SVL 25.4–26.0 mm, *N* = 3), snout subovoid in dorsal view (vs. rounded), snout acute in lateral view (vs. rounded), tongue with lingual papilla (vs. without lingual papilla), groin red (vs. greyish-white).

For more differences with *Micrixalus frigidus* and *M. nigraventris*, see 'Comparison' of those species.

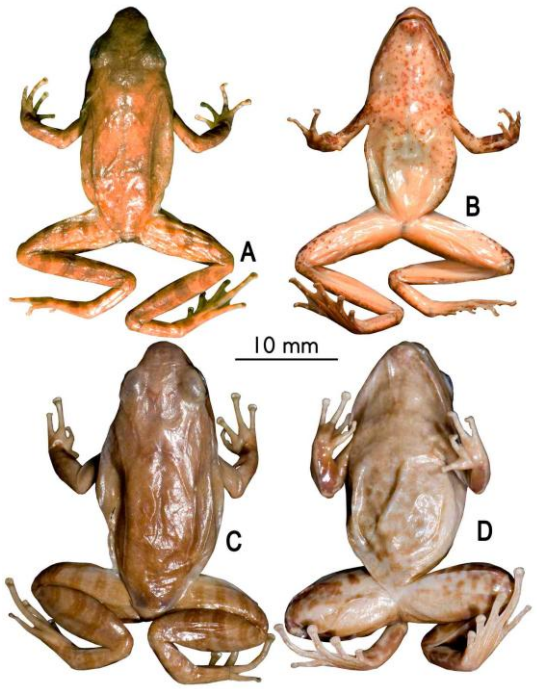

Figure 43. A–B. Neotype of *Limnodytes ? phyllophila* Jerdon, 1854 "1853" (NHM 1947.2.29.87), from "Nilgherries [= Nilgiri Hills]": **A.** dorsal view, **B.** ventral view; **C–D.** Lectotype of *Ixalus silvaticus* Boulenger, 1882 (NHM 82.2.10.52), from "Malabar": **C.** dorsal view, **D.** ventral view.

Comments. Jerdon (1854 "1853") named this taxon with a brief description and later its name bearing type was reported as lost (Jerdon, 1870). Günther (1869 "1868") described another taxon from "Nilgherries [= Nilgiri Hills]", *Ixalus opisthorhodus*, which was considered as synonym of *Micrixalus phyllophilus* (Jerdon, 1854 "1853") by Dubois (1987 "1986"); subsequently Dubois (1987 "1986") designated the holotype of *Ixalus opisthorhodus* Günther, 1869 "1868", as neotype of *Micrixalus phyllophilus*. We studied the original description of this taxon (Jerdon, 1854 "1853") and the holotype of *Ixalus opisthorhodus*, and follow the synonymy by Dubois (1987 "1986").

Description of neotype (*all measurements in mm*). Adult male (SVL 22.5); head small (HW 7.4, HL 8.3), longer than wide, flat above; snout subovoid in dorsal view, acute in lateral view, its length (SL 3.4) longer than horizontal diameter of eye (EL 2.8); loreal region vertical and concave with rounded canthus rostralis; interorbital space flat, wider (IUE 2.2) than upper eyelid (UEW 1.8); distance between back of eye (IBE 6.3) 1.5 times the distance between front of eye (IFE 4.2); nostril oval, closer to eye (EN 1.0) than tip of snout (NS 1.8); tympanum (TYD 1.0) 36% of eye diameter (EL 2.8); tongue moderately large, emarginate, with lingual papilla; supratympanic fold that extends from posterior corner of eye to near the shoulder, well developed. Forelimbs (FAL 4.4) shorter than hand length (HAL 5.1); finger discs moderately wide compared to finger width (fd1 0.6, fw1 0.3; fd2 0.8, fw2 0.2; fd3 0.9, fw3 0.3; fd4 0.8, fw4 0.3); subarticular tubercles well developed, oval, single, all present; prepollex weakly developed; round palmar tubercles present. Thigh length (TL 11.0) shorter than shank (SHL 11.3), and longer than foot (FOL 9.6); toe discs wide compared to toe width (td1 0.7, tw1 0.2; td2 1.0, tw2 0.3; td3 1.0, tw3 0.3; td4 1.1, tw4 0.3; td5 1.0, tw5 0.3); webbing present: I1–2II1–2III1–2$^{3}/_{4}$IV2$^{3}/_{4}$–1V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes and upper eyelids shagreened to sparsely granular; posterior part of back shagreened to granular; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, discontinuous; scattered glandular ridge on dorsum; flanks shagreened with short tubercles; dorsal parts of forelimb without glandular projections; thigh, tibia and tarsus with weakly developed glandular projections; dorsal parts of forelimb shagreened; thigh, tibia and tarsus with weakly developed granular projections and glandular ridge; toe V with short granular projections from the base up to the knee; ventral surface of throat, chest and abdomen smooth; posterior parts of thigh shagreened to sparsely granular.

Colour in preservation. Dorsum light brown; a dark grey streak starting from the tip of snout, extending over the eyes and tympanum, and ending near the shoulder; lateral sides of head (snout and tympanic area) distinctly dark grey;

flanks grey with black speckles; dorsolateral folds reddish-brown; forelimbs, dorsal surfaces of thigh, tibia and feet light brown with dark brown cross-bands, posterior parts of thigh grey with dark grey reticulations; throat, chest and belly reddish-brown with greyish-brown reticulations; webbing blackish-grey. **Colour in life** (BNHS 5801). Dorsum uniform reddish-brown; a white streak starting from the tip of snout, extending over the eyes and tympanum, and ending near the shoulder; lateral sides of head (snout and tympanic area) distinctly reddish-brown; iris light brown with reddish tinge; flanks light yellowish-red; groin red; dorsal surface of limbs reddish-brown with dark brown cross-bands; throat and chest light brown with dark brown spots; belly light yellowish-white with scattered grey reticulations; thighs light red with brown patches, shank and foot red with marginal brown spots; webbing dark brown.

Variations. See Table 5 for morphometric characters of seven adult males and three adult females. For colour variations see Figure 44.

Secondary sexual characters. Male: Single prominent oval-shaped nuptial pad on finger I present, cream-coloured; single gular pouch while calling. Female (BNHS 5799): ova yellowish-white with minute black spots (diameter 1.3–1.7 mm, *N* = 20).

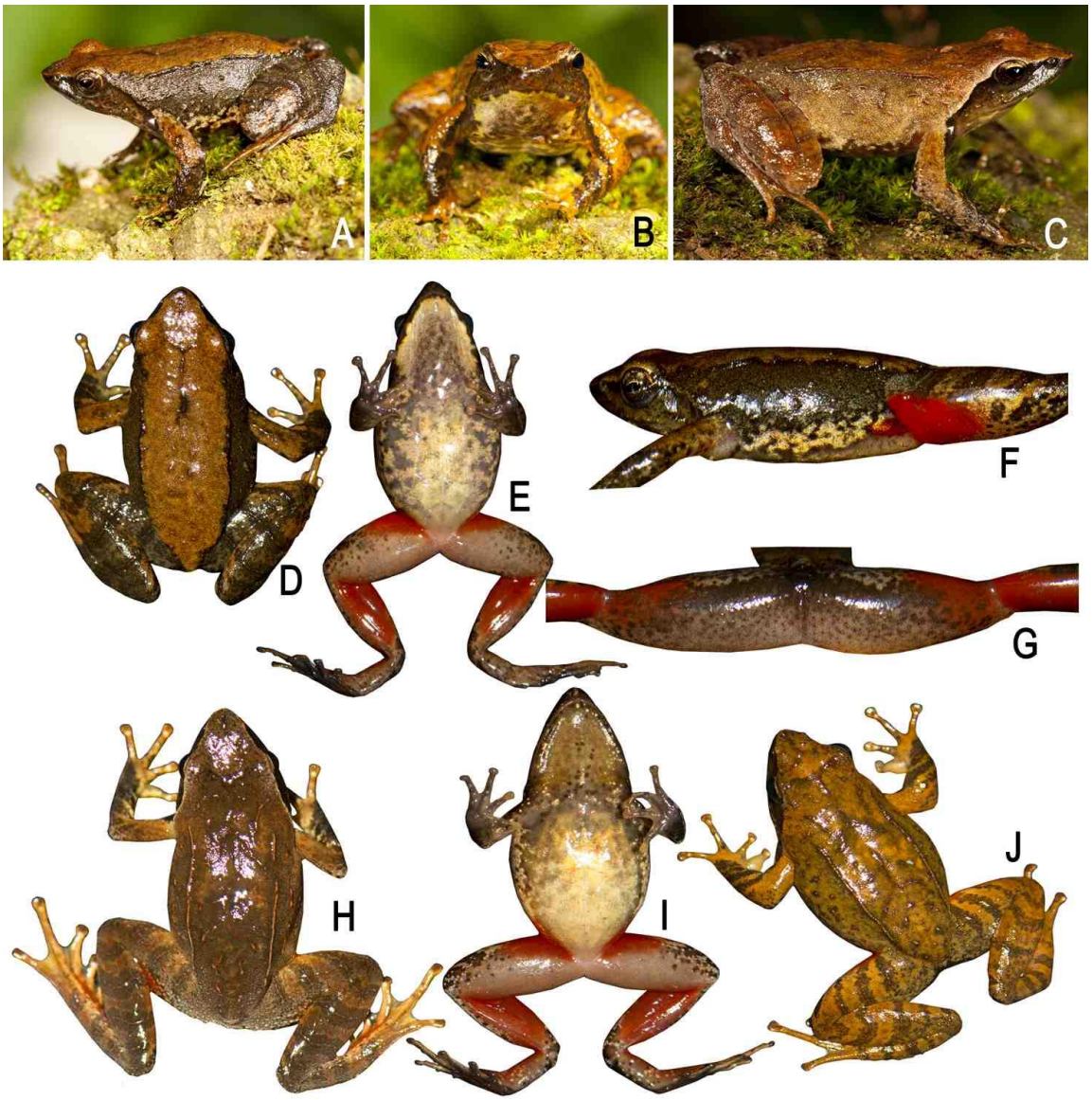

Figure 44. *Micrixalus phyllophilus* in life: **A.** dorsolateral view, **B.** front view (RS, BNHS 5801, m); **C.** dorsolateral view (RS, BNHS 5802, m); **D.** dorsal view, **E.** ventral view, **F.** lateral view of thigh and groin, **G.** posterior side of thigh (RS, BNHS 5801, m); **H.** dorsal view, **I.** ventral view (RS, BNHS 5805, f); **J.** dorsal view (RS, BNHS 5802, m). Photos: SDB.

Distribution. *Micrixalus phyllophilus* is known only from the high altitudes (above 1800 m asl) of Nilgiri hills in the Western Ghats. The present study found this species in Avalanche, Longwood Shola and Naduvattam (Nilgiris dist.) in Tamil Nadu state (Fig. 3, Table 1).

Habitat and natural history. The preferred habitat of this species is shallow and slow moving streams located inside shola forests. The majority of male specimens were found actively calling and collected between 10:00–16:00 h.

***Micrixalus silvaticus* (Boulenger, 1882)**
Forest Dancing Frog
(Figs 3, 40D, 43C–D, 45; Tables 1–5)

Original name and description. *Ixalus silvaticus* Boulenger, 1882. *Catalogue of the Batrachia Salientia s. Ecaudata in the Collection of the British Museum*, ed. 2: 496. **Lectotype.** NHM 82.2.10.52, an adult female, SVL 26.0 mm, by present designation. **Type locality.** "Malabar". **Current status of specific name.** Valid name, as *Micrixalus silvaticus* (Boulenger, 1882).

Referred specimens. *Kerala*: *Idukki dist.*, Kadalar estate, BNHS 5807, an adult male, collected by SDB and Systematics lab team, 22 September 2011; "Malabar", NHM82.2.10.59, NHM 82.2.10.58, two adult males, NHM 82.2.10.53 and NHM 82.2.10.55, two adult females, collected by Beddome.

Comparison. *Micrixalus silvaticus* could be confused with *M. frigidus*, *M. nigraventris* and *M. phyllophilus*. For differences with *M. frigidus*, *M. nigraventris and M. phyllophilus* see 'Comparison' of those species.

Comments. Boulenger (1882) described this species based on eight specimens, NHM 82.2.10.52–59 (six females and two males), from "Malabar". We examined all the syntypes at NHM and found them to be homogenous in identity, possessing a unique character, i.e. "brown above, with rather indistinct darker markings, the most constant being a broad chevron between the eyes; sides of head blackish brown". In order to avoid any possible doubt or confusion, we hereby designate NHM 82.2.10.52 (an adult female) from "Malabar", with snout-vent size (SVL 26.0 mm) almost same as that measured by Boulenger ("snout to vent" 27.0 mm), as lectotype of *Micrixalus silvaticus* (Figs 43C–D).

Description of lectotype (*all measurements in mm*). Adult female (SVL 26.0); head small (HW 9.0, HL 9.6), longer than wide, flat above; snout rounded in dorsal and lateral view, its length (SL 4.1) longer than horizontal diameter of eye (EL 3.2); loreal region acute with rounded canthus rostralis; interorbital space flat, wider (IUE 2.8) than upper eyelid (UEW 1.9); distance between back of eye (IBE 7.5) 1.9 times the distance between front of eye (IFE 3.9); nostril oval, closer to eye (EN 1.3) than tip of snout (NS 1.9); tympanum (TYD 1.4) 44% of eye diameter (EL 3.2); tongue moderately large, emarginate, without lingual papilla; supratympanic fold that extends from posterior corner of eye to near the shoulder, well developed. Forelimbs (FAL 5.1) shorter than hand length (HAL 5.9); finger discs moderately wide compared to finger width; subarticular tubercles well developed, oval, single, all present, prepollex weakly developed; round palmar tubercles present. Thigh length (TL 11.5) equal to shank (SHL 11.5), and longer than foot (FOL 10.6); toe discs wide compared to toe width; webbing present: I2–2II2^{-}–2$^{4}/_{5}$III2$^{4}/_{5}$–3$^{1}/_{4}$IV3$^{1}/_{4}$–2V; subarticular tubercles weakly developed, oval, all present; inner metatarsal tubercles distinct and moderately short; outer metatarsal tubercles rounded, rather prominent.

Skin of snout, between eyes and upper eyelids shagreened to granular; dorsolateral folds that extend from the posterior corner of the eye to the entire body length on both sides, discontinuous; scattered glandular ridge on dorsum; thigh, tibia and tarsus with weakly developed glandular projections and glandular ridge; ventral surface of throat, chest and abdomen smooth; posterior parts of thigh shagreened to sparsely granular.

Colour in preservation. Dorsum light brown; a greyish-brown streak starting from the tip of snout, extending over the eyes and tympanum, and ending near the shoulder; lateral sides of head (snout and tympanic area) distinctly dark grey; flanks grey; forelimbs, dorsal surfaces of thigh, tibia and feet light brown with dark brown cross-bands, posterior parts of thigh grey with dark grey reticulations; throat, chest and belly light brown with brown reticulations. **Colour in life** (SDB 2011.1035). Dorsum uniform reddish-brown; a white streak starting from the tip of snout, extending over the eyes and tympanum, and ending near the shoulder; lateral sides of head (snout and tympanic area) distinctly blackish-brown; iris light brown with reddish tinge; flanks light greyish-brown; groin greyish-white; dorsal surface of limbs reddish-brown with dark brown cross-bands; throat and chest light orange; belly creamy white with orange reticulations; thigh, shank and foot light grey.

Variations. See Table 5 for morphometric characters of three adult males and three adult females. For colour variations see Figure 45.

Secondary sexual characters. Male (NHM 82.2.10.59): Single prominent oval-shaped nuptial pad on finger I present, cream-coloured.

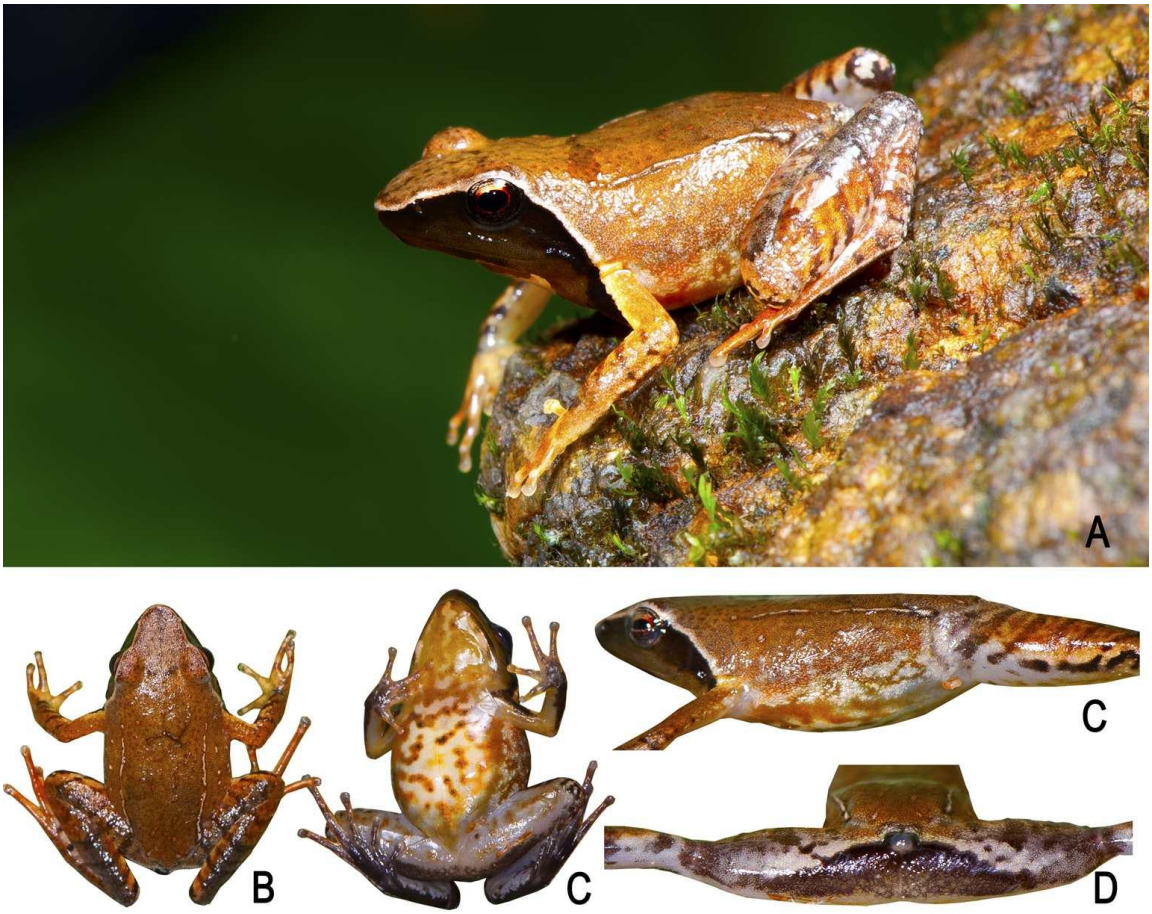

Figure 45. *Micrixalus silvaticus* in life: **A**. dorsolateral view, **B.** dorsal view, **C.** ventral view, **D.** lateral view of thigh and groin, **E.** posterior side of thighs (RS, BNHS 5807, m). Photos: SDB.

Female (NHM 82.2.10.52): ova yellowish- white with minute black spots (diameter 1.3–1.5 mm, *N* = 10).

Distribution. The present study recorded *Micrixalus silvaticus* only from one locality, Kadalar estate (Idukki dist., Kerala), which lies south of Palghat gap in the Western Ghats (Fig. 3, Table 1).

Habitat and natural history. The sole specimen of this species was found under leaf litter near a perennial stream inside a plantation located close to shola forest.

DISCUSSION

Our results conform to the trend of high species diversity reported by recent studies in the Western Ghats (e.g., Abraham *et al.*, 2013; Biju and Bossuyt, 2009; Biju *et al.*, 2009, 2011; Zachariah *et al.*, 2011), thereby highlighting the fact that the amphibian diversity of this region still remains underestimated. Biju (2001) estimated the presence of at least a 100 new anuran species in the Western Ghats. In the following years, 75 amphibian species have already been described from this region (e.g., Abraham *et al.*, 2013; Biju and Bossuyt, 2009; Biju *et al.*, 2009, 2011; Zachariah *et al.*, 2011) (Fig. 1), and we predict that there could possibly be another 100 new species awaiting formal description, before saturation in new discoveries can be expected. Discovering cryptic diversity is not only vital for understanding the patterns and processes of evolution, but also an important step towards prioritizing conservation needs and avoiding the risk of loosing biodiversity even before taxonomic recognition, in other words – *nameless extinction*.

Ancient lineages like Micrixalidae represent the few remaining relicts of the evolutionary history of ranid anurans (Roelants *et al.*, 2004), and their occurrence only in the Western Ghats further stresses on the need to understand the true diversity within these groups. Apart from containing significant evolutionary information, many of the Western Ghats endemic lineages are known to possess unique ecological and behavioural adaptations (Biju and Bossuyt, 2003; Biju *et al.*, 2011; Bossuyt and Milinkovitch, 2000;

Roelants *et al.*, 2004). An improved understanding of diversity at the species level can provide better insights into the evolution of such specializations. For example, in the genus *Micrixalus*, we did not observe foot-flagging behaviour in all species, and it seems that the presence and absence of foot-flagging is likely to vary based on degree of webbing and habitat preference of species. This could probably suggest that visual communication evolved more specifically in species that prefer noisy torrent environments (Hebets and Papaj, 2005; Hödl and Amézquita, 2001; Preininger *et al*., 2013b). Further studies with focus on breeding and behavioural aspects of all *Micrixalus* species will be necessary to address questions on such evolutionary adaptations.

Roelants *et al.* (2004) discussed the occurrence of low species level diversity in *Micrixalus* and morphological uniformities in extant members of this genus. However, our barcoding study identified 14 clearly divergent clades in addition to the 10 known *Micrixalus* species. Detailed morphological examination of these small-sized frogs, believed to be morphologically cryptic, showed the presence of several characters to distinguish each of these species. Therefore, it is evident that due to the absence of careful morphological investigation and comprehensive surveys in the entire Western Ghats, true diversity in this ancient lineage remained unknown. This could be the scenario in several other understudied amphibian lineages in the Western Ghats, for which species richness and endemism remain to be explored. In such precarious circumstances, the DNA barcoding approach holds promise to rapidly inventory species and predict priority locations for effective conservation (Fouquet *et al.*, 2007; Funk *et al.*, 2011; Hebert and Gregory, 2005; Hebert *et al.*, 2003; Janzen *et al.*, 2009; Vences *et al.*, 2005b; Vieites *et al.*, 2009).

Molecular methods have dramatically improved our ability to uncover species and realize the magnitude of cryptic diversity (Fouquet *et al.*, 2007; Funk *et al.*, 2011; Hebert *et al.*, 2003; Vieites *et al.*, 2009). However, use of genetic information for species delimitation is yet to reach its full potential, particularly in diverse tropical and megadiversity regions such as India, where this approach has so far been applied only to selected amphibian groups (Abraham *et al*., 2013; Biju and Bossuyt, 2003, 2009; Biju *et al*., 2009, 2011, 2013; Nair *et al*., 2012). Furthermore, understanding relationships between species in a phylogenetic framework can provide insights into patterns of morphological synapomorphies. Our study found significant patterns of morphological similarity among different species, specifically for characters such as, webbing, dorsolateral folds, colouration of lateral sides of head, which suggested a basis for grouping of species by morphology. A phylogenetic investigation using a combination of mitochondrial and nuclear markers can be useful in substantiating these species grouping.

Integrative taxonomic approach has gained fast acceptance, especially in the field of amphibian systematics (e.g., Padial and De la Riva, 2009; Vieites *et al*., 2009). Apart from external morphology, several studies have used molecular and acoustic data to understand species diversiy (e.g., Fouquet *et al.*, 2007; Vences *et al*., 2010). However, the use of internal morphological characters to identify unique features at species or generic level still remains an understudied subject in Indian anuran systematics. Our study provides the first detailed osteological description of a clear and double-stained anuran specimen from India, but due to the lack of osteological information for closely related members, a comparative description could not be provided. Nevertheless, we note the absence of Septomaxilla bone in *Micrixalus fuscus*. Future research with a greater focus on internal skeletal characters in ancient and endemic anuran lineages of the Western Ghats would make useful contributions to taxonomy and evolutionary studies.

The ultimate goal of biodiversity conservation can be achieved by setting priorities, and the role of systematics is crucial in providing information required for focused conservation efforts (Bickford *et al.*, 2007; McLeod, 2010; Savage, 1995; Vredenburg *et al.*, 2007). Accurate identification of species and knowledge of true diversity are essential to identify regions with high levels of species richness and endemism. In a scenario where new information is available, conservation assessment of individual species and threats in their habitats need to be revisited. Micrixalidae, previously a family of 11 species with taxonomic confusions, ambiguous distinguishing characters and patchy distribution records, and which is now known to be a two-fold more diverse lineage with restricted distribution range of species, is in an urgent need of conservation reassessment. Immediate attention in this regard can go a long way in conserving extant members of this ancient and endemic group of frogs.

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Table 1. Collection localities of *Micrixalus* species discussed in the text. Localities are arranged by State. Species described in the present study are shown in bold.

Locality	Altitude	Coordinates		Species recorded
	(meters)	Latitude (°N)	Longitude (°E)	
INDIA				
Tamil Nadu				
Coimbatore district				
Andiparai shola, Valparai	600	10.3669	76.967	***M. nelliyampathi***
Grass hills	1800	10.3166	77.0667	***M. frigidus, M. nelliyampathi***
Puthuthottam, Valparai	1142	10.3438	76.9711	***M. nelliyampathi***
Dindigul district				
Kodaikanal	1780	10.2333	77.4833	***M. nigraventris***
Kanyakumari district				
Glenback estate, Kiriparai	450	08.4188	77.4182	*M. herrei*
Nilgiris district				
Avalanche	2000	11.2667	76.5667	*M. phyllophilus*
Coonoor	1397	11.3328	76.8087	***M. spelunca***
Longwood shola, Kotagiri	1960	11.4353	76.8763	*M. phyllophilus*
Mukkurthi National Park	2139	11.3818	76.5485	*M. phyllophilus*
Naduvattam	1890	11.3833	76.5667	*M. phyllophilus*
Tirunelveli district				
Putherichariun, Shencottah	140	08.9833	77.2944	*M. herrei*
Kakkachi 1	1200	08.5443	77.4278	*M. fuscus*, ***M. kodayari***
Kakkachi 2	1289	08.5507	77.3916	*M. fuscus*
Kakkachi 3	1294	08.5492	77.3858	*M. fuscus*
Kodayar	1346	08.5243	77.5069	***M. kodayari***
Sengaltheri	1000	08.5371	77.4544	*M. fuscus*
Kerala				
Idukki district				
Kadalar estate 1, Munnar	1414	10.1324	76.9995	***M. adonis***
Kadalar estate 2, Munnar	1429	10.1311	77.0005	*M. silvaticus*
Letchmi estate, Sevenmallay	1519	10.0668	77.0024	***M. adonis***
Sevenmallay	1476	10.0833	77.1333	***M. adonis***
Thekkady 1, Periyar TR	929	09.5857	77.1621	***M. adonis***, *M. gadgili*
Thekkady 2, Periyar TR	980	09.5803	77.1593	*M. gadgili*
Eravikulam National Park 1	2105	10.1846	77.0900	***M. nigraventris***
Eravikulam National Park 2	2150	10.3498	77.1997	***M. frigidus***
Kannur district				
Aralam WLS	461	11.9406	75.8658	*M. saxicola*
Meenmutty, Aralam WLS	358	11.9384	75.8573	*M. elegans*, *M. saxicola*
Kollam district				
Kovachal, Shendurney WLS	816	08.8497	77.1759	*M. herrei*
Pandimotta, Shendurney WLS	1221	08.8265	77.2122	***M. mallani***
Palakkad district				
Kesavapara, Nelliyampathy	923	10.5243	76.6673	*M. gadgili*, ***M. nelliyampathi***
Poopara, Parambikulam TR	955	10.3516	76.8215	***M. nelliyampathi***

Sairandhri, Silent Valley	962	11.0949	76.4505	***M. sairandhri***, *M. thampii*
Kuddam, Siruvani	758	10.9696	76.6545	*M. thampii*
Singappara, Siruvani	880	10.9789	76.6154	*M. thampii*
Pathanamthitta district				
Gavi	1143	09.7491	77.1427	*M. gadgili*
Sabarimala	1108	09.3180	77.1407	*M. gadgili*, ***M. mallani***
Thiruvananthapuram district				
Athirimala	1425	08.7934	77.3424	*M. fuscus*, ***M. mallani***
Attayar 1, Agasthyamala hills	605	08.6341	77.2093	*M. herrei*
Attayar 2, Agasthyamala hills	680	08.6545	77.1905	*M. herrei*
Chathankod	116	08.6608	77.1525	*M. herrei*
Chathankod–Bonnacaud	488	08.6737	77.1575	*M. herrei*
Kallar, Ponmudi	180	08.8490	77.1322	*M. herrei*
Pandipath, Agasthyamala hills	1323	08.6795	77.1933	*M. fuscus*
Ponkalapara	1370	08.6247	77.2425	***M. mallani***
Ponmudi	1005	08.7681	77.1096	***M. sali***
Wayanad district				
Banasura	1560	11.6893	75.8956	*M. saxicola*
Chethalayam falls, Kurichiat	870	11.7603	76.2520	*M. nudis*
Kurichiyarmala 1	1210	11.6006	75.9664	***M. kurichiyari***
Kurichiyarmala 2	1167	11.5989	75.9769	*M. saxicola*
Periya	730	11.8336	75.8570	*M. saxicola*
Settukunnu	823	11.6172	75.9913	*M. saxicola*
Suganthagiri	1300	11.6356	76.1270	*M. saxicola*
Karnataka				
Chikmagalur district				
Kemmanagundi	865	13.3000	75.4500	***M. candidus***, *M. kottigeharensis*
Kottigehara 1	798	13.2084	75.8316	***M. candidus***, *M. kottigeharensis*
Kottigehara 2	850	13.1241	75.4954	*M. kottigeharensis*
Muthodi	1100	13.5650	75.6232	*M. kottigeharensis*
Dakshina Kannada district				
Charmadi Ghats 1	489	13.0753	75.4552	*M. kottigeharensis*, *M. saxicola*
Charmadi Ghats 2	608	13.0798	75.4650	*M. elegans*
Charmadi Ghats 3	929	13.1184	75.5103	***M. specca***
Hassan district				
Kempholay	880	12.8567	75.6955	*M. elegans*, *M. saxicola*
Maranhalli, Sakleshpur	761	12.8680	75.7032	*M. elegans*, *M.kottigeharensis*, *M. saxicola*
Sakleshpur	840	13.0833	75.7000	*M. elegans*, *M. saxicola*
Kodagu district				
Bhagamandala	921	12.4012	75.5435	*M. elegans*
Yavakapady 1, Coorg	1187	12.2169	75.6588	*M. elegans*, *M. saxicola*
Yavakapady 2 Coorg	1146	12.2189	75.6573	*M. elegans*
Yavakapady 3, Coorg	1102	12.2201	75.6557	*M. elegans*
Shimoga district				
Niluvase	686	13.7393	75.1082	***M. niluvasei***
Uttara Kannada district				
Kathlekan	554	14.2739	74.7469	*M. kottigeharensis*
Unchalli falls	444	14.4091	74.7468	*M. kottigeharensis*, *M. saxicola*
Waddighat, Yana	411	14.6112	74.5571	*M. kottigeharensis*
Maharashtra				
Sindhudurg district				
Amboli	781	15.9496	74.0002	***M. uttaraghati***
Colonial locations				
“Anamallays”	–	–	–	*M. fuscus*?
“Malabar”	–	–	–	*M. fuscus*?, *M. silvaticus*, *M. saxicola*
“Nilgherries”	–	–	–	*M. phyllophilus*
“Sevagherry”	–	–	–	*M. fuscus*
“Torocata”	–	–	–	*M. fuscus*?
“Travancore”	–	–	–	*M. fuscus*

Table 2. List of 16S and COI gene sequences used in the study for intra and interspecific pairwise comparisons and barcoding of *Micrixalus* species. Species are arranged alphabetically.

Species	Collection Locality	Voucher Number	Accession Number	
			16S	COI
Micrixalus adonis sp. nov.	Kadalar estate	BNHS 5662	KJ711257	KJ711395
	Kadalar estate	BNHS 5663	KJ711258	KJ711396
	Letchmi estate	BNHS 5667	KJ711259	KJ711397
	Sevenmallay	BNHS 5656	KJ711260	KJ711398
	Thekkady	BNHS 5668	KJ711261	KJ711399
Micrixalus candidus sp. nov.	Kemmanagundi	BNHS 5608	KJ711262	KJ711400
	Kottigehara	BNHS 5609	KJ711263	KJ711401
Micrixalus elegans	Bhagamandala	BNHS 5617	KJ711264	KJ711402
	Charmadi Ghats	SDBDU 2011.1397	KJ711265	KJ711403
	Kempholay	BNHS 5612	KJ711266	KJ711404
	Kempholay	SDBDU 2010.003	KJ711267	KJ711405
	Kempholay	BNHS 5613	KJ711268	KJ711406
	Kempholay	BNHS 5808	KJ711269	KJ711407
	Maranhalli	BNHS 5616	KJ711270	KJ711408
	Maranhalli	BNHS 5614	KJ711271	KJ711409
	Meenmutty	SDBDU 2008.412	KJ711272	KJ711410
	Yavakapady	BNHS 5620	KJ711273	KJ711411
	Yavakapady	BNHS 5618	KJ711274	KJ711412
	Yavakapady	BNHS 5619	KJ711275	KJ711413
Micrixalus frigidus sp. nov.	Eravikulam NP	BNHS 5788	KJ711276	KJ711414
	Grass hills	BNHS 5790	KJ711277	KJ711415
Micrixalus fuscus	Kakkachi	SDBDU 2002.2047	KJ711278	KJ711416
	Kakkachi	BNHS 5669	KJ711279	KJ711417
	Kakkachi	BNHS 5670	KJ711280	KJ711418
	Kakkachi	SDBDU 2006.2299	KJ711281	–
	Pandipath	BNHS 5676	KJ711282	KJ711419
	Sengaltheri	SDBDU 2002.874	KJ711283	KJ711420
	Sengaltheri	BNHS 5673	KJ711284	KJ711421
Micrixalus gadgili	Kesavapara	SDBDU 2011.1148	KJ711285	KJ711422
	Kesavapara	SDBDU 2011.1149	KJ711286	KJ711423
	Sabarimala	BNHS 5714	KJ711287	KJ711424
	Thekkady	SDBDU 2006.4801	KJ711288	KJ711425
	Thekkady	BNHS 5719	KJ711289	KJ711426
	Thekkady	SDBDU 2012.1842	KJ711290	KJ711427
	Thekkady	SDBDU 2012.1843	KJ711291	KJ711428
Micrixalus herrei	Attayar	SDBDU 2012.2314	KJ711292	KJ711429
	Chathankod	SDBDU 2006.4766	KJ711293	KJ711430
	Chathankod	SDBDU 2009.106	KJ711294	KJ711431
	Chathankod	BNHS 5681	KJ711295	KJ711432
	Chathankod	BNHS 5683	KJ711296	KJ711433
	Glenback estate	BNHS 5687	KJ711297	KJ711434
	Kallar	BNHS 5678	KJ711298	KJ711435
	Kallar	BNHS 5677	KJ711299	KJ711436
	Kovachal	SDBDU 2011.918	KJ711300	KJ711437
	Puthericharium	SDBDU 2002.4054	KJ711301	KJ711438
Micrixalus kodayari sp. nov.	Kakkachi	BNHS 5692	KJ711302	KJ711439
	Kodayar	BNHS 5689	KJ711303	–
Micrixalus kottigeharensis	Charmadi Ghats	BNHS 5750	KJ711304	KJ711440
	Kathlekan	BNHS 5758	KJ711305	KJ711441
	Kathlekan	BNHS 5755	KJ711306	KJ711442
	Kemmanagundi	SDBDU 2003.40268	KJ711307	KJ711443
	Kemmanagundi	SDBDU 2010.005	KJ711308	KJ711444
	Kemmanagundi	BNHS 5749	KJ711309	–
	Kottigehara	BNHS 5747	KJ711310	KJ711445
	Kottigehara	SDBDU 2010.124	KJ711311	KJ711446
	Kottigehara	SDBDU 2012.55	KJ711312	KJ711447
	Kottigehara	SDBDU 2012.62	KJ711313	KJ711448
	Maranhalli	BNHS 5754	KJ711314	KJ711449

	Maranhalli	BNHS 5751	KJ711315	KJ711450
	Maranhalli	BNHS 5753	KJ711316	KJ711451
	Muthodi	SDBDU 2003.40215	KJ711317	KJ711452
	Unchalli falls	BNHS 5762	KJ711318	KJ711453
	Waddighat	BNHS 5760	KJ711319	KJ711454
	Waddighat	SDBDU 2011.1347	KJ711320	KJ711455
Micrixalus kurichiyari sp. nov.	Kurichiyarmala	SDBDU 2008.413	KJ711321	KJ711456
	Kurichiyarmala	BNHS 5622	KJ711322	KJ711457
Micrixalus mallani sp. nov.	Athirimala	BNHS 5700	KJ711323	KJ711458
	Athirimala	SDBDU 2002.495	KJ711324	KJ711459
	Pandimotta	BNHS 5695	KJ711325	KJ711460
	Pandimotta	BNHS 5694	KJ711326	KJ711461
	Ponkalapara	BNHS 5701	KJ711327	KJ711462
	Sabarimala	BNHS 5698	KJ711328	KJ711463
Micrixalus nelliyampathi sp. nov.	Andiparai shola	BNHS 5710	KJ711329	KJ711464
	Andiparai shola	BNHS 5711	KJ711330	KJ711465
	Grass hills	BNHS 5712	KJ711331	KJ711466
	Kesavapara	BNHS 5705	KJ711332	KJ711467
	Kesavapara	BNHS 5702	KJ711333	KJ711468
	Kesavapara	SDBDU 2011.1154	KJ711334	KJ711469
	Poopara	SDBDU 2011.562	KJ711335	KJ711470
	Puthuthottam	SDBDU 2001.785	KJ711336	KJ711471
Micrixalus nigraventris sp. nov.	Eravikulam NP	BNHS 5797	KJ711337	KJ711472
	Kodaikanal	BNHS 5793	KJ711338	KJ711473
	Kodaikanal	BNHS 5795	KJ711339	KJ711474
Micrixalus niluvasei sp. nov.	Niluvase	BNHS 5629	KJ711340	KJ711475
	Niluvase	BNHS 5627	KJ711341	KJ711476
	Niluvase	BNHS 5630	KJ711342	KJ711477
	Niluvase	BNHS 5628	KJ711343	KJ711478
Micrixalus nudis	Chethalayam falls	BNHS 5724	KJ711344	KJ711479
	Chethalayam falls	BNHS 5725	KJ711345	KJ711480
	Chethalayam falls	BNHS 5729	KJ711346	KJ711481
Micrixalus phyllophilus	Avalanche	SDBDU 2001.504	KJ711347	KJ711482
	Longwood shola	BNHS 5801	KJ711348	KJ711483
	Longwood shola	BNHS 5802	KJ711349	–
	Naduvattam	BNHS 5806	KJ711350	KJ711484
Micrixalus sairandhri sp. nov.	Sairandhri	BNHS 5637	KJ711351	KJ711485
	Sairandhri	BNHS 5638	KJ711352	KJ711486
Micrixalus sali sp. nov.	Ponmudi	BNHS 5737	KJ711353	KJ711487
	Ponmudi	BNHS 5732	KJ711354	KJ711488
Micrixalus saxicola	Aralam WLS	BNHS 5769	KJ711355	KJ711489
	Aralam WLS	SDBDU 2011.1084	KJ711356	KJ711490
	Banasura	BNHS 5765	KJ711357	KJ711491
	Banasura	SDBDU 2002.3021	KJ711358	KJ711492
	Charmadi Ghats	BNHS 5772	KJ711359	KJ711493
	Kempholay	SDBDU 2010.010	KJ711360	KJ711494
	Kottigehara	BNHS 5771	KJ711361	KJ711495
	Kurichiyarmala	BNHS 5766	KJ711362	–
	Maranhalli	BNHS 5773	KJ711363	KJ711496
	Meenmutty	SDBDU 2008.427	KJ711364	KJ711497
	Periya	BNHS 5764	KJ711365	KJ711498
	Periya	BNHS 5763	KJ711366	KJ711499
	Periya	SDBDU 2012.911	KJ711367	KJ711500
	Sakleshpur	SDBDU 2005.4599	KJ711368	KJ711501
	Sakleshpur	SDBDU 2005.4661	KJ711369	KJ711502
	Settukunnu	SDBDU 2011.854	KJ711370	KJ711503
	Settukunnu	BNHS 5768	KJ711371	KJ711504
	Suganthagiri	SDBDU 2005.4736	KJ711372	KJ711505
	Suganthagiri	SDBDU 2007.5092	KJ711373	KJ711506
	Unchalli falls	BNHS 5777	KJ711374	KJ711507
	Yavakapady	BNHS 5775	KJ711375	KJ711508
	Yavakapady	BNHS 5776	KJ711376	KJ711509
Micrixalus silvaticus	Kadalar estate	BNHS 5807	KJ711377	KJ711510
Micrixalus specca sp. nov.	Charmadi Ghats	BNHS 5784	KJ711378	KJ711511

	Charmadi Ghats	BNHS 5785	KJ711379	KJ711512
Micrixalus spelunca sp. nov.	Coonoor	SDBDU 2005.4731	KJ711380	KJ711513
	Coonoor	BNHS 5644	KJ711381	KJ711514
	Coonoor	BNHS 5645	KJ711382	KJ711515
Micrixalus thampii	Kuddam	BNHS 5746	KJ711383	KJ711516
	Kuddam	SDBDU 2011.1271	KJ711384	KJ711517
	Kuddam	BNHS 5744	KJ711385	KJ711518
	Sairandhri	BNHS 5739	KJ711386	KJ711519
	Sairandhri	BNHS 5738	KJ711387	KJ711520
	Sairandhri	SDBDU 2010.131	KJ711388	KJ711521
	Sairandhri	BNHS 5743	KJ711389	KJ711522
	Sairandhri	SDBDU 2011.963	KJ711390	KJ711523
	Singappara	SDBDU 2011.1226	KJ711391	–
Micrixalus uttaraghati sp. nov.	Amboli	SDBDU 2007.6084	KJ711392	KJ711524
	Amboli	BNHS 5648	KJ711393	KJ711525
Out group				
Nyctibatrachus sp.	Nelliyampathy, Kerala	SDBDU 2011.1138	KJ711394	KJ711526

Table 3. Uncorrected intraspecific pairwise distances in *Micrixalus* species for 16S and COI genes. Mean, standard deviation (SD), minimum (Min) and maximum (Max) values are provided over all pairwise comparisons among individuals or populations of a species. *N* is the number of sequenced individuals. The original pairwise distances are shown in percentage. Species described in the present study are shown in bold.

	16S					COI				
Species	**N**	**Mean**	**SD**	**Min**	**Max**	**N**	**Mean**	**SD**	**Min**	**Max**
M. adonis	5	0.7	0.5	0.0	1.7	5	2.4	2.7	0.2	5.7
M. candidus	2	0.6	–	–	–	2	2.0	2.0	–	–
M. elegans	12	0.4	0.3	0.0	1.1	12	0.3	0.2	0.0	0.7
M. frigidus	2	0.0	–	–	–	2	0.0	–	–	–
M. fuscus	7	0.1	0.2	0.0	0.4	6	0.3	0.2	0.0	6.6
M. gadgili	7	0.8	0.7	0.0	1.9	7	2.6	2.4	0.0	5.1
M. herrei	10	1.1	1.1	0.0	2.5	10	0.2	0.3	0.0	0.8
M. kodayari	2	0.0	–	–	–	1	–	–	–	–
M. kottigeharensis	17	0.7	0.6	0.0	1.5	16	5.2	3.4	0.0	8.5
M. kurichiyari	2	0.0	–	–	–	2	0.5	–	–	–
M. mallani	6	0.7	0.6	0.0	1.7	6	0.8	0.9	0.0	2.1
M. nelliyampathi	8	0.7	0.5	0.0	1.3	8	0.6	0.4	0.0	1.1
M. nigraventris	3	0.5	0.4	0.0	0.8	3	2.4	2.1	0.0	3.6
M. niluvasei	4	0.0	0.0	0.0	0.0	4	0.1	0.1	0.0	0.2
M. nudis	3	0.0	0.0	0.0	0.0	3	0.0	0.0	0.0	0.0
M. phyllophilus	4	0.9	0.5	0.0	1.3	3	3.8	0.7	0.0	4.6
M. sairandhri	2	0.0	–	–	–	2	0.2	–	–	–
M. sali	2	0.04	–	–	–	2	0.5	–	–	–
M. saxicola	22	0.8	0.6	0.0	2.3	21	2.1	1.3	0.0	3.7
M. silvaticus	1	–	–	–	–	1	–	–	–	–
M. specca	2	0.2	–	–	–	2	0.0	–	–	–
M. spelunca	3	0.0	0.0	0.0	0.0	3	0.0	0.0	0.0	0.0
M. thampii	9	0.6	0.6	0.0	1.5	8	1.9	2.0	0.0	4.3
M. uttaraghati	2	0.0	–	–	–	2	0.0	–	–	–

Table 4. Uncorrected nterspecific pairwise distances between closely related *Micrixalus* species (based on individual NJ trees). Mean, standard deviation, minimum and maximum values are provided over all pairwise comparisons of individuals sequenced from the two species being compared. *N* is the number of pairwise comparisons. The original *p*-distances are shown as percentages.

16S							COI						
Species 1	**Species 2**	**N**	**Mean**	**SD**	**Min**	**Max**	**Species 1**	**Species 2**	**N**	**Mean**	**SD**	**Min**	**Max**
M. adonis	*M. herrei*	50	4.8	0.5	4.2	5.7	*M. adonis*	*M. nelliyampathi*	40	10.9	0.5	9.8	11.5
M. adonis	*M. nelliyampathi*	40	4.2	0.6	3.2	5.5	*M. adonis*	*M. herrei*	50	14.0	0.5	12.9	14.9
M. adonis	*M. fuscus*	35	5.0	0.1	4.6	5.2	*M. adonis*	*M. mallani*	30	13.9	0.3	13.3	14.3
M. adonis	*M. mallani*	30	5.1	0.4	4.7	6.1	*M. adonis*	*M. fuscus*	30	12.5	0.3	12.1	12.9
M. herrei	*M. nelliyampathi*	80	3.9	0.7	3.0	5.3	*M. adonis*	*M. kodayari*	5	14.4	0.2	14.2	14.6
M. herrei	*M. fuscus*	70	5.6	0.2	5.1	6.1	*M. nelliyampathi*	*M. herrei*	80	11.6	0.5	11.0	12.8
M. herrei	*M. mallani*	60	4.8	0.6	4.2	6.0	*M. nelliyampathi*	*M. mallani*	48	11.5	0.4	10.6	12.3
M. nelliyampathi	*M. fuscus*	56	4.2	0.3	3.1	4.6	*M. nelliyampathi*	*M. fuscus*	48	9.7	0.1	9.5	10.0
M. nelliyampathi	*M. mallani*	48	4.1	0.2	3.8	4.4	*M. nelliyampathi*	*M. kodayari*	8	15.1	0.1	14.9	15.2
M. fuscus	*M. mallani*	42	5.4	0.2	4.9	5.6	*M. herrei*	*M. mallani*	60	9.6	0.6	8.2	10.5
M. candidus	*M. niluvasei*	8	7.7	0.1	7.6	7.8	*M. herrei*	*M. fuscus*	60	12.6	0.1	12.4	13.0
M. candidus	*M. kurichiyari*	4	5.8	0.1	5.7	5.9	*M. herrei*	*M. kodayari*	10	15.3	0.1	15.2	15.4
M. candidus	*M. uttaraghati*	4	7.6	0.01	7.59	7.6	*M. mallani*	*M. fuscus*	36	12.7	0.4	11.8	13.3
M. niluvasei	*M. kurichiyari*	8	7.8	0.0	–	–	*M. mallani*	*M. kodayari*	6	15.0	0.1	14.9	15.1
M. niluvasei	*M. uttaraghati*	8	8.2	0.0	–	–	*M. fuscus*	*M. kodayari*	6	12.5	0.1	12.4	12.7
M. kurichiyari	*M. uttaraghati*	4	7.6	0.0	–	–	*M. silvaticus*	*M. frigidus*	2	11.8	–	–	–
M. sali	*M. gadgili*	14	4.2	0.3	3.6	4.8	*M. silvaticus*	*M. nigraventris*	3	14.4	0.1	14.3	14.4
M. sali	*M. silvaticus*	2	8.8	0.02	8.78	8.80	*M. silvaticus*	*M. phyllophilus*	3	17.5	0.1	17.4	17.6
M. sali	*M. frigidus*	4	8.9	0.1	8.8	9.0	*M. frigidus*	*M. nigraventris*	6	15.1	0.2	14.9	15.2
M. sali	*M. nigraventris*	6	9.2	0.4	8.6	9.6	*M. frigidus*	*M. phyllophilus*	6	15.2	0.2	15.1	15.4
M. sali	*M. kodayari*	4	8.6	0.01	8.57	8.59	*M. nigraventris*	*M. phyllophilus*	9	14.6	0.4	13.9	15.2
M. sali	*M. phyllophilus*	8	7.8	0.2	7.6	8.2	*M. sali*	*M. gadgili*	14	7.0	0.3	6.5	7.7
M. gadgili	*M. silvaticus*	7	10.2	0.2	10.1	10.5	*M. sali*	*M. candidus*	4	17.6	0.1	17.6	17.7
M. gadgili	*M. frigidus*	14	9.7	0.2	9.3	9.9	*M. sali*	*M. kurichiyari*	4	16.1	0.1	15.9	16.2
M. gadgili	*M. nigraventris*	21	10.7	0.3	10.1	11.2	*M. sali*	*M. uttaraghati*	4	16.2	0.2	16.1	16.4
M. gadgili	*M. kodayari*	14	9.7	0.1	9.7	9.9	*M. sali*	*M. sairandhri*	4	16.8	0.2	16.5	17.1
M. gadgili	*M. phyllophilus*	28	8.1	0.3	7.6	8.7	*M. gadgili*	*M. candidus*	14	18.9	0.6	18.0	19.5
M. silvaticus	*M. frigidus*	2	5.0	0.0	–	–	*M. gadgili*	*M. kurichiyari*	14	17.6	0.1	17.3	17.7
M. silvaticus	*M. nigraventris*	3	9.0	0.3	8.6	9.1	*M. gadgili*	*M. uttaraghati*	14	15.9	0.7	14.9	16.4
M. silvaticus	*M. kodayari*	2	9.5	0.0	–	–	*M. gadgili*	*M. sairandhri*	14	16.3	0.1	16.2	16.5
M. silvaticus	*M. phyllophilus*	5	9.0	0.3	8.8	9.3	*M. candidus*	*M. kurichiyari*	4	10.7	0.2	10.5	11.0
M. frigidus	*M. nigraventris*	6	7.2	0.3	6.9	7.4	*M. candidus*	*M. uttaraghati*	4	17.5	0.2	17.4	17.7
M. frigidus	*M. kodayari*	4	8.8	0.0	–	–	*M. candidus*	*M. sairandhri*	4	17.9	0.2	17.7	18.2
M. frigidus	*M. phyllophilus*	8	8.2	0.2	8.0	8.4	*M. kurichiyari*	*M. uttaraghati*	4	16.3	0.1	16.2	16.4
M. nigraventris	*M. kodayari*	6	9.2	0.2	9.0	9.3	*M. kurichiyari*	*M. sairandhri*	4	17.3	0.1	17.2	17.3

M. nigraventris	*M. phyllophilus*	12	7.8	0.2	7.4	8.0	*M. uttaraghati*	*M. sairandhri*	4	14.0	0.1	13.9	14.1
M. kodayari	*M. phyllophilus*	8	6.8	0.2	6.5	7.0	*M. elegans*	*M. thampii*	96	9.0	0.2	8.7	9.3
M. saxicola	*M. kottigeharensis*	**374**	4.3	0.4	3.4	5.7	*M. elegans*	*M. nudis*	36	9.3	0.2	9.2	9.5
M. saxicola	*M. specca*	44	4.6	0.3	4.0	5.1	*M. elegans*	*M. spelunca*	36	13.8	0.1	13.6	13.9
M. kottigeharensis	*M. specca*	34	5.0	0.5	4.0	5.5	*M. elegans*	*M. niluvasei*	48	17.0	0.1	16.9	17.3
M. sairandhri	*M. spelunca*	6	11.3	0.0	–	–	*M. thampii*	*M. nudis*	24	6.4	0.5	6.1	7.4
M. elegans	*M. nudis*	36	2.7	0.2	2.3	3.1	*M. thampii*	*M. spelunca*	24	12.6	0.2	12.3	12.9
M. elegans	*M. thampii*	**108**	3.1	0.1	2.9	3.4	*M. thampii*	*M. niluvasei*	32	16.5	0.2	16.2	16.9
M. nudis	*M. thampii*	27	2.1	0.1	2.1	2.3	*M. nudis*	*M. spelunca*	9	13.1	0.0	–	–
							M. nudis	*M. niluvasei*	12	16.3	0.1	16.2	16.4
							M. spelunca	*M. niluvasei*	12	16.0	0.1	15.9	16.0
							M. saxicola	*M. specca*	42	14.0	0.4	13.3	14.9
							M. saxicola	*M. kottigeharensis*	336	12.2	0.7	11.0	13.6
							M. specca	*M. kottigeharensis*	32	14.1	0.3	13.4	14.6

Table 5. Morphometric measurements (in mm) of the specimens used in this study. Status of specimens is given after the Museum number. Abbreviations are defined in the materials and methods. Species are arranged by 'Taxonomic groups'.

Species	Sex	Locality	Museum Number	SVL	HW	HL	TYD	SL	IUE	UEW	MN	EN	NS	EL	FAL	HAL	TL	SHL	FOL
***Micrixalus elegans* GROUP**																			
Micrixalus candidus sp. nov.																			
	M	Kemmanagundi	BNHS 5608 (HT)	20.2	6.2	7.1	0.6	3.1	1.5	1.0	5.2	1.4	1.1	2.5	3.7	5.0	9.7	9.7	8.2
	M	Kottigehara	BNHS 5609 (PT)	16.6	5.5	6.2	0.6	2.5	1.3	1.1	5.4	1.4	0.9	2.1	3.6	4.4	9.7	9.3	8.0
	M	Kottigehara	BNHS 5610 (PT)	13.0	4.7	4.9	0.5	2.1	1.4	0.9	3.5	0.9	0.8	1.8	2.4	3.7	8.4	7.7	7.5
	M	Kottigehara	BNHS 5611 (PT)	11.6	5.3	6.1	0.5	2.4	1.6	1.1	4.8	1.2	0.9	1.5	3.3	3.3	7.9	7.6	7.4
			Average	**15.4**	**5.4**	**6.1**	**0.6**	**2.5**	**1.5**	**1.0**	**4.7**	**1.2**	**0.9**	**2.0**	**3.3**	**4.1**	**8.9**	**8.6**	**7.8**
			Standard deviation	**3.9**	**0.6**	**0.9**	**0.1**	**0.4**	**0.1**	**0.1**	**0.9**	**0.2**	**0.1**	**0.4**	**0.6**	**0.8**	**0.9**	**1.1**	**0.4**
Micrixalus elegans																			
	M	Kempholay	BNHS 5612 (RS)	15.5	5.0	5.2	0.7	2.4	1.8	0.8	4.0	1.1	0.9	1.7	3.0	3.8	7.6	7.6	7.1
	M	Kempholay	BNHS 5613 (RS)	15.5	5.2	5.5	0.7	2.6	1.8	1.2	4.0	1.1	1.1	2.0	3.5	4.0	8.5	8.5	7.2
	M	Maranhalli	BNHS 5614 (RS)	14.7	4.9	5.0	0.6	2.1	1.8	0.9	3.9	0.9	0.8	1.9	2.9	3.5	8.1	8.1	7.0
	M	Maranhalli	BNHS 5615 (RS)	14.7	5.0	5.4	0.7	2.4	1.7	1.1	3.9	0.9	1.0	1.7	2.9	4.1	8.1	8.2	7.2
	M	Yavakapady	BNHS 5618 (RS)	13.0	4.3	4.9	0.5	2.0	1.5	1.0	4.0	1.2	1.2	1.9	2.4	3.5	7.2	7.2	6.2

		Average	**14.7**	**4.9**	**5.2**	**0.6**	**2.3**	**1.7**	**1.0**	**4.0**	**1.0**	**1.0**	**1.8**	**2.9**	**3.8**	**7.9**	**7.9**	**6.9**
		Standard deviation	**1.0**	**0.3**	**0.3**	**0.1**	**0.2**	**0.1**	**0.2**	**0.1**	**0.1**	**0.2**	**0.1**	**0.4**	**0.3**	**0.5**	**0.5**	**0.4**
F	Kempholay	BNHS 5808 (NT)	21.0	6.4	7.0	0.8	3.5	2.7	1.2	5.7	1.6	1.6	2.4	4.2	5.6	10.6	10.5	8.0
F	Maranhalli	BNHS 5616 (RS)	19.0	5.2	5.8	0.8	3.0	2.4	1.1	5.0	1.3	1.3	2.0	3.3	5.0	10.1	9.9	8.6
F	Bhagamandala	BNHS 5617 (RS)	20.7	6.4	6.7	0.8	3.4	2.4	1.5	5.0	1.3	1.3	2,5	3.6	5.1	10.4	10.0	8.0
F	Yavakapady	BNHS 5619 (RS)	17.7	6.0	6.5	0.8	2.9	2.2	1.1	4.3	1.2	1.2	1.9	3.2	4.9	9.2	10.0	8.6
F	Yavakapady	BNHS 5620 (RS)	20.3	6.1	6.6	0.9	3.2	2.0	1.3	5.1	1.3	1.3	2.1	3.9	5.3	11.0	10.9	9.4
		Average	**19.7**	**6.0**	**6.5**	**0.8**	**3.2**	**2.3**	**1.2**	**5.0**	**1.3**	**1.3**	**2.1**	**3.6**	**5.2**	**10.3**	**10.3**	**8.5**
		Standard deviation	**1.4**	**0.5**	**0.4**	**0.0**	**0.3**	**0.3**	**0.2**	**0.5**	**0.2**	**0.2**	**0.2**	**0.4**	**0.3**	**0.7**	**0.4**	**0.6**
Micrixalus kurichiyari sp. nov.																		
M	Kurichiyarmala	BNHS 5621 (HT)	18.6	6.1	7.3	1.0	3.2	2.3	1.5	5.4	1.5	1.5	2.6	4.0	5.0	9.1	9.8	9.2
M	Kurichiyarmala	BNHS 5622 (PT)	19.7	6.0	7.1	1.0	3.1	2.2	1.4	5.7	1.3	1.4	2.5	3.9	5.1	9.2	9.7	9.5
M	Kurichiyarmala	BNHS 5623 (PT)	18.7	6.0	7.5	1.0	3.4	2.2	1.3	5.3	1.5	1.5	2.5	4.0	5.0	9.3	9.9	9.5
M	Kurichiyarmala	BNHS 5624 (PT)	18.8	6.0	7.2	0.9	3.1	2.0	1.4	5.3	1.5	1.4	2.1	3.8	5.0	9.1	9.6	8.9
M	Kurichiyarmala	BNHS 5625 (PT)	17.4	6.0	7.1	0.9	3.0	2.0	1.3	5.4	1.4	1.4	2.3	3.7	5.0	9.1	9.7	9.1
M	Kurichiyarmala	BNHS 5626 (PT)	18.4	6.1	7.3	1.0	3.1	2.2	1.4	5.5	1.4	1.4	2.5	3.6	5.0	9.2	9.6	9.5
		Average	**18.6**	**6.0**	**7.3**	**1.0**	**3.2**	**2.2**	**1.4**	**5.4**	**1.4**	**1.4**	**2.4**	**3.8**	**5.0**	**9.2**	**9.7**	**9.3**
		Standard deviation	**0.7**	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.1**	**0.2**	**0.2**	**0.0**	**0.1**	**0.1**	**0.3**
Micrixalus niluvasei sp.nov.																		
M	Niluvase	BNHS 5627 (HT)	15.5	4.9	5.3	0.4	1.8	1.8	1.2	4.4	0.9	0.5	1.2	2.9	3.6	8.8	8.7	6.9
M	Niluvase	BNHS 5628 (PT)	16.2	5.4	6.1	0.6	2.4	1.9	1.1	4.9	1.0	0.4	1.8	3.0	4.0	8.7	8.9	7.1
		Average	**15.9**	**5.2**	**5.7**	**0.5**	**2.1**	**1.9**	**1.2**	**4.7**	**1.0**	**0.5**	**1.5**	**3.0**	**3.8**	**8.8**	**8.8**	**7.0**
		Standard deviation	**0.4**	**0.3**	**0.4**	**0.1**	**0.3**	**0.0**	**0.0**	**0.3**	**0.1**	**0.1**	**0.3**	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**
F	Niluvase	BNHS 5629 (PT)	21.5	6.6	7.2	0.8	3.4	2.4	1.4	5.3	1.9	1.1	2.3	4.1	5.1	10.4	10.5	9.3
F	Niluvase	BNHS 5630 (PT)	19.9	5.8	6.7	0.9	3.0	1.9	1.2	5.3	1.7	1.0	1.9	3.9	4.8	10.1	10.1	8.5
F	Niluvase	BNHS 5631 (PT)	19.8	6.3	6.6	0.7	2.7	1.9	1.1	4.9	1.8	1.1	2.1	3.7	4.6	10.0	9.9	8.7
F	Niluvase	BNHS 5632 (PT)	20.7	6.0	7.0	1.0	2.8	1.8	1.2	5.6	1.6	1.1	1.9	4.0	5.0	10.6	10.6	9.4
		Average	**20.5**	**6.2**	**6.9**	**0.9**	**3.0**	**2.0**	**1.2**	**5.3**	**1.8**	**1.1**	**2.1**	**3.9**	**4.9**	**10.3**	**10.3**	**9.0**
		Standard deviation	**0.8**	**0.4**	**0.3**	**0.1**	**0.3**	**0.3**	**0.1**	**0.3**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.4**
Micrixalus sairandhri sp.nov.																		
M	Sairandhri	BNHS 5633 (HT)	17.8	5.5	6.8	0.6	2.9	1.6	1.5	5.5	1.5	1.4	2.4	3.8	4.9	10.3	9.8	8.7
M	Sairandhri	BNHS 5634 (PT)	17.9	5.9	6.6	0.7	3.0	1.4	1.4	4.9	1.1	1.3	2.3	3.8	4.9	10.3	9.4	9.1
M	Sairandhri	BNHS 5635 (PT)	17.1	5.8	6.5	0.8	2.5	1.5	1.6	4.9	1.1	1.3	2.2	3.5	4.7	9.6	9.1	8.9

M	Sairandhri	BNHS 5636 (PT)	18.7	5.9	6.8	0.6	3.0	1.6	1.6	5.1	1.5	1.3	2.4	3.7	4.9	10.7	9.7	9.1
M	Sairandhri	BNHS 5637 (PT)	17.4	5.6	6.3	0.6	2.9	1.6	1.6	4.8	1.2	1.4	1.9	3.4	4.7	10.0	9.2	8.9
M	Sairandhri	BNHS 5638 (PT)	17.8	5.5	6.6	0.7	2.7	1.5	1.5	5.0	1.1	1.1	2.1	3.6	4.9	9.9	9.0	8.6
		Average	**17.8**	**5.7**	**6.6**	**0.7**	**2.8**	**1.5**	**1.5**	**5.0**	**1.3**	**1.3**	**2.2**	**3.6**	**4.8**	**10.1**	**9.4**	**8.9**
		Standard deviation	**0.5**	**0.2**	**0.2**	**0.1**	**0.2**	**0.1**	**0.1**	**0.2**	**0.2**	**0.1**	**0.2**	**0.1**	**0.1**	**0.3**	**0.3**	**0.2**
F	Sairandhri	BNHS 5639 (PT)	22.9	7.1	7.2	0.8	3.5	2.1	2.0	5.4	1.5	1.6	2.4	4.4	5.9	12.3	11.5	10.7
Micrixalus spelunca sp.nov.																		
M	Coonoor	BNHS 5640 (HT)	17.2	5.9	5.9	0.6	2.6	2.3	1.3	4.8	1.4	1.1	2.1	3.5	4.5	9.5	8.5	8.5
M	Coonoor	BNHS 5641 (PT)	17.7	5.8	5.9	0.6	2.6	2.1	1.1	4.8	1.1	1.0	2.1	3.2	4.8	9.5	8.3	8.3
M	Coonoor	BNHS 5642 (PT)	15.5	5.6	5.5	0.5	2.6	1.9	1.1	4.5	1.2	1.0	1.7	2.8	4.2	9.1	8.1	8.1
M	Coonoor	BNHS 5643 (PT)	15.8	5.4	5.4	0.5	1.1	2.0	1.0	4.2	1.2	1.1	1.7	3.2	4.3	9.9	8.7	8.6
M	Coonoor	BNHS 5645 (PT)	16.8	5.5	5.4	0.5	2.5	1.9	1.3	4.3	1.4	1.1	2.2	3.0	4.5	9.1	8.3	8.3
M	Coonoor	BNHS 5646 (PT)	16.7	5.5	5.7	0.6	2.3	2.0	1.2	4.6	1.1	1.2	1.0	3.5	4.4	9.0	8.7	8.8
		Average	**16.6**	**5.6**	**5.6**	**0.6**	**2.3**	**2.0**	**1.2**	**4.5**	**1.2**	**1.1**	**1.8**	**3.2**	**4.5**	**9.4**	**8.4**	**8.4**
		Standard deviation	**0.8**	**0.2**	**0.2**	**0.1**	**0.6**	**0.2**	**0.1**	**0.3**	**0.1**	**0.1**	**0.4**	**0.3**	**0.2**	**0.3**	**0.2**	**0.3**
F	Coonoor	BNHS 5644 (PT)	21.8	6.3	6.4	0.6	3.4	2.0	1.4	5.5	1.4	1.1	1.1	4.4	5.2	10.5	9.1	9.1
Micrixalus uttaraghati sp. nov.																		
M	Amboli	BNHS 5647 (HT)	17.4	5.8	6.2	0.8	2.6	2.1	1.2	4.9	1.1	1.5	1.8	2.7	4.7	10.2	9.7	8.0
M	Amboli	BNHS 5648 (PT)	16.6	5.1	5.8	0.7	2.6	1.8	1.2	4.8	0.9	1.5	2.9	2.8	4.6	10.2	8.4	7.9
M	Amboli	BNHS 5649 (PT)	15.4	5.6	5.3	0.7	2.6	1.8	1.1	3.8	0.9	1.3	1.8	3.3	4.4	10.0	8.4	7,7
M	Amboli	BNHS 5650 (PT)	14.6	5.3	5.7	0.6	2.6	2.0	1.1	4.5	0.8	1.3	1.9	3.0	4.4	9.4	8.0	7.5
M	Amboli	BNHS 5651 (PT)	15.8	5.5	6.0	0.6	2.4	1.9	1.0	4.5	0.9	1.3	1.8	3.0	4.3	9.0	8.2	7.8
M	Amboli	BNHS 5652 (PT)	15.3	5.1	5.7	0.7	2.5	1.9	1.2	4.0	0.9	1.3	1.8	2.9	4.0	8.0	7.5	7.3
M	Amboli	BNHS 5653 (PT)	14.6	5.3	5.2	0.6	2.5	2.0	1.3	4.3	0.8	1.2	1.7	3.1	4.3	8.1	7.6	7.4
		Average	**15.7**	**5.4**	**5.7**	**0.7**	**2.5**	**1.9**	**1.2**	**4.4**	**0.9**	**1.3**	**2.0**	**3.0**	**4.4**	**9.3**	**8.3**	**7.7**
		Standard deviation	**1.0**	**0.3**	**0.4**	**0.1**	**0.1**	**0.1**	**0.1**	**0.4**	**0.1**	**0.1**	**0.4**	**0.2**	**0.2**	**0.9**	**0.7**	**0.3**
F	Amboli	BNHS 5654 (PT)	20.1	6.2	6.8	0.7	3.2	2.2	1.4	5.5	1.1	1.6	1.9	3.4	5.2	10.3	9.8	8.8
***Micrixalus fuscus* GROUP**																		
Micrixalus adonis sp. nov.																		
M	Sevenmallay	BNHS 5655 (HT)	22.6	6.7	8.0	1.0	3.8	2.3	1.8	6.5	1.4	1.7	2.8	4.7	5.8	11.5	12.3	10.2
M	Sevenmallay	BNHS 5656 (PT)	21.1	6.2	7.9	1.1	3.1	1.8	1.5	6.0	1.4	1.2	2.7	4.6	5.6	11.2	12.3	10.1
M	Kadalar estate	BNHS 5657 (PT)	23.5	6.8	8.2	1.1	3.4	2.1	2.0	6.3	1.6	1.6	2.6	4.8	5.8	12.1	13.1	10.7
M	Kadalar estate	BNHS 5658 (PT)	22.5	6.8	8.1	1.2	3.4	2.3	2.0	6.6	1.5	1.5	2.7	4.2	5.9	11.3	12.5	10.3

M	Kadalar estate	BNHS 5659 (PT)	22.6	6.8	8.1	1.3	3.2	2.0	2.0	6.7	1.6	1.4	3.2	4.7	5.8	11.8	12.9	10.3
M	Kadalar estate	BNHS 5660 (PT)	21.9	6.6	8.0	1.1	3.1	2.1	1.2	6.5	1.4	1.4	2.6	4.5	5.6	10.7	11.9	9.9
M	Kadalar estate	BNHS 5661 (PT)	24.1	6.9	8.6	1.3	3.8	2.0	1.9	6.8	1.4	1.5	2.7	4.9	6.0	11.4	12.1	10.6
M	Letchmi estate	BNHS 5666 (PT)	22.6	6.9	8.1	1.0	3.5	2.1	1.4	6.0	1.4	1.6	2.6	4.9	5.5	10.9	12.2	10.1
		Average	**22.6**	**6.7**	**8.1**	**1.1**	**3.4**	**2.1**	**1.7**	**6.4**	**1.5**	**1.5**	**2.7**	**4.7**	**5.8**	**11.4**	**12.4**	**10.3**
		Standard deviation	**0.9**	**0.2**	**0.2**	**0.1**	**0.3**	**0.2**	**0.3**	**0.3**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.5**	**0.4**	**0.3**
F	Kadalar estate	BNHS 5662 (PT)	28.6	8.1	8.6	1.1	4.4	2.7	2.1	7.3	1.8	1.7	3.0	5.7	7.1	13.8	15.7	11.6
F	Kadalar estate	BNHS 5663 (PT)	30.1	8.7	9.3	1.4	4.5	2.4	2.6	8.2	1.9	1.7	3.4	5.2	7.3	13.1	15	12.1
F	Kadalar estate	BNHS 5664 (PT)	26.5	7.9	9.1	1.3	4.3	2.3	2.0	7.0	1.8	1.7	2.9	5.4	6.9	13.0	14.5	11.7
F	Kadalar estate	BNHS 5665 (PT)	27.6	7.9	8.8	1.2	4.3	2.3	2.3	7.8	1.7	1.6	3.3	5.2	6.7	13.1	14.6	11.7
F	Letchmi estate	BNHS 5667 (PT)	28.1	8.6	9.5	1.3	4.2	2.4	2.1	7.1	1.9	1.8	3.1	5.2	7.6	13.0	14.8	12.1
F	Thekkady	BNHS 5668 (PT)	27.6	7.8	9.2	1.1	4.2	2.6	2.0	8.0	1.8	1.7	3.1	5.1	6.8	13.1	15.7	11.1
		Average	**28.1**	**8.2**	**9.1**	**1.2**	**4.3**	**2.5**	**2.2**	**7.6**	**1.8**	**1.7**	**3.1**	**5.3**	**7.1**	**13.2**	**15.1**	**11.7**
		Standard deviation	**1.2**	**0.4**	**0.3**	**0.1**	**0.1**	**0.2**	**0.2**	**0.5**	**0.1**	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**	**0.5**	**0.4**
Micrixalus fuscus																		
M	Kakkachi	BNHS 5669 (RS)	28.2	8.2	9.1	1.1	4.2	2.4	1.7	7.2	1.7	1.7	3.5	5.2	7.1	14.5	14.9	12.1
M	Kakkachi	SDBDU 2006.2296 (RS)	27.9	8.1	9.1	0.9	4.1	2.3	1.8	7.2	1.6	1.6	3.6	5.1	7.1	14.4	14.9	12.3
M	Kakkachi	BNHS 5670 (RS)	28.8	8.3	9.2	1.1	4.3	2.5	1.9	7.3	1.6	1.8	3.2	5.1	7.3	14.7	15.1	12.4
		Average	**28.3**	**8.2**	**9.1**	**1.0**	**4.2**	**2.4**	**1.8**	**7.2**	**1.6**	**1.7**	**3.4**	**5.1**	**7.1**	**14.5**	**15.0**	**12.3**
		Standard deviation	**0.5**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.2**	**0.2**	**0.1**	**0.2**
F	“Travancore”	NHM 74.4.29.258 (LT)	32.1	8.3	10.5	1.2	5.1	2.7	2.5	8.8	2.1	2.2	3.5	5.2	7.9	14.9	16.0	13.6
F	“Travancore”	NHM 74.4.29.259 (PL)	30.6	8.7	10.3	1.1	4.9	2.5	2.0	8.5	2	2.1	3.3	5.0	7.4	14.8	15.9	13.2
F	Kakkachi	BNHS 5671 (RS)	32.7	8.4	10.4	1.1	5.0	2.4	2.0	8.9	2.3	2.1	3.6	4.9	7.8	15.5	16.1	13.6
F	Kakkachi	BNHS 5672 (RS)	33.1	9.2	10.4	1.3	5.3	3.1	2.1	8.1	2.5	2.5	3.6	5.5	7.9	16.1	16.2	13.9
F	Sengaltheri	BNHS 5673 (RS)	30.1	8.6	9.9	1.1	4.8	2.6	1.6	8.1	2.1	2.0	3.0	5.0	7.5	14.2	15.8	13.6
F	Sengaltheri	BNHS 5674 (RS)	31.1	8.2	9.7	1.0	4.8	2.9	2.0	8.4	2.0	2.0	3.2	5.2	7.4	14.8	16.0	16.5
F	Athirimala	BNHS 5675 (RS)	32.1	8.8	11.1	1.2	5.1	2.8	1.9	8.9	2.4	2.4	3.2	5.8	7.7	15.2	15.3	13.0
F	Pandipath	BNHS 5676 (RS)	30.9	8.8	10.0	1.2	4.7	2.6	1.9	8.4	2.1	2.2	3.1	5.1	8.1	14.4	15.8	13.3
		Average	**31.6**	**8.6**	**10.2**	**1.2**	**4.9**	**2.7**	**2.0**	**8.5**	**2.2**	**2.2**	**3.3**	**5.2**	**7.7**	**15.0**	**15.9**	**13.8**
		Standard deviation	**1.1**	**0.3**	**0.3**	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.6**	**0.3**	**1.1**
Micrixalus herrei																		
M	Kallar	BNHS 5677 (TT)	17.7	6.0	6.0	0.9	2.8	1.7	1.3	4.9	1.2	1.1	2.3	3.6	4.8	10.4	10.5	8.9

M	Kallar	BNHS 5678 (RS)	18.3	5.9	6.0	0.9	2.8	1.9	1.6	5.0	1.1	0.9	2.4	3.6	4.9	9.2	9.1	8.9
M	Chathankod	BNHS 5679 (RS)	19.4	6.3	6.3	1.0	2.8	2.0	1.5	5.3	1.3	1.1	2.8	3.8	5.3	10.2	10.3	9.5
M	Chathankod	BNHS 5681 (RS)	18.8	5.9	6.0	0.7	2.8	1.4	1.1	5.6	1.0	0.8	2.6	3.7	5.1	10.5	10.4	8.7
M	Chathankod	BNHS 5682 (RS)	18.3	6.0	6.1	0.9	2.7	1.7	1.5	5.0	1.3	1.1	2.4	3.7	4.9	9.6	10.1	9.0
M	Chathankod	BNHS 5684 (RS)	18.8	6.2	6.2	0.9	2.7	1.8	1.6	5.5	1.5	1.1	2.4	3.7	4.8	9.9	10.0	9.0
M	Ponmudi	BNHS 5685 (RS)	16.7	5.9	6.0	0.7	2.7	1.5	1.7	5.3	1.5	1.2	2.4	3.5	4.4	10.3	10.2	8.8
M	Kovachal	BNHS 5686 (RS)	19.1	6.2	6.1	1.0	2.9	1.6	1.2	5.3	1.7	1.2	2.8	3.9	5.1	10.2	10.2	9.4
M	Kiriparai	BNHS 5687 (RS)	17.3	5.9	6.0	0.8	2.4	1.6	1.3	4.8	1.4	1.1	2.2	3.4	4.6	10.1	10.1	8.7
		Average	**18.3**	**6.0**	**6.1**	**0.9**	**2.7**	**1.7**	**1.4**	**5.2**	**1.3**	**1.1**	**2.5**	**3.7**	**4.9**	**10.0**	**10.1**	**9.0**
		Standard deviation	**0.9**	**0.2**	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**	**0.3**	**0.2**	**0.1**	**0.2**	**0.2**	**0.3**	**0.4**	**0.4**	**0.3**
F	Chathankod	BNHS 5680 (RS)	24.8	8.4	8.6	0.9	3.8	2.1	1.6	7.0	1.6	1.4	2.3	4.4	5.8	12.8	12.9	11.6
F	Chathankod	BNHS 5683 (RS)	26.6	8.3	8.5	1.4	3.9	2.6	2.0	6.7	1.7	1.6	3.0	5.0	6.4	14.0	14.1	12.5
F	Putherichariu m	BNHS 5688 (RS)	26.1	8.5	8.4	1.1	3.7	2.0	1.9	6.7	1.8	1.5	2.7	4.9	6.6	13.5	13.6	12.2
		Average	**25.8**	**8.4**	**8.5**	**1.1**	**3.8**	**2.2**	**1.8**	**6.8**	**1.7**	**1.5**	**2.7**	**4.8**	**6.3**	**13.4**	**13.5**	**12.1**
		Standard deviation	**0.9**	**0.1**	**0.1**	**0.3**	**0.1**	**0.3**	**0.2**	**0.2**	**0.1**	**0.1**	**0.4**	**0.3**	**0.4**	**0.6**	**0.6**	**0.5**
Micrixalus kodayari sp. nov.																		
M	Kodayar	BNHS 5690 (PT)	18.7	6.6	7.8	0.9	3.2	1.7	1.4	6.2	1.4	1.4	2.4	4.3	5.5	10.9	10.9	9.5
M	Kodayar	BNHS 5691 (PT)	17.7	5.8	6.4	0.8	2.5	1.6	1.3	5.3	1.4	1.4	2.3	3.6	4.6	9.5	9.6	7.6
		Average	**18.2**	**6.2**	**7.1**	**0.9**	**2.9**	**1.7**	**1.4**	**5.8**	**1.4**	**1.4**	**2.4**	**4.0**	**5.1**	**10.2**	**10.3**	**8.6**
		Standard deviation	**0.7**	**0.6**	**1.0**	**0.1**	**0.5**	**0.1**	**0.1**	**0.6**	**0.0**	**0.0**	**0.1**	**0.5**	**0.6**	**1.0**	**0.9**	**1.3**
F	Kodayar	BNHS 5689 (HT)	24.6	8.0	8.8	0.9	3.6	2.0	1.9	6.8	1.6	1.7	2.3	4.9	6.1	12.9	12.9	11.2
F	Kakkachi	BNHS 5692 (PT)	25.6	8.2	8.7	1.1	3.8	2.2	2.0	7.0	1.8	1.6	2.7	5.0	6.5	13.1	13.2	11.4
F	Kakkachi	BNHS 5693 (PT)	25.1	8.1	8.7	1.1	3.9	2.2	2.1	6.9	1.8	1.7	2.9	5.1	6.4	13.0	13.0	11.5
		Average	**25.1**	**8.1**	**8.7**	**1.0**	**3.8**	**2.1**	**2.0**	**6.9**	**1.7**	**1.7**	**2.6**	**5.0**	**6.3**	**13.0**	**13.0**	**11.4**
		Standard deviation	**0.5**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.3**	**0.1**	**0.2**	**0.1**	**0.2**	**0.2**
Micrixalus mallani sp. nov.																		
M	Pandimotta	BNHS 5694 (HT)	19.5	6.1	7.2	0.9	3.1	1.7	1.2	5.4	1.1	1.3	2.3	3.8	5.1	10.5	10.1	9.2
M	Sabarimala	BNHS 5696 (PT)	22.4	6.4	7.4	1.1	3.3	2.1	1.7	5.6	1.6	1.4	2.6	4.0	5.5	10.7	10.8	9.3
M	Sabarimala	BNHS 5697 (PT)	21.5	6.1	7.1	1.0	3.2	2.2	1.3	5.4	1.4	1.3	2.4	4.2	5.7	10.5	10.5	9.3
M	Sabarimala	BNHS 5698 (PT)	20.8	6.1	7.1	1.0	3.2	1.9	1.4	5.1	1.2	1.2	2.3	4.1	5.7	10.3	10.4	9.6
		Average	**21.1**	**6.2**	**7.2**	**1.0**	**3.2**	**2.0**	**1.4**	**5.4**	**1.3**	**1.3**	**2.4**	**4.0**	**5.5**	**10.5**	**10.5**	**9.4**
		Standard deviation	**1.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.2**	**0.3**	**0.2**	**0.3**	**0.2**
F	Pandimotta	BNHS 5695 (PT)	27.7	8.1	9.5	1.2	4.2	2.4	1.6	7.1	2.3	1.7	3.3	5.2	6.6	14.1	14.1	11.7

F	Athirimala	BNHS 5699 (PT)	25.4	7.9	8.2	1.1	4.1	2.1	1.6	6.6	2.0	1.8	3.0	5.2	6.2	13.2	13.3	11.9
F	Athirimala	BNHS 5700 (PT)	27.3	7.9	9.1	1.1	4.1	2.5	1.4	7.2	2.2	2.2	2.9	5.3	6.1	14.3	14.2	11.1
F	Ponkalappara	BNHS 5701 (PT)	25.1	7.6	9.1	1.1	4.3	2.2	1.9	6.8	1.9	1.5	2.7	4.7	6.1	13.1	13.2	10.8
		Average	**26.4**	**7.9**	**9.0**	**1.1**	**4.2**	**2.3**	**1.6**	**6.9**	**2.1**	**1.8**	**3.0**	**5.1**	**6.3**	**13.7**	**13.7**	**11.4**
		Standard deviation	**1.3**	**0.2**	**0.6**	**0.0**	**0.1**	**0.2**	**0.2**	**0.3**	**0.2**	**0.3**	**0.3**	**0.3**	**0.2**	**0.6**	**0.5**	**0.5**
Micrixalus nelliyampathi sp.nov.																		
M	Kesavapara	BNHS 5702 (HT)	23.7	7.2	8.4	0.8	4.1	2.1	1.8	6.3	1.3	1.7	3.0	5.1	6.2	11.9	12.1	11.8
M	Kesavapara	BNHS 5703 (PT)	21.5	6.2	8.2	1.1	3.7	2.3	1.7	5.9	1.2	1.5	2.8	4.0	5.5	9.9	11.3	9.8
M	Kesavapara	BNHS 5704 (PT)	21.4	6.1	8.1	0.9	3.4	2.1	1.2	5.9	1.1	1.5	2.6	3.9	5.6	9.8	11.2	9.8
M	Poopara	BNHS 5707 (PT)	21.3	6.3	8.0	1.2	3.6	2.3	1.2	6.1	1.4	1.7	2.5	4.2	5.8	10.0	11.9	10.0
M	Andiparai	BNHS 5708 (PT)	21.7	6.5	8.0	1.0	3.5	1.9	1.3	6.1	1.4	1.7	2.6	4.1	5.9	10.1	11.9	10.0
M	Andiparai	BNHS 5709 (PT)	23.4	7.1	8.4	1.0	4.1	2.2	1.8	6.3	1.2	1.9	2.0	5.0	6.0	11.6	12.6	11.6
M	Andiparai	BNHS 5711 (PT)	22.2	6.9	8.4	1.1	3.8	2.1	1.6	6.1	1.5	1.4	2,8	5.0	6.0	11.3	12.8	11.3
		Average	**22.2**	**6.6**	**8.2**	**1.0**	**3.7**	**2.1**	**1.5**	**6.1**	**1.3**	**1.6**	**2.6**	**4.5**	**5.9**	**10.7**	**12.0**	**10.6**
		Standard deviation	**1.0**	**0.4**	**0.2**	**0.1**	**0.3**	**0.1**	**0.3**	**0.2**	**0.1**	**0.2**	**0.3**	**0.5**	**0.2**	**0.9**	**0.6**	**0.9**
F	Kesavapara	BNHS 5705 (PT)	28.5	8.5	9.9	1.2	4.5	3.4	2.1	7.4	1.9	2.3	3.2	5.1	6.8	13.1	14.8	13.1
F	Kesavapara	BNHS 5706 (PT)	27.1	7.9	9.1	1.1	4.4	3.1	2.0	7.3	1.6	2.6	3.0	4.8	7.4	12.1	14.9	12.1
F	Andiparai	BNHS 5710 (PT)	29.5	8.2	10.0	1.3	4.8	3.4	2.1	8.1	2.0	2.6	3.1	5.5	7.1	13.3	15.1	13.2
F	Grass hills	BNHS 5712 (PT)	29.1	8.4	11.2	1.2	4.7	3.3	2.1	7.8	2.1	2.5	3.1	5.4	7.6	13.0	15.0	12.9
F	Grass hills	BNHS 5713 (PT)	25.6	7.5	8.7	1.5	4.1	2.9	1.9	7.0	2.0	2.6	2.8	4.7	7.2	12.2	14.1	12.1
		Average	**28.0**	**8.1**	**9.8**	**1.3**	**4.5**	**3.2**	**2.0**	**7.5**	**1.9**	**2.5**	**3.0**	**5.1**	**7.2**	**12.7**	**14.8**	**12.7**
		Standard deviation	**1.6**	**0.4**	**1.0**	**0.2**	**0.3**	**0.2**	**0.1**	**0.4**	**0.2**	**0.1**	**0.2**	**0.4**	**0.3**	**0.6**	**0.4**	**0.5**
***Micrixalus nudis* GROUP**																		
Micrixalus gadgili																		
M	Sabarimala	BNHS 5714 (RS)	16.1	5.1	5.3	0.5	2.3	1.7	1.3	4.8	0.8	1.2	1.8	3.5	3.6	8.2	8.4	7.7
M	Gavi	BNHS 5715 (RS)	15.7	4.9	5.1	0.4	2.4	1.5	1.2	4.2	0.7	1.1	1.7	3.1	3.5	8.2	8.5	7.4
M	Thekkady	BNHS 5717 (RS)	16.2	4.8	5.5	0.5	2.6	1.7	1.2	4.6	0.9	1.4	1.9	3.2	3.5	7.8	8.0	7.1
M	Thekkady	BNHS 5718 (RS)	15.5	4.8	5.1	0.6	2.5	1.6	1.1	4.1	0.8	1.4	1.9	3.1	3.6	7.8	7.9	7.4
M	Thekkady	BNHS 5719 (RS)	15.1	4.8	5.1	0.6	2.4	1.3	1.3	4.1	0.8	1.3	2.0	3.1	3.7	8.3	8.6	7.4
M	Kesavapara	BNHS 5720 (RS)	15.1	4.8	5.4	0.5	2.2	1.7	1.3	4.5	0.9	1.3	1.8	3.2	3.8	7.8	7.9	7.1
M	Kesavapara	BNHS 5721 (RS)	15.9	4.9	5.5	0.5	2.4	1.6	1.1	4.4	0.8	1.2	1.6	3.1	4.3	8.1	8.2	7.8
M	Kesavapara	BNHS 5722 (RS)	15.9	4.8	5.1	0.6	2.2	1.7	1.3	4.2	0.9	1.3	1.8	3.1	3.9	8.3	7.9	7.3
		Average	**15.7**	**4.9**	**5.3**	**0.5**	**2.4**	**1.6**	**1.2**	**4.4**	**0.8**	**1.3**	**1.8**	**3.2**	**3.7**	**8.1**	**8.2**	**7.4**

F	"Pamba, Sabarigiri"	ZSI-SRS VA/780 (HT)	17.0	5.3	6.5	0.6	2.2	1.8	1.3	4.6	1.1	1.5	1.7	3.8	4.2	9.0	9.4	8.4
F	Gavi	BNHS 5716 (RS)	18.2	5.8	6.8	0.9	2.9	2.0	1.4	5.0	1.2	1.7	2.0	4.1	4.5	9.3	9.6	8.8
		Average	**17.6**	**5.6**	**6.7**	**0.8**	**2.6**	**1.9**	**1.4**	**4.8**	**1.2**	**1.6**	**1.9**	**4.0**	**4.4**	**9.2**	**9.5**	**8.6**
		Standard deviation	**0.8**	**0.4**	**0.2**	**0.2**	**0.5**	**0.1**	**0.1**	**0.3**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.3**
Micrixalus nudis																		
M	Chethalayam falls	BNHS 5723 (RS)	16.3	5.2	5.9	0.9	2.6	1.5	1.6	4.9	1.5	0.9	2.1	3.2	4.3	8.2	8.3	7.6
M	Chethalayam falls	BNHS 5725 (RS)	15.4	5.3	5.7	0.7	2.6	1.4	1.9	4.8	1.4	0.9	2.1	3.0	4.2	8.4	8.6	7.8
M	Chethalayam falls	BNHS 5726 (RS)	15.2	5.0	5.5	0.7	2.5	1.9	1.4	4.7	1.6	1.0	2.3	3.3	4.3	8.5	8.9	7.7
M	Chethalayam falls	BNHS 5727 (RS)	15.6	5.3	5.4	0.5	1.8	1.8	1.4	4.5	1.5	1.1	2.0	3.6	4.3	8.7	9.0	7.8
M	Chethalayam falls	BNHS 5728 (RS)	15.8	5.2	5.8	0.6	2.6	1.5	1.6	5.8	1.6	1.1	2.1	3.1	4.2	8.4	8.6	7.6
		Average	**15.7**	**5.2**	**5.7**	**0.7**	**2.4**	**1.6**	**1.6**	**4.9**	**1.5**	**1.0**	**2.1**	**3.2**	**4.3**	**8.4**	**8.7**	**7.7**
		Standard deviation	**0.4**	**0.1**	**0.2**	**0.1**	**0.3**	**0.2**	**0.2**	**0.5**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.2**	**0.3**	**0.1**
F	Chethalayam falls	BNHS 5724 (RS)	20.3	6.1	6.8	0.8	3.1	1.7	1.5	5.5	1.6	1.2	2.1	4.2	4.9	10.6	10.6	9.4
F	Chethalayam falls	BNHS 5729 (RS)	20.5	6.1	6.8	0.8	3.1	1.9	1.6	5.5	1.8	1.2	2.2	4.0	4.8	10.5	10.5	9.7
F	Chethalayam falls	BNHS 5730 (RS)	20.7	6.2	6.9	0.7	2.9	1.9	1.5	5.4	1.7	1.2	2.5	4.1	4.9	10.4	10.6	9.6
		Average	**20.5**	**6.1**	**6.8**	**0.8**	**3.0**	**1.8**	**1.5**	**5.5**	**1.7**	**1.2**	**2.3**	**4.1**	**4.9**	**10.5**	**10.6**	**9.6**
		Standard deviation	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.0**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**
Micrixalus sali sp. nov.																		
M	Ponmudi	BNHS 5731 (HT)	14.8	4.6	5.5	0.4	2.4	1.7	1.2	4.4	1.0	1.0	1.8	3.1	3.9	7.8	7.7	6.9
M	Ponmudi	BNHS 5735 (PT)	14.8	4.7	5.4	0.5	2.4	1.7	1.2	4.6	1.2	1.2	1.8	3.2	3.4	7.5	7.8	6.8
M	Ponmudi	BNHS 5736 (PT)	13.8	4.5	5.5	0.5	2.4	1.4	1.0	3.6	1.0	1.0	1.4	3.1	3.3	7.6	7.6	6.5
M	Ponmudi	BNHS 5732 (PT)	14.5	4.7	5.2	0.5	2.4	1.7	1.0	3.8	1.1	1.1	1.8	3.1	3.9	6.9	7.0	6.6
M	Ponmudi	BNHS 5733 (PT)	14.9	4.6	5.0	0.5	2.5	1.7	1.0	4.1	1.1	1.1	1.7	3.4	3.6	7.7	7.8	6.7
M	Ponmudi	BNHS 5734 (PT)	14.7	4.6	5.1	0.5	2.8	1.7	1.1	4.0	1.0	0.9	1.9	3.2	3.9	7.7	7.9	6.7
		Average	**14.6**	**4.6**	**5.3**	**0.5**	**2.5**	**1.7**	**1.1**	**4.1**	**1.1**	**1.1**	**1.7**	**3.2**	**3.7**	**7.5**	**7.6**	**6.7**
		Standard deviation	**0.4**	**0.1**	**0.2**	**0.0**	**0.2**	**0.1**	**0.1**	**0.4**	**0.1**	**0.1**	**0.2**	**0.1**	**0.3**	**0.3**	**0.3**	**0.1**
F	Ponmudi	BNHS 5737 (RS)	16.2	5.1	5.6	0.8	2.5	1.9	1.1	4.2	1.3	1.3	1.7	3.1	7.5	7.1	7.0	6.7
Micrixalus thampii																		
M	Sairandhri	BNHS 5738 (RS)	16.2	5.4	6.1	0.9	2.7	1.7	1.5	4.7	1.3	1.3	1.8	3.5	3.9	8.8	8.9	7.9
M	Sairandhri	BNHS 5740 (RS)	14.7	5.4	6.0	0.8	2.8	1.2	1.2	4.2	1.2	1.2	1.8	3.1	3.9	8.7	8.8	8.3
M	Sairandhri	BNHS 5741 (RS)	14.4	5.1	5.6	0.7	2.4	1.5	1.2	4.3	1.1	1.1	1.7	2.7	3.6	7.9	8.5	7.4
M	Sairandhri	BNHS 5742 (RS)	16.1	5.3	6.0	0.7	2.9	1.7	1.3	4.8	1.3	1.2	1.9	3.3	3.9	9.9	9.1	7.9
M	Kuddam	BNHS 5744 (RS)	15.0	5.0	5.5	0.6	2.5	1.6	1.2	4.5	0.9	0.9	2.2	2.8	3.5	7.8	8.3	7.2

M	Kuddam	BNHS 5745 (RS)	15.3	4.9	5.6	0.7	2.5	1.6	1.2	4.5	1.0	1.0	1.9	2.8	3.6	7.9	7.9	7.1
		Average	**15.3**	**5.2**	**5.8**	**0.7**	**2.6**	**1.6**	**1.3**	**4.5**	**1.1**	**1.1**	**1.9**	**3.0**	**3.7**	**8.5**	**8.6**	**7.6**
		Standard deviation	**0.7**	**0.2**	**0.3**	**0.1**	**0.2**	**0.2**	**0.1**	**0.2**	**0.2**	**0.1**	**0.2**	**0.3**	**0.2**	**0.8**	**0.4**	**0.5**
F	Sairandhri	BNHS 5739 (RS)	21.1	7.4	7.2	0.9	3.3	2.2	1.4	5.4	1.5	1.4	2.0	4.3	5.5	10.7	11.1	9.9
F	Sairandhri	BNHS 5743 (RS)	19.5	6.0	6.2	0.9	3.0	2.1	1.5	4.2	1.2	1.2	2.0	3.6	4.7	10.0	10.0	9.2
F	Kuddam	BNHS 5746 (RS)	18.4	6.2	6.7	0.8	2.8	2.0	1.6	4.6	1.4	1.4	1.8	3.7	4.5	9.8	9.7	8.8
		Average	**19.7**	**6.5**	**6.7**	**0.9**	**2.9**	**2.1**	**1.5**	**4.7**	**1.4**	**1.3**	**1.9**	**3.9**	**4.9**	**10.2**	**10.3**	**9.3**
		Standard deviation	**1.4**	**0.8**	**0.5**	**0.1**	**0.1**	**0.1**	**0.1**	**0.6**	**0.2**	**0.1**	**0.1**	**0.4**	**0.5**	**0.5**	**0.7**	**0.6**
***Micrixalus saxicola* GROUP**																		
Micrixalus kottigeharensis																		
M	Kottigehara	BNHS 5747 (NT)	22.1	6.5	7.6	0.8	3.5	2.0	1.5	5.7	1.8	1.6	1.9	4.4	5.6	11.4	12.7	10.6
M	Kottigehara	BNHS 5748 (RS)	22.5	6.7	8.2	0.6	3.7	1.1	1.7	6.8	1.7	1.5	2.4	4.5	5.9	12.7	13.4	10.8
M	Maranhalli	BNHS 5751 (RS)	22.1	6.5	7.7	0.7	3.3	2.1	1.7	6.1	1.6	1.6	2.1	4.7	5.9	12.7	12.3	12.2
M	Maranhalli	BNHS 5752 (RS)	23.9	7.2	8.6	0.5	3.6	2.1	1.9	6.8	1.7	1.7	2.7	4.3	6.0	11.6	12.8	10.6
M	Kathlekan	BNHS 5755 (RS)	22.5	6.4	8.1	0.7	3.4	1.9	1.5	6.6	1.6	1.6	2.2	4.9	5.5	12.2	11.9	11.2
M	Kathlekan	BNHS 5756 (RS)	23.8	6.4	8.5	0.6	3.9	2.4	1.4	6.4	1.6	1.5	2.4	5.0	6.0	13	12.3	11.2
M	Kathlekan	BNHS 5757 (RS)	22.9	6.5	8.8	0.7	3.9	1.9	1.4	6.7	1.5	1.6	2.3	4.6	6.0	12.9	12.4	11.2
M	Waddighat	BNHS 5759 (RS)	23.3	6.7	8.6	0.6	2.9	1.6	1.7	6.1	1.6	1.6	2.6	4.8	6.0	12.4	13.0	10.9
		Average	**22.9**	**6.6**	**8.3**	**0.7**	**3.5**	**1.9**	**1.6**	**6.4**	**1.6**	**1.6**	**2.3**	**4.7**	**5.9**	**12.4**	**12.6**	**11.1**
		Standard deviation	**0.7**	**0.3**	**0.4**	**0.1**	**0.3**	**0.4**	**0.2**	**0.4**	**0.1**	**0.1**	**0.3**	**0.2**	**0.2**	**0.6**	**0.5**	**0.5**
F	Kemmanagundi	BNHS 5749 (RS)	28.7	8.1	10.2	1.0	4.4	2.7	1.8	8.3	2.3	2.2	3.0	5.7	7.3	14.5	14.7	12.9
F	Charmadi Ghats	BNHS 5750 (RS)	28.1	7.8	9.2	1.3	4.0	2.3	1.9	7.5	1.9	1.8	2.5	5.5	6.9	15.4	15.8	13.2
F	Maranhalli	BNHS 5753 (RS)	30.4	8.6	11.0	1.0	4.8	2.9	1.8	8.8	2.1	2.1	2.8	6.1	6.7	15.1	15.4	13.7
F	Maranhalli	BNHS 5754 (RS)	28.6	8.5	9.1	1.0	4.2	2.6	1.8	6.9	2.2	1.6	2.1	5.7	6.7	15.6	15.0	13.6
F	Kathlekan	BNHS 5758 (RS)	28.4	8.2	10.1	7.8	4.8	2.6	1.8	8.2	2.0	1.6	2.5	5.4	6.8	14.5	15.5	12.8
F	Waddighat	BNHS 5760 (RS)	32.6	9.1	9.6	1.5	4.8	2.9	1.8	8.6	2.7	2.5	3.0	5.6	8.8	16.3	16.8	14.6
F	Waddighat	BNHS 5761 (RS)	27.6	8.3	10.0	1.1	4.5	2.7	1.7	8.2	1.7	1.7	2.6	5.7	7.2	16.0	15.6	13.4
F	Unchalli falls	BNHS 5762 (RS)	28.1	8.9	10	1.1	3.9	2.7	1.9	7.7	1.9	1.6	1.5	5.3	7.0	14.8	15.0	13.3
		Average	**29.1**	**8.4**	**9.9**	**2.0**	**4.4**	**2.7**	**1.8**	**8.0**	**2.1**	**1.9**	**2.5**	**5.6**	**7.2**	**15.3**	**15.5**	**13.4**
		Standard deviation	**1.7**	**0.4**	**0.6**	**2.4**	**0.4**	**0.2**	**0.1**	**0.6**	**0.3**	**0.3**	**0.5**	**0.2**	**0.7**	**0.7**	**0.6**	**0.6**
Micrixalus saxicola																		
M	Periya	BNHS 5763 (RS)	20.0	6.1	7.3	0.8	3.3	2.1	1.5	5.1	1.4	1.3	2.4	4.1	5.0	12.2	12.1	9.7
M	Kurichiyarmala	BNHS 5766 (RS)	21.5	6.0	7.8	1.0	3.4	1.9	1.5	6.1	1.6	1.7	2.2	4.0	5.0	12.4	12.5	10.3

M	Aralam	BNHS 5770 (RS)	20.5	6.4	6.7	0.9	4.4	1.9	1.5	5.4	1.6	1.6	2.8	4.3	4.8	12.6	12.5	10.3
M	Aralam	BNHS 5769 (RS)	20.8	6.2	7.4	1.1	3.2	1.9	1.7	6.4	1.6	1.4	2.6	4.0	5.5	12.6	12.5	10.1
M	Kottigehara	BNHS 5771 (RS)	20.0	6.2	7.8	0.9	3.3	1.9	1.5	5.9	1.5	1.4	2.3	4.4	5.2	12.5	12.5	10.5
M	Maranhalli	BNHS 5773 (RS)	20.1	6.1	7.5	0.8	3.2	1.9	1.5	7.1	1.5	1.2	2.1	4.1	5.4	11.5	11.5	10.0
M	Kempholay	BNHS 5774 (RS)	20.0	6.0	7.5	0.9	2.9	1.8	1.3	6.0	1.2	1.2	2.4	3.8	4.8	11.7	11.6	9.7
M	Yavakapady	BNHS 5775 (RS)	20.6	6.7	7.8	1.0	3.2	2.7	1.4	7.9	1.4	1.4	2.4	4.1	5.7	12.2	12.1	10.3
M	Unchalli falls	BNHS 5777 (RS)	21.6	6.5	7.2	1.0	3.6	2.2	1.6	5.5	1.3	1.5	2.2	4.0	5.2	12.5	12.4	9.9
		Average	**20.6**	**6.2**	**7.4**	**0.9**	**3.4**	**2.0**	**1.5**	**6.2**	**1.5**	**1.4**	**2.4**	**4.1**	**5.2**	**12.2**	**12.2**	**10.1**
		Standard deviation	**0.6**	**0.2**	**0.4**	**0.1**	**0.4**	**0.3**	**0.1**	**0.9**	**0.1**	**0.2**	**0.2**	**0.2**	**0.3**	**0.4**	**0.4**	**0.3**
F	"Malabar"	BMNH 72.4.17.203 (LT)	28.8	7.6	9.7	1.4	4.1	2.5	1.9	7.1	1.8	2.1	3.5	5.2	6.2	14.7	14.8	13.3
F	Periya	SDB 2002.3023 (RS)	26.1	7.5	9.6	1.2	4.1	2.2	1.6	7.6	1.6	2.0	3.0	5.6	6.4	15.1	15.1	12.7
F	Banasura	SDB 2002.3015 (RS)	26.6	7.4	8.6	1.2	4.2	2.4	1.9	7.3	2.1	1.8	2.4	4.9	6.9	14.3	14.2	12.4
F	Kurichiyarmala	SDB 2012.2331 (RS)	28.3	7.5	9.7	1.1	4.1	2.3	1.1	7.5	2.2	1.8	3.2	4.9	6.5	14.8	14.9	13.1
F	Settukunnu	SDB 2011.857 (RS)	25.8	7.2	8.3	1.1	4.0	2.3	1.6	7.0	1.9	1.8	2.6	5.1	6.3	15.0	15.1	12.1
F	Charmadi Ghats	SDB 2011.1383 (RS)	25.2	6.7	8.8	1.2	3.9	2.0	2.0	6.7	1.6	1.4	3.0	4.8	6.2	14.2	14.3	12.4
F	Yavakapady	SDB 2012.2238 (RS)	26.0	7.5	8.5	1.3	4.2	2.3	1.6	6.6	1.8	1.7	2.2	4.7	6.9	14.7	14.8	12.9
		Average	**26.7**	**7.3**	**9.0**	**1.2**	**4.1**	**2.3**	**1.7**	**7.1**	**1.9**	**1.8**	**2.8**	**5.0**	**6.5**	**14.7**	**14.7**	**12.7**
		Standard deviation	**1.3**	**0.3**	**0.6**	**0.1**	**0.1**	**0.2**	**0.3**	**0.4**	**0.2**	**0.2**	**0.5**	**0.3**	**0.3**	**0.3**	**0.4**	**0.4**
Micrixalus specca sp. nov.																		
M	Charmadi Ghats	BNHS 5778 (HT)	22.8	6.8	8.6	0.9	3.6	2.0	1.6	6.7	1.7	1.6	2.7	4.7	5.0	11.9	13.0	11.4
M	Charmadi Ghats	BNHS 5779 (PT)	23.1	6.4	8.6	0.7	3.8	2.1	1.4	6.6	1.8	1.8	2.7	4.2	5.4	12.1	13.2	11.1
M	Charmadi Ghats	BNHS 5780 (PT)	23.2	7.0	8.9	1.0	3.8	2.2	1.4	5.9	1.7	1.7	2.5	4.7	5.5	12.0	13.2	10.9
M	Charmadi Ghats	BNHS 5781 (PT)	19.8	6.1	7.6	0.8	3.3	1.6	1.5	5.8	1.3	1.4	2.4	4.5	4.7	9.0	12.1	9.2
		Average	**22.2**	**6.6**	**8.4**	**0.9**	**3.6**	**2.0**	**1.5**	**6.3**	**1.6**	**1.6**	**2.6**	**4.5**	**5.2**	**11.3**	**12.9**	**10.7**
		Standard deviation	**1.6**	**0.4**	**0.6**	**0.1**	**0.2**	**0.3**	**0.1**	**0.5**	**0.2**	**0.2**	**0.2**	**0.2**	**0.4**	**1.5**	**0.5**	**1.0**
F	Charmadi Ghats	BNHS 5782 (PT)	27.6	7.6	9.0	1.0	4.0	2.1	1.8	6.9	1.7	1.7	2.7	5.4	6.1	15.0	15.9	13.4
F	Charmadi Ghats	BNHS 5783 (PT)	25.8	8.0	8.3	1.3	3.7	3.4	1.8	6.8	1.9	1.8	2.3	5.3	5.7	14.2	14.9	12.0
F	Charmadi Ghats	BNHS 5784 (PT)	29.2	7.8	9.5	1.1	4.2	2.3	1.9	7.7	1.9	1.9	2.8	5.1	6.0	14.3	15.6	13.0
F	Charmadi Ghats	BNHS 5785 (PT)	24.6	8.3	8.6	1.0	3.4	2.0	1.4	7.7	1.7	1.4	2.7	5.2	6.6	15.3	16.2	13.7
		Average	**26.8**	**7.9**	**8.9**	**1.1**	**3.8**	**2.5**	**1.7**	**7.3**	**1.8**	**1.7**	**2.6**	**5.3**	**6.1**	**14.7**	**15.7**	**13.0**
		Standard deviation	**2.0**	**0.3**	**0.5**	**0.1**	**0.4**	**0.6**	**0.2**	**0.5**	**0.1**	**0.2**	**0.2**	**0.1**	**0.4**	**0.5**	**0.6**	**0.7**

***Micrixalus silvaticus* GROUP**

Micrixalus frigidus sp. nov.																		
M	Eravikulam NP	BNHS 5786 (HT)	24.0	7.7	8.8	1.1	3.6	2.7	1.5	7.0	1.9	1.6	2.6	4.4	7.0	12.3	12.8	11.9
M	Grass hills	BNHS 5789 (PT)	25.9	8.2	10.5	1.2	4.3	3.2	2.0	8.1	2.1	2.1	2.7	5.0	7.6	12.9	13.0	11.5
		Average	**25.0**	**8.0**	**9.7**	**1.2**	**4.0**	**3.0**	**1.8**	**7.6**	**2.0**	**1.9**	**2.7**	**4.7**	**7.3**	**12.6**	**12.9**	**11.7**
		Standard deviation	**1.3**	**0.4**	**1.2**	**0.1**	**0.5**	**0.4**	**0.4**	**0.8**	**0.1**	**0.4**	**0.1**	**0.4**	**0.4**	**0.4**	**0.1**	**0.3**
F	Eravikulam NP	BNHS 5787 (PT)	31.1	9.3	11.3	1.4	4.7	2.9	2.2	9.4	2.2	1.8	3.2	5.4	7.8	14.7	14.7	13.3
F	Eravikulam NP	BNHS 5788 (PT)	29.6	8.3	10.3	1.1	4.3	3.1	2.1	7.8	1.9	1.9	2.8	5.5	7.9	13.8	13.7	11.8
F	Grass hills	BNHS 5790 (PT)	31.8	8.8	11.1	1.3	4.6	3.5	1.9	9.1	2.0	1.9	3.2	5.8	8.8	14.8	14.9	13.3
F	Grass hills	BNHS 5791 (PT)	30.1	8.7	10.8	1.1	4.7	3.4	2.1	8.4	2.0	2.0	2.9	5.6	8.4	14.5	14.5	13.2
F	Grass hills	BNHS 5792 (PT)	32.7	9.3	11.4	1.5	4.8	3.7	1.7	9.4	2.4	2.2	3.1	5.7	8.9	14.9	15.0	13.9
		Average	**31.0**	**8.9**	**11.0**	**1.3**	**4.6**	**3.3**	**2.0**	**8.8**	**2.1**	**2.0**	**3.0**	**5.6**	**8.4**	**14.5**	**14.6**	**13.1**
		Standard deviation	**1.3**	**0.4**	**0.4**	**0.2**	**0.2**	**0.3**	**0.2**	**0.7**	**0.2**	**0.2**	**0.2**	**0.2**	**0.5**	**0.4**	**0.5**	**0.8**
Micrixalus nigraventris sp. nov.																		
M	Kodaikanal	BNHS 5793 (HT)	20.7	6.8	6.4	0.7	3.3	2.6	1.6	4.7	1.4	1.6	2.3	4.3	5.3	10.1	10.1	9.5
M	Kodaikanal	BNHS 5794 (PT)	20.9	7.1	6.7	0.7	3.5	2.6	1.7	5.4	1.5	1.5	2.4	4.6	5.1	10.1	10.1	9.4
		Average	**20.8**	**7.0**	**6.6**	**0.7**	**3.4**	**2.6**	**1.7**	**5.1**	**1.5**	**1.6**	**2.4**	**4.5**	**5.2**	**10.1**	**10.1**	**9.5**
		Standard deviation	**20.8**	**7.0**	**6.6**	**0.7**	**3.4**	**2.6**	**1.7**	**5.1**	**1.5**	**1.6**	**2.4**	**4.5**	**5.2**	**10.1**	**10.1**	**9.5**
F	Kodaikanal	BNHS 5795 (PT)	23.3	8.3	9.1	1.2	3.7	3.0	1.9	7.3	1.8	1.3	2.6	5.5	6.3	12.0	12.0	10.8
F	Eravikulam NP	BNHS 5796 (PT)	23.0	7.4	9.3	7.4	4.3	2.4	1.6	7.3	2.0	1.6	1.8	4.7	6.7	12.1	12.6	12.1
F	Eravikulam NP	BNHS 5797 (PT)	26.6	8.7	9.5	1.2	3.9	3.0	1.8	7.5	1.9	1.6	2.6	5.3	7.4	12.3	12.2	12.2
		Average	**24.3**	**8.1**	**9.3**	**3.3**	**4.0**	**2.8**	**1.8**	**7.4**	**1.9**	**1.5**	**2.3**	**5.2**	**6.8**	**12.1**	**12.3**	**11.7**
		Standard deviation	**2.0**	**0.7**	**0.2**	**3.6**	**0.3**	**0.3**	**0.2**	**0.1**	**0.1**	**0.2**	**0.5**	**0.4**	**0.6**	**0.2**	**0.3**	**0.8**
Micrixalus phyllophilus																		
M	"Nilgherries"	NHM 1947.2.29.87 (NT)	22.5	7.4	8.3	1.0	3.4	2.2	1.8	7.4	1.0	1.8	2.8	4.4	5.1	11.0	11.3	9.6
M	Avalache	BNHS 5798 (RS)	24.8	8.1	9.3	1.2	3.9	2.9	1.7	7.2	1.4	1.8	2.6	5.2	6.5	12.2	12.9	12.0
M	Longwood shola	BNHS 5801 (RS)	25.8	8.4	9.9	1.3	4.0	2.8	1.7	8.0	1.6	1.8	2.8	5.0	7.0	12.9	13.3	11.8
M	Longwood shola	BNHS 5802 (RS)	24.8	8.0	9.2	1.0	3.9	2.5	1.7	6.9	1.9	1.6	2.5	5.0	6.6	12.6	12.9	11.9
M	Longwood shola	BNHS 5803 (RS)	25.9	8.3	9.7	1.0	3.9	2.9	1.7	8.1	1.9	1.8	2.7	5.3	6.9	12.8	12.9	12.1
M	Longwood shola	BNHS 5804 (RS)	25.3	8.3	9.1	1.1	3.6	2.8	1.7	7.6	1.2	1.9	2.8	5.2	7.1	12.9	12.8	12.4
M	Naduvattam	BNHS 5806 (RS)	24.2	8.2	9.5	1.1	3.5	2.6	1.7	7.6	1.3	1.7	2.4	4.9	6.6	12.9	12.8	11.6
		Average	**24.8**	**8.1**	**9.3**	**1.1**	**3.7**	**2.7**	**1.7**	**7.5**	**1.5**	**1.8**	**2.7**	**5.0**	**6.5**	**12.5**	**12.7**	**11.6**
		Standard deviation	**1.2**	**0.3**	**0.5**	**0.1**	**0.2**	**0.3**	**0.0**	**0.4**	**0.3**	**0.1**	**0.2**	**0.3**	**0.7**	**0.7**	**0.6**	**0.9**

F	Avalanche	BNHS 5799 (RS)	32.5	9.8	10.9	1.2	4.8	3.3	2.4	8.8	2.1	2.5	3.0	5.5	8.2	14.7	15.3	15.0
F	Longwood shola	BNHS 5800 (RS)	30.0	9.8	10.9	1.0	4.2	3.0	1.7	8.0	1.9	2.3	2.9	6.6	7.8	14.8	15.3	14.4
F	Longwood shola	BNHS 5805 (RS)	28.9	9.5	11.3	9.0	4.1	2.9	1.8	8.1	1.5	2.3	3.1	6.0	7.8	14.5	14.5	13.2
		Average	**30.5**	**9.7**	**11.0**	**3.7**	**4.4**	**3.1**	**2.0**	**8.3**	**1.8**	**2.4**	**3.0**	**6.0**	**7.9**	**14.7**	**15.0**	**14.2**
		Standard deviation	**1.8**	**0.2**	**0.2**	**4.6**	**0.4**	**0.2**	**0.4**	**0.4**	**0.3**	**0.1**	**0.1**	**0.6**	**0.2**	**0.2**	**0.5**	**0.9**
Micrixalus silvaticus																		
M	"Malabar"	NHM 82.2.10.59 (PL)	18.5	6.0	7.0	0.7	3.3	2.1	1.2	5.5	1.4	1.1	2.5	3.5	4.4	9.7	9.5	8.1
M	"Malabar"	NHM 82.2.10.58 (PL)	19.8	6.2	7.2	0.8	4.0	2.2	1.4	5.7	1.4	1.4	2.3	3.6	5.0	10.1	10.3	8.4
M	Kadalar	BNHS 5807 (RS)	19.8	6.1	7.1	0.7	4.1	2.3	1.4	5.6	1.3	1.4	2.5	3.8	5.2	10.2	10.2	8.5
		Average	**19.4**	**6.1**	**7.1**	**0.7**	**3.8**	**2.2**	**1.3**	**5.6**	**1.4**	**1.3**	**2.4**	**3.6**	**4.9**	**10.0**	**10.0**	**8.3**
		Standard deviation	**0.8**	**0.1**	**0.1**	**0.1**	**0.4**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.2**	**0.4**	**0.3**	**0.4**	**0.2**
F	"Malabar"	NHM 82.2.10.52 (LT)	26.0	9.0	9.6	1.4	4.1	2.8	1.9	7.3	1.3	1.9	3.2	5.1	5.9	11.5	11.5	10.6
F	"Malabar"	NHM 82.2.10.53 (PL)	25.6	8.2	9.2	1.3	4.0	2.5	1.6	7.1	1.3	1.7	3.1	4.7	5.8	11.4	11.5	10.6
F	"Malabar"	NHM 82.2.10.55 (PL)	25.4	7.9	9.1	1.2	4.0	2.5	1.7	7.1	1.3	1.6	3.1	5.0	5.9	11.2	11.3	10.5
		Average	**25.7**	**8.4**	**9.3**	**1.3**	**4.0**	**2.6**	**1.7**	**7.2**	**1.3**	**1.7**	**3.1**	**4.9**	**5.9**	**11.4**	**11.4**	**10.6**
		Standard deviation	**0.3**	**0.6**	**0.3**	**0.1**	**0.1**	**0.2**	**0.2**	**0.1**	**0.0**	**0.2**	**0.1**	**0.2**	**0.1**	**0.2**	**0.1**	**0.1**