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MONOGRAPH

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LEAPING FROGS (ANURA: RANIXALIDAE) OF THE WESTERN GHATS OF INDIA: AN INTEGRATED TAXONOMIC REVIEW

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Abstract: Leaping frogs of the family Ranixalidae are endemic to the Western Ghats of India and are currently placed in a single genus, *Indirana*. Based on specimens collected from their entire range and a comprehensive study of type material defining all known species, we propose a revised taxonomy for the leaping frogs using an integrative approach including an analysis of the mitochondrial 16S rRNA and nuclear rhodopsin genes, as well as multivariate morphometrics. Both genetic and morphological analyses suggest that the genus *Indirana* is paraphyletic and a distinct monophyletic group, *Walkerana* gen. nov., is described herein. The new genus is separated from *Indirana* sensu stricto by an apomorphic character state of reduced webbing, with one phalange free on the first and second toe (vs. no free phalanges), two phalanges free on the third and fifth toe (vs. one free phalange), and three phalanges free on the fourth toe (vs. 2–2½ phalanges free). This review includes (i) identification of lectotypes and redescription of three species of the genus *Walkerana*; (ii) identification of lectotypes for *Indirana beddomii* and *I. semipalmata* and their redescription; (iii) redescription of *I. brachytarsus* and *I. gundia*; and (iv) descriptions of four new species, namely, *I. duboisi* and *I. tysoni* from north of the Palghat gap, and *I. yadera* and *I. sarojamma* from south of the Palghat gap; and (iv) a key to the genera and species in the family Ranixalidae.

Keywords: Discriminant analysis, genetic gap analysis, *Indirana*, molecular phylogeny, new combinations, new genus, new species, taxonomy, *Walkerana* gen. nov.

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INTRODUCTION

The taxonomic history of anurans currently grouped into the genus *Indirana*, in the monotypic family Ranixalidae, dates back to Günther (1876), who described four species, *Polypedates beddomii*, *P. brachytarsus*, *P. brevipalmatus* and *Ixalus diplostictus* from the Malabar Coast of southwestern India. Boulenger (1882) transferred these species to the genus *Rana*; however, as the name *brevipalmata* was preoccupied by *R. brevipalmata* Peters, 1871, Boulenger (1882) provided a replacement name *R. leptodactyla* for *P. brevipalmatus*. Boulenger (1882) also synonymized *P. brachytarsus* with *R. beddomii* and described two other related species, *R. phrynoderma* and *R. semipalmata*. Subsequently, Boulenger (1888) described another member of the same group, *R. leithii* from Matheran in the northern Western Ghats. The combination of these species into a single group was a result of Boulenger's (1920) monograph on *Rana*, in which he defined the subgenus *Discodeles* by using characters including "toes, often also fingers, dilated at the end, the dilation, or disc, bearing a crescentic or horseshoe-shaped horizontal groove, outer metatarsals united or separated only in the distal third; omosternum forked at the base". Although Boulenger (1920) included three other species from the Solomon Islands, Oceania, in the same subgenus, he specifically considered a distinct 'Ranae beddomiana' group to consolidate the six species, namely, *R. (Discodeles) beddomii*, *R. (D.) diplosticta*, *R. (D.) leithii*, *R. (D.) leptodactyla*, *R. (D.) phrynoderma*, and *R. (D.) semipalmata*. Rao (1937) later added *R. (D.) tenuilingua* from Kemphole Forest, Karnataka, India to the same group, elevating the number of species to seven.

Laurent (1986) erected the genus *Indirana* and transferred the seven species to it, but he was apparently unaware that Inger et al. (1984) had already resurrected *R. brachytarsus* from the synonymy with *R. beddomii*. During the same year, Dubois (1986) erected a new genus, *Ranixalus*, in his description of *Ranixalus gundia*. Dubois (1987a) subsequently transferred the six 'Ranae beddomiana' group members, *R. tenuilingua*, as well as *Rana brachytarsus*, to *Ranixalus*, making the total number of species under *Ranixalus* nine. Dubois (1987b), based on the priority in publication date, synonymized *Ranixalus* with *Indirana*. In their review of the frog genus *Philautus*, Bossuyt & Dubois (2001) transferred *P. longicrus* Rao, 1937 to genus *Indirana*, elevating the number of species under *Indirana* to 10.

With recent description of two species (Padhye et al. 2014; Modak et al. 2015), the genus *Indirana* currently

comprises 12 species, including: *I. beddomii* (Günther, 1876), *I. brachytarsus* (Günther, 1876), *I. chiravasi* Padhye et al., 2014, *I. diplosticta* (Günther, 1876), *I. gundia* (Dubois, 1986), *I. leithii* (Boulenger, 1888), *I. leptodactyla* (Boulenger, 1882), *I. longicrus* (Rao, 1937), *I. phrynoderma* (Boulenger, 1882), *I. salelkari* Modak et al., 2015, *I. semipalmata* (Boulenger, 1882), and *I. tenuilingua* (Rao, 1937).

Dubois (1987a) proposed the tribe Ranixalini, later treated as the subfamily Ranixalinae by Dubois (1992), with the type genus *Ranixalus* (now a synonym of *Indirana*) and included two other genera, *Nannophrys* and *Nyctibatrachus*, based on the presence of femoral glands in males. On the basis of priority, the subfamily Indiraninae Blommers-Schlösser, 1993, is a junior synonym of Ranixalinae Dubois, 1987. Van Bocxlaer et al. (2006) in their taxonomic analysis using three nuclear and one mitochondrial genetic markers elevated the taxon to the family Ranixalidae with the genus *Indirana* as its sole member.

More recent molecular studies (Nair et al. 2012a; Modak et al. 2014) have revealed that several species in the genus *Indirana* are undescribed. Although some studies have been published that attempt to resolve these issues by the study of topotypic material to assist in delineating geographic distribution boundaries of species (e.g., Modak et al. 2014), and by defining new species using an integrated taxonomic approach (Padhye et al. 2014; Modak et al. 2015), a detailed taxonomic review of leaping frogs is still pending.

In the current study, using type material of known species, and with freshly collected material from throughout the Western Ghats, emphasizing type localities of known species, we present genetic barcodes for species of *Indirana* and provide species delimitation based on genetic gap analysis. We describe a new genus, redescribe the known species in the family, and describe four new species of *Indirana*.

MATERIALS AND METHODS

Study site and specimen collection

Specimens of the family Ranixalidae were studied from the Western Ghats mountain ranges in the Indian states of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, and Gujarat (Fig. 1). Specimens were collected with permissions from the respective state forest departments (permit nos. WL12-7972/2010; WL10-3548/2012; WL10-3548/2013; PS/PCCF/WL/CR/22/2013-14; PCCF(WL)/E2/CR-22/2013-14;

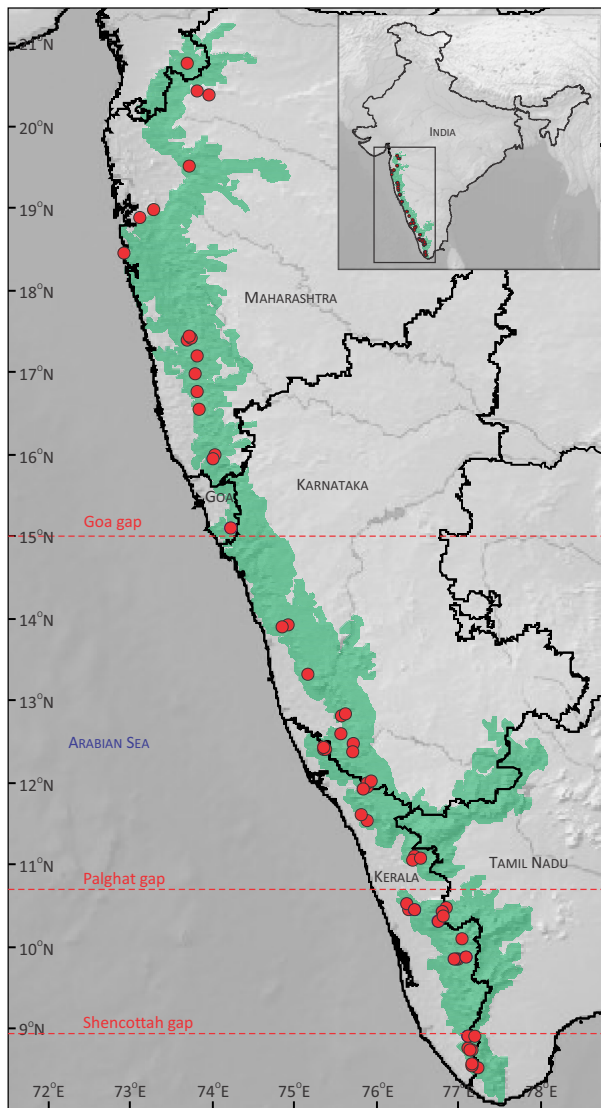


Figure 1. Peninsular India highlighting Western Ghats mountain ranges (green shaded area) and sampling locations (red circles). Goa, Palghat and Shencottah gaps are shown with red broken lines.

1-566-WL&ET/12-13/1034; 2/21/GEN/WL&ET(S)/2012-13/4; No.2-WL-Perm/NP-2009-12-FD/ 2195; Desk-9/Trg./ Survey & Coll./C.R.No.14(11-12)/66/13-14; D-4(WL)/Research/2263/2013-14; WI5 (A)/9699/2013 Permit No. 8/2-14; Roc.No. WL/2048/2013). Specimens were collected during the day as well as night through opportunistic surveys in a variety of habitats including grasslands, forest floors, stream banks, paddy fields, caves, cliff faces, and rock crevices near streams and waterfalls. Collected specimens were euthanized using buffered tricaine methanesulfonate. Tissue samples were taken from the thigh muscle and preserved in 100% ethanol for molecular analysis. Whole specimens

were preserved in either absolute ethanol or 4% formaldehyde and later transferred to 70% ethanol for long-term storage.

Museum details

Specimens studied in this paper have been deposited in the museums of (i) the Bombay Natural History Society, Mumbai (BNHS); (ii) the Wildlife Information Liaison Development Society, Coimbatore (WILD); (iii) the Zoological Survey of India, Western Regional Center, Pune (ZSI-WRC); and (iv) the Zoology Research Laboratory at Abasaheb Garware College, Pune (AGCZRL) in India. Type specimens from the Natural History Museum, London (BMNH), and the Muséum National d'histoire Naturelle, Paris (MNHN), were also studied.

Morphometry

Measurements were completed using digital calipers (Ocean Premium Measuring Instruments) to the nearest 0.1mm. A total of 32 characters were measured, which included characters used by Padhye et al. (2014), Modak et al. (2015), and additional five characters. Abbreviations and definitions of morphometric characters are as follows: snout–urostyle length (SUL; length of specimen from snout to the visible tip of urostyle); head length (HL; measured from the posterior border of the tympanum to the tip of the snout); head width (HW; width of head between the posterior borders of the tympanum); snout length (SL; from the anterior edge of the orbit to the tip of the snout); eye length (EL; horizontal length of the eye); maximum tympanum length (TYL); upper eyelid width (UEW); snout–nostril distance (SNL); eye–nostril distance (ENL); internarial distance (INL); interorbital distance (IOD; minimum distance between the eyelids); upper arm length (UAL); forearm length (FoAL); palmar length (PAL, proximal edge of outermost palmar tubercle to tip of third finger); length of fingers 1–4 (F1–F4; measured from the base of the most proximal subarticular tubercle); finger 3 disc width (F3D); finger 3 width at the base of the disc (F3W); thigh length (THL; measured from hip joint to joint between thigh and shank); tibia/shank length (TL; measured from joint between thigh and shank to joint between shank and tibiotarsal articulation); astragalocalcaneal length (ACL; measured from joint between shank and tibiotarsal articulation to the base of the inner metatarsal tubercle); foot length (FOL; measured from the base of the inner metatarsal tubercle to the tip of the fourth toe); total foot length (TFOL; from the tibio-tarsal articulation to the tip of fourth toe); length of toes 1–5 (T1–T5; measured from the base of the most proximal

subarticular tubercle); toe 4 disc width (T4D); and toe 4 width at the base of the disc (T4W). Webbing formulae were determined following the method of Savage & Heyer (1967), as modified by Myers & Duellman (1982). Characters related to the roof of buccal cavity were studied following Modak et al. (2015).

Statistical analysis of morphometry

Since all the characters showed positive linear relationship with SUL, statistical analysis of the morphometric data was performed on size-adjusted measurements by taking all measurements as percent of SUL to remove body size variation bias. Discriminant analysis (DA) was performed to understand whether related species form significantly different clusters (Huberty & Olejnik 2006). Mahalanobis distances (see Harris 2001) between pair of individuals were calculated and used for computing Fisher's distances (distance between the centroids of the clusters, divided by the sum of their standard deviations) between two clusters to check if the clusters were significantly different. Only in the case of comparison between species of the new genus (because there were more characters than number of specimens) we performed principle component analysis (PCA) of size-adjusted characters with correlation matrix between characters, and maximizing the variation between groups. Statistical analysis was performed in PAST 3.09 (Hammer et al. 2001).

Molecular analysis

Thigh muscles of 70 specimens (Table 1) were used for extracting DNA and conducting molecular analyses. Genomic DNA extraction, polymerase chain reaction (PCR) for the mitochondrial 16S rRNA and nuclear rhodopsin partial genes, PCR product purification, and sequencing were performed following the protocols detailed in Padhye et al. (2014). Sequences were checked using the BLAST tool (Altschul et al. 1990) to identify the nearest congeners. Sequences are deposited in GenBank under the accession numbers KX641759–KX641828 for 16S rRNA and KX641829–KX641886 for rhodopsin genes. Additional sequences of related species from the study by Modak et al. (2014, 2015) and Padhye et al. (2014) and five outgroups, namely *Nyctibatrachus aliciae*, *N. major*, *Micrixalus fuscus*, *M. kottigeharensis* and *Nasikabatrachus sahyadrensis*, were retrieved from the NCBI GenBank (<http://www.ncbi.nlm.nih.gov/>). GenBank accession numbers of the sequences used for the analysis are provided in Table 1. Gene sequences were aligned separately for 16S rRNA and rhodopsin

using MUSCLE (Edgar 2004) implemented in MEGA 6 (Tamura et al. 2013). Genes were concatenated to make a super gene alignment with 922 bases using DAMBE (Xia 2013). Alignment was partitioned into four charsets corresponding to 16s rRNA gene and three codon positions of rhodopsin gene to create a full partition. We used a greedy strategy (Lanfear et al. 2012) implemented in IQ-TREE (Nguyen et al. 2015) to find the best partition scheme for the data using minimum Bayesian information criterion (BIC) value (Schwarz 1978; Nei & Kumar 2000). The best fit partition scheme was used to perform maximum likelihood analysis using IQ-TREE (Nguyen et al. 2015). Reliability of the phylogenetic tree was estimated using ultrafast bootstrap values run for 1000 iterations (Minh et al. 2013). The phylogenetic tree was edited in FigTree v1.4.2 (Rambaut 2009). This tree was also used to understand the phylogeographic distribution of *Indirana* in the Western Ghats using GenGIS 2.5 (Parks et al. 2013). Digital elevation map for phylogeography analysis was downloaded from Spatial Data Access Tool (<http://webmap.ornl.gov/wcsdown/>).

Since 16S rRNA gene has been suggested as a better barcoding region (Vences et al. 2005), we used this marker for analysis. Raw (p) distances between pairs of 16S rRNA sequences were calculated in MEGA 6 (Tamura et al. 2013). The frequency distributions of genetic distances was plotted to understand whether the distribution of the distances followed a bimodal distribution with a natural gap separating the two peaks. Such a gap is an indication of separation of intra- and interspecies genetic distances, which can be used to identify a gap in genetic distances that can be reliably used to separate two closely related species (Meyer & Paulay 2005; Meier et al. 2008). Intra- and interspecific distances were plotted as the mean, with minimum and maximum value indicated as error bars, to identify genetic gaps for delineating species. To substantiate our genetic gap analysis we also analyzed the 16S rRNA sequences using Automatic Barcode Gap Discovery (ABGD) software with simple distances (Puillandre et al. 2012) so as to understand species delimitation.

Further, we identified taxonomically important sites (defined below) within the 16S rRNA gene sequence for delineating and diagnosing eight species of *Indirana* that are morphologically similar. All available sequences for the given species were aligned with the complete 16S rRNA gene of *Fejervarya cancrivora* (Gravenhorst) extracted from whole mitochondrial genome sequence EU652694. Character (nucleotide) numbers were considered relative to the alignment with the complete 16S rRNA gene of *Fejervarya cancrivora*. Characters that

Table 1. Details of species, locality, vouchers and GenBank accession numbers for sequences used for genetic analysis. Note: '-' indicates not available.

Genus/Species	Locality	Latitude	Longitude	Altitude (m)	Specimen no.	16S rRNA	rho	Reference
<i>Iridopoda</i>								
<i>I. beddomii</i>	Peruvannamuzhi	11.535	75.880	63	WILD-14-AMP-420	KX641761	KX641831	This study
<i>I. beddomii</i>	Kunthipuzha	11.049	76.440	95	WILD-14-AMP-421	KX641762	KX641832	This study
<i>I. beddomii</i>	Sairandhri	11.093	76.464	1001	WILD-14-AMP-409	KX641764	KX641834	This study
<i>I. beddomii</i>	Aralam	11.946	75.878	546	WILD-13-AMP-138	KX641763	KX641833	This study
<i>I. beddomii</i>	Kakkayam	11.548	75.889	60	WILD-14-AMP-413	KX641765	KX641835	This study
<i>I. beddomii</i>	Peruvannamuzhi	11.599	75.819	38	WILD-14-AMP-411	KX641759	KX641829	This study
<i>I. beddomii</i>	Peruvannamuzhi	11.599	75.819	38	WILD-14-AMP-414	KX641760	KX641830	This study
<i>I. brachytarsus</i>	Neyyar	8.534	77.232	109	WILD-13-AMP-234	KX641766	KX641836	This study
<i>I. brachytarsus</i>	Neyyar	8.559	77.159	104	WILD-13-AMP-247	KX641775	KX641844	This study
<i>I. brachytarsus</i>	Ponmudi	8.737	77.145	903	WILD-13-AMP-301	KX641767	KX641837	This study
<i>I. brachytarsus</i>	Ponmudi	8.967	77.052	91	WILD-13-AMP-241	KX641774	KX641843	This study
<i>I. brachytarsus</i>	Ponmudi	8.735	77.140	837	WILD-13-AMP-293	KX641777	KX641845	This study
<i>I. brachytarsus</i>	Chimmony	10.447	76.395	48	WILD-14-AMP-475	KX641770	KX641839	This study
<i>I. brachytarsus</i>	Peechi-Vazhani	10.426	76.466	61	WILD-14-AMP-478	KX641772	KX641841	This study
<i>I. brachytarsus</i>	Ponmudi	8.563	77.165	138	WILD-13-AMP-285	KX641776	-	This study
<i>I. brachytarsus</i>	Painavu	9.844	76.959	743	WILD-14-AMP-358	KX641768	KX641838	This study
<i>I. brachytarsus</i>	Vellakkamaly	9.843	76.979	704	WILD-14-AMP-437	KX641769	-	This study
<i>I. brachytarsus</i>	Chimmony	10.447	76.395	48	WILD-14-AMP-477	KX641771	KX641840	This study
<i>I. brachytarsus</i>	Painavu	9.844	76.959	743	WILD-14-AMP-359	KX641778	KX641846	This study
<i>I. brachytarsus</i>	Vellakkamaly	9.843	76.979	704	WILD-14-AMP-442	KX641779	KX641847	This study
<i>I. brachytarsus</i>	Topslip	10.471	76.842	748	WILD-15-AMP-609	KX641773	KX641842	This study
<i>I. chiravasi</i>	Koyna	17.392	73.678	862	WILD-15-AMP-530	KX641780	KX641848	This study
<i>I. chiravasi</i>	Kitawade	16.001	74.018	722	WILD-15-AMP-612	KX641782	-	This study
<i>I. chiravasi</i>	Chandoli	17.210	73.811	920	WILD-15-AMP-535	KX641781	KX641849	This study
<i>I. chiravasi</i>	Amboli	15.956	73.997	744	WILD-14-AMP-489	KM386530	KM386538	Padhye et al. (2014)
<i>I. chiravasi</i>	Amboli	15.956	73.997	744	BNHS 5890	KM386531	KM386539	Padhye et al. (2014)
<i>I. duboisi</i>	Mookambika	13.917	74.913	634	WILD-15-AMP-630	KX641815	KX641875	This study
<i>I. duboisi</i>	Mookambika	13.894	74.831	498	WILD-15-AMP-631	KX641816	KX641876	This study
<i>I. duboisi</i>	Muduba	13.322	75.146	724	BNHS 5980	KX641817	-	This study
<i>I. gundia</i>	Aralam	11.933	75.838	162	WILD-13-AMP-139	KX641783	KX641850	This study
<i>I. gundia</i>	Coorg	12.005	75.890	817	WILD-13-AMP-210	KX641784	KX641851	This study
<i>I. gundia</i>	Kutta	12.027	75.932	812	WILD-13-AMP-211	KX641785	KX641852	This study
<i>I. gundia</i>	Ranipuram	12.414	75.353	785	WILD-15-AMP-614	KX641787	-	This study
<i>I. gundia</i>	Gundia	12.825	75.569	128	WILD-14-AMP-499	KM386532	KM386540	Padhye et al. (2014)
<i>I. gundia</i>	Gundia	12.829	75.607	224	WILD-14-AMP-500	KM386533	KM386541	Padhye et al. (2014)
<i>I. gundia</i>	Subramanya Sullya	12.651	75.573	98	WILD-16-AMP-649	KX641790	KX641856	This study
<i>I. gundia</i>	Aralam	11.931	75.836	180	WILD-13-AMP-136	KX641786	KX641853	This study
<i>I. gundia</i>	Ranipuram	12.419	75.358	757	WILD-15-AMP-616	KX641788	KX641854	This study
<i>I. gundia</i>	Ranipuram	12.416	75.364	794	WILD-15-AMP-618	KX641789	KX641855	This study
<i>I. leithii</i>	Karnala	18.878	73.110	25	WILD-15-AMP-525	KX641791	KX641857	This study
<i>I. leithii</i>	Javalya fort	20.374	73.960	1221	AGCZRL-Amphibia-549	KX641792	-	This study

Genus/Species	Locality	Latitude	Longitude	Altitude (m)	Specimen no.	16S rRNA	rho	Reference
<i>I. leithii</i>	Ahwa Dang	20.764	73.676	395	AGCZRL-Amphibia-552	KX641794	-	This study
<i>I. leithii</i>	Achala fort	20.432	73.814	1106	AGCZRL-Amphibia-548	KX641793	-	This study
<i>I. leithii</i>	Ahwa Dang	20.764	73.676	395	AGCZRL-Amphibia-555	KX641795	-	This study
<i>I. leithii</i>	Matheran	18.989	73.268	801	BNHS 5591	KF590638	KF590648	Modak et al. (2014)
<i>I. leithii</i>	Ratangad	19.500	73.700	1094	AGCZRL-Amphibia-113	KF590646	KF590656	Modak et al. (2014)
<i>I. leithii</i>	Gaganbawda	16.550	73.831	600	AGCZRL-Amphibia-195	KJ442877	KJ442881	Modak et al. (2014)
<i>I. leithii</i>	Ratangad	19.500	73.700	1094	AGCZRL-Amphibia-112	KF590645	KF590655	Modak et al. (2014)
<i>I. leithii</i>	Visapur	18.720	73.490	1035	WILD-013-AMP-178	KF590644	KF590654	Modak et al. (2014)
<i>I. leithii</i>	Koynanagar	17.410	73.740	839	WILD-013-AMP-177	KF590643	KF590653	Modak et al. (2014)
<i>I. leithii</i>	Tamhini	18.480	73.410	579	WILD-013-AMP-175	KF590641	KF590651	Modak et al. (2014)
<i>I. leithii</i>	Harishchandrabad	19.390	73.780	1329	WILD-013-AMP-174	KF590640	KF590650	Modak et al. (2014)
<i>I. leithii</i>	Harishchandrabad	19.390	73.780	1329	WILD-013-AMP-173	KF590639	KF590649	Modak et al. (2014)
<i>I. leithii</i>	Tamhini	18.480	73.410	579	WILD-013-AMP-176	KF590642	KF590652	Modak et al. (2014)
<i>I. leithii</i>	Anuskura ghat	16.761	73.795	603	AGCZRL-Amphibia-193	KJ442876	KJ442880	Modak et al. (2014)
<i>I. leithii</i>	Anjaneri	19.925	73.579	888	AGCZRL-Amphibia-199	KJ442874	KJ442878	Modak et al. (2014)
<i>I. leithii</i>	Amba ghat	16.982	73.781	630	AGCZRL-Amphibia-192	KJ442875	KJ442879	Modak et al. (2014)
<i>I. leithii</i>	Matheran	18.989	73.268	801	BNHS 5590	KF590637	KF590647	Modak et al. (2014)
<i>I. sarojamma</i>	Ponmudi	8.967	77.052	91	BNHS 5981	KX641796	KX641858	This study
<i>I. salelkari</i>	Netravali	15.095	74.211	78	BNHS 5931	KP826824	KP826827	Modak et al. (2015)
<i>I. salelkari</i>	Netravali	15.095	74.211	78	WILD-15-AMP-551	KP826825	KP826828	Modak et al. (2015)
<i>I. salelkari</i>	Netravali	15.095	74.211	78	AGCZRL-Amphibia-210	KP826826	KP826829	Modak et al. (2015)
<i>I. semipalmata</i>	Sholayar	10.308	76.742	722	WILD-15-AMP-610	KX641797	KX641859	This study
<i>I. semipalmata</i>	Chimmony	10.447	76.462	61	WILD-14-AMP-471	KX641808	KX641870	This study
<i>I. semipalmata</i>	Chimmony	10.447	76.462	61	WILD-14-AMP-473	KX641810	KX641872	This study
<i>I. semipalmata</i>	Kunthipuzha	11.049	76.440	95	WILD-14-AMP-419	KX641799	KX641861	This study
<i>I. semipalmata</i>	Chimmony	10.447	76.462	61	WILD-14-AMP-474	KX641811	KX641873	This study
<i>I. semipalmata</i>	Peechi-Vazhani	10.532	76.366	96	WILD-14-AMP-470	KX641807	KX641869	This study
<i>I. semipalmata</i>	Sholayar	10.308	76.742	722	WILD-15-AMP-611	KX641798	KX641860	This study
<i>I. semipalmata</i>	Parambukulam	10.418	76.793	661	WILD-14-AMP-503	KX641812	KX641874	This study
<i>I. semipalmata</i>	Idukki	9.874	77.076	797	WILD-14-AMP-440	KX641814	-	This study
<i>I. semipalmata</i>	Silent Valley	11.072	76.535	556	WILD-14-AMP-416	KX641806	KX641868	This study
<i>I. semipalmata</i>	Peechi-Vazhani	10.532	76.366	96	WILD-14-AMP-472	KX641809	KX641871	This study
<i>I. semipalmata</i>	Kizhukanam	9.874	77.076	797	WILD-14-AMP-438	KX641800	KX641862	This study
<i>I. semipalmata</i>	Painavu	9.849	76.949	803	WILD-14-AMP-354	KX641813	-	This study
<i>I. semipalmata</i>	Shendurney	8.916	77.110	174	WILD-13-AMP-269	KX641801	KX641863	This study
<i>I. semipalmata</i>	Shendurney	8.910	77.119	230	WILD-13-AMP-270	KX641802	KX641864	This study
<i>I. semipalmata</i>	Shendurney	8.909	77.119	281	WILD-13-AMP-271	KX641803	KX641865	This study
<i>I. semipalmata</i>	Shendurney	8.909	77.119	222	WILD-13-AMP-296	KX641804	KX641866	This study

Genus/Species	Locality	Latitude	Longitude	Altitude (m)	Specimen no.	16S rRNA	rho	Reference
<i>I. semipalmata</i>	Idukki	9.874	77.076	797	WILD-14-AMP-351	KX641805	KX641867	This study
<i>I. tysoni</i>	Ranipuram	12.419	75.353	932	BNHS 5979	KX641818	KX641877	This study
<i>I. tysoni</i>	Ranipuram	12.419	75.353	932	WILD-15-AMP-615	KX641819	KX641878	This study
<i>I. tysoni</i>	Wattakole	12.380	75.822	1051	WILD-16-AMP-650	KX641820	KX641879	This study
<i>I. yadera</i>	Neyyar	8.563	77.165	138	WILD-13-AMP-338	KX641821	KX641880	This study
<i>I. yadera</i>	Vagamalai	9.874	77.076	797	BNHS 5982	KX641822	KX641881	This study
<i>I. yadera</i>	Chimmony	10.445	76.460	55	WILD-14-AMP-479	KX641823	KX641882	This study
<i>Walkerana</i>								
<i>W. diplosticta</i>	Bonacaud	8.686	77.183	877	WILD-15-AMP-640	KX641828	KX641886	This study
<i>W. leptodactyla</i>	Eravikulam	10.144	77.037	1899	WILD-13-AMP-192	KX641825	KX641884	This study
<i>W. leptodactyla</i>	Eravikulam	10.145	77.038	1940	WILD-13-AMP-186	KX641826	-	This study
<i>W. leptodactyla</i>	Eravikulam	10.145	77.038	1940	WILD-13-AMP-184	KX641827	KX641885	This study
<i>W. phrynoderma</i>	Anamalai	10.354	76.815	928	WILD-14-AMP-509	KX641824	KX641883	This study
Outgroup								
<i>Micrixalus fuscus</i>	-	-	-	-	-	GU136106	AF249120	GenBank
<i>Micrixalus kottigeharensis</i>	-	-	-	-	-	AF249041	AF249121	GenBank
<i>Nyctibatrachus aliciae</i>	-	-	-	-	-	AF249063	AF249114	GenBank
<i>Nyctibatrachus major</i>	-	-	-	-	-	AF249052	AF249113	GenBank
<i>Nasikabatrachus sahyadrensis</i>	-	-	-	-	-	AY364381	AY364381	GenBank

were identical within a species but showed variation between the species, alone or in combination, were considered taxonomically informative sites and used as diagnostic for the given species.

RESULTS

Identification of topotypes, putative topotypes, and their barcodes for known species

Günther (1876) did not provide an exact type locality for *Indirana beddomii*, and the syntypes of this species came from Malabar, Travancore, Anamallays (=Anamalai), and Sevagherry (=Sivagiri). In fact, the syntypes of *I. beddomii* represent a species complex, which necessitates the designation of a lectotype from among the syntypes (see Taxonomy section below). The original illustration provided by Günther (1876: Plate LXIII B) depicts specimen BMNH 1947.2.27.72, originating in Malabar, and we hereby designate this specimen as the lectotype of *I. beddomii*. This specimen closely resembles the population we studied at Peruvannamuzhi, Malabar Wildlife Sanctuary (11.599°N & 75.819°E, elevation 38m), located north of the Palghat gap. Because Malabar is not a precise locality (see Biju 2001), being the first revisers we designate

Peruvannamuzhi, Malabar Wildlife Sanctuary, Kerala, India as the putative type locality of *I. beddomii*. This is pertinent, given that our specimen (WILD-14-AMP-414) from this locality closely resembles the lectotype, based on the following key characters: (i) one phalange free of webbing on the inner side of the third toe; (ii) heels just overlap when thighs are held at right angles to body axis, loreal region more oblique; and (iii) structure and placement of vomerine teeth. Further, Peruvannamuzhi also falls into the larger Malabar region of the British era. Therefore, the 16S rRNA gene sequence KX641760 is topotypic and can be considered as a barcode to allow genetic identification of *I. beddomii*.

In the original description of *Indirana brachytarsus*, Günther (1876) suggested that the species hailed from Anamalai and Sivagiri, both south of the Palghat gap. From among the syntypes, Inger et al. (1984) designated the specimen originating from Anamalai (BMNH 1947.2.27.92) as lectotype of the species. Specimen WILD-15-AMP-609 from our collection, originating from Topslip of Anamalai in Tamil Nadu (10.471°N & 76.842°E, elevation 748m), is conspecific with the lectotype according to the following key characters: (i) 1½ phalange free of webbing on inner side of third toe; (ii) buccal cavity shallow 8.4–19.2% HL; (iii) heels strongly overlap when thighs are held at right angles to body axis;

and (iv) structure and placement of vomerine teeth and choanae in buccal cavity. We therefore consider this specimen as a putative topotype and its 16S rRNA gene sequence KX641773 as a genetic barcode to identify *I. brachytarsus*.

Padhye et al. (2014) provided genetic data for paratypes of *Indirana chiravasi*. As these paratypes were from the same locality as that of the holotype, they are also isotypes and therefore the 16S rRNA gene sequences KM386530 and KM386531 represent topotypic material of *I. chiravasi* and are therefore genetic barcodes for identifying *I. chiravasi*.

Günther (1876) did not provide exact type locality for *Indirana diplosticta*, and the syntypes came from Malabar. Because three syntypes are available, designation of a lectotype is essential to stabilize taxonomy. We could not decipher which of the three specimens was used in the original illustration (Günther 1876: Plate LXIII C), however, BMNH 1947.2.2.21 is most similar to the illustration. We therefore designate BMNH 1947.2.2.21 as lectotype for the species (see Taxonomy section below). This specimen closely resembles the population we studied at Bonacaud (8.686°N & 77.183°E, elevation 877m), Peppara Wildlife Sanctuary. Since Malabar is not a precise locality, as first revisers we designate Bonacaud, Peppara Wildlife Sanctuary, Kerala, India, as the putative type locality of *I. diplosticta*. This is pertinent, given that our specimen (WILD-15-AMP-640) from this locality closely resembles the lectotype. Therefore, the 16S rRNA gene sequence KX641828 is topotypic and can be considered as a genetic barcode to allow genetic identification of *I. diplosticta*.

Padhye et al. (2014) provided genetic information of *Indirana gundia* from the type locality Gundia, Karnataka, India. We can therefore consider sequences KM386532 and KM386533 as 16S rRNA gene barcodes for identifying *I. gundia*.

Modak et al. (2014) provided the 16S rRNA gene sequence KF590637 for *Indirana leithii* from its type locality in Matheran, Maharashtra, India, and considered this as topotypic sequence. We follow these authors and consider this sequence as a genetic barcode for *I. leithii*.

In the discussion of his replacement name *Rana leptodactyla* for Günther's (1876) *Polypedatus brevipalmatus*, Boulenger (1882) suggested that several types of Günther's species came from Anamalai and Malabar. We could not locate any syntypes originating from Anamalai in the collection of BMNH. However, three syntypes, from Malabar (BMNH 1947.2.29.39, BMNH 1947.2.29.40 and BMNH 1947.2.29.41) were studied. Although we also examined several other

specimens collected by Col. R.C. Beddome (BMNH 1874.4.28.503–509) and Jerdon (BMNH 1874.4.28.503–509), the type status of these specimens are uncertain (see Taxonomic section below). Because three syntypes are available, designation of a lectotype is essential to stabilize taxonomy. We therefore designate BMNH 1947.2.29.39 as lectotype for the species (see Taxonomy section below), based on the priority in voucher number as no illustration or specific comments on any one of the syntypes is available in the original description. This specimen closely resembles the population we studied at Eravikulam National Park (10.145°N & 77.038°E, elevation 1940m), and because Malabar is not a precise locality, as first revisers we designate Eravikulam National Park, Kerala, India, as the putative type locality of *I. leptodactyla*. This is pertinent, given that our specimen (WILD-13-AMP-184) from this locality closely resembles lectotype. Therefore, the 16S rRNA gene sequence KX641827 is topotypic and can be considered as a genetic barcode to allow genetic identification of *I. leptodactyla*.

Boulenger (1882) described *Rana phrynoderma* from Anamalai based on two syntypes (BMNH 1947.2.3.8 and 1947.2.3.9). To stabilize taxonomy, we designate BMNH 1947.2.3.8 as the lectotype for *I. phrynoderma* (see Taxonomy section below), based on the priority in voucher number as no illustration or specific comments on any one of the syntypes is available in the original description. Our specimen WILD-14-AMP-509 from Parambikulam Tiger Reserve (10.354°N & 76.815°E, elevation 928m) in Anamalai of Kerala is conspecific with the syntypes of *I. phrynoderma* and therefore we consider the sequence KX641824 as a genetic barcode that can serve in identifying the species.

Modak et al. (2015) provided the 16S rRNA gene sequence KP826824 of the holotype while describing *Indirana salelkari*, which is the genetic barcode for identifying the species.

In his description of *Indirana semipalmata*, Boulenger (1882) mentioned Malabar as the type locality. Because two syntypes (BMNH 1947.2.29.50 and 1947.2.29.51) are available, designation of a lectotype is essential to stabilize taxonomy. We could not decipher which of the two specimens was used in the original illustration (Boulenger 1882: Plate IV Fig. 3); however, BMNH 1947.2.29.50 is most similar to the illustration and therefore we designate BMNH 1947.2.29.50 as the lectotype for the species (see Taxonomy section below). This specimen closely resembles the population we studied at Painavu, Idukki Wildlife Sanctuary (9.849°N & 76.949°E, elevation 803m). Because Malabar is not a

precise locality, as first revisers we designate Painavu, Idukki Wildlife Sanctuary, Kerala, India, as the putative type locality of *I. semipalmata*. This is pertinent, given that our specimen (WILD-14-AMP-354) from this locality closely resembles the lectotype, based on the following key characters: (i) reduced webbing with at least ½ phalange free on 3rd and 5th toe and 2¼ phalanges free on 4th toe; and (ii) tympanum diameter more than 50% of eye diameter. Therefore, the 16S rRNA gene sequence KX641813 is topotypic and can be considered as a genetic barcode to allow genetic identification of *I. semipalmata*.

Genetic barcodes for *I. longicrus* and *I. tenuilingua* cannot be assigned because of taxonomic ambiguity as explained under the Taxonomy section.

PHYLOGENETIC ANALYSIS

Analysis of best partition scheme for mitochondrial 16S rRNA gene and three codon positions of nuclear rhodopsin gene implied transition model with rate heterogeneity (TIM2+R3, BIC = 11498.60, lnL=-5186.11, df=165) as the best nucleotide substitution model for all partitions. In the maximum likelihood tree (Fig. 2), a deep branching clade separates species with highly reduced webbing (*I. phrynoderma*, *I. leptodactyla*, *I. diplosticta*) from other species of *Indirana*. We identify this clade as a distinct genus and erect *Walkerana* gen. nov. (see Taxonomy section below) within the family Ranixalidae. Intra- and interspecific genetic raw uncorrected *p* distances in 16S rRNA gene for species of *Indirana* are provided in Table 2, for *Walkerana* gen. nov. in Table 3, and between species of *Indirana* and *Walkerana* gen. nov. in Table 4. In the genus *Indirana*, maximum intraspecific genetic distance in 16S rRNA gene is 1.9% in *I. semipalmata*, while the minimum interspecific distance is 2.4% between *I. duboisi* sp. nov. and *I. salelkari*. The gap between the two is marked as a genetic gap for species delimitation in Fig. 3. This gap is also evident in a frequency distribution of pairwise distances for all samples of *Indirana* (Fig. 3 inset). This genetic gap revealed presence of 11 species in genus *Indirana*, which included three proposed new species. Analysis using Automatic Barcode Gap Discovery (ABGD) software also revealed same grouping into 11 species with partition having prior maximal distance $P = 0.00596$. We had limited samples of species in *Walkerana* gen. nov., as most of the species occur within protected areas with limited access and permission to collect only a few individuals. Nevertheless, we find that the maximum intraspecific genetic distance is 0.4% in *W. leptodactyla* comb. nov., and the minimum interspecific

Table 2. Raw (p) uncorrected genetic distances (%) in 16S rRNA gene between species of *Indirana* expressed as mean (minimum–maximum). Diagonal values in bold are intra specific distances.

Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
<i>I. beddomii</i> (1)	1.0 (0.0–1.7)										
<i>I. brachytarsus</i> (2)	5.8 (5.2–6.7)	0.5 (0.0–1.2)									
<i>I. chiravasi</i> (3)	7.4 (7.1–7.9)	8.0 (7.5–9.0)	0								
<i>I. duboisi</i> (4)	7.0 (6.5–7.9)	7.8 (7.3–8.5)	3.0 (2.7–3.1)	0.3 (0.0–0.4)							
<i>I. gundia</i> (5)	4.8 (4.2–5.5)	7.0 (6.4–7.9)	3.7 (3.6–3.8)	3.1 (2.7–3.3)	0.1 (0.0–0.4)						
<i>I. leithii</i> (6)	4.6 (3.3–5.9)	6.0 (5.1–7.4)	9.2 (8.4–10.3)	8.2 (7.6–9.2)	7.2 (6.3–8.4)	0.6 (0.0–1.6)					
<i>I. salelkari</i> (7)	7.8 (7.6–8.2)	8.9 (8.5–9.2)	3.4 (3.4–3.4)	2.4 (2.4–2.5)	4.0 (4.0–4.0)	9.0 (8.5–9.9)	0				
<i>I. sorajamma</i> (8)	4.9 (4.8–5.4)	7.2 (7.0–8.2)	7.9 (7.9–7.9)	7.6 (7.5–7.8)	6.2 (6.2–6.4)	6.0 (5.3–7.0)	8.5 (8.5–8.5)	0			
<i>I. semipalmata</i> (9)	5.5 (4.6–5.9)	6.3 (5.6–7.7)	4.9 (4.6–5.6)	4.5 (4.2–5.0)	3.1 (2.6–3.3)	7.0 (6.0–8.8)	5.5 (5.2–6.0)	8.0 (7.5–8.3)	0.9 (0.0–1.9)		
<i>I. tysoni</i> (10)	4.6 (4.0–5.2)	6.0 (5.6–6.3)	6.9 (6.9–6.9)	7.3 (7.1–7.6)	5.8 (5.5–5.9)	5.8 (5.1–6.9)	8.2 (8.2–8.2)	5.6 (5.6–5.6)	6.3 (5.9–6.9)	0	
<i>I. yadava</i> (11)	5.5 (5.2–5.8)	8.0 (7.5–9.0)	8.6 (8.5–8.7)	8.2 (7.9–8.5)	7.1 (6.8–7.3)	6.7 (6.0–7.8)	9.4 (9.3–9.5)	3.4 (3.3–3.5)	7.7 (7.1–8.5)	5.7 (5.6–5.8)	0.1 (0.0–0.2)

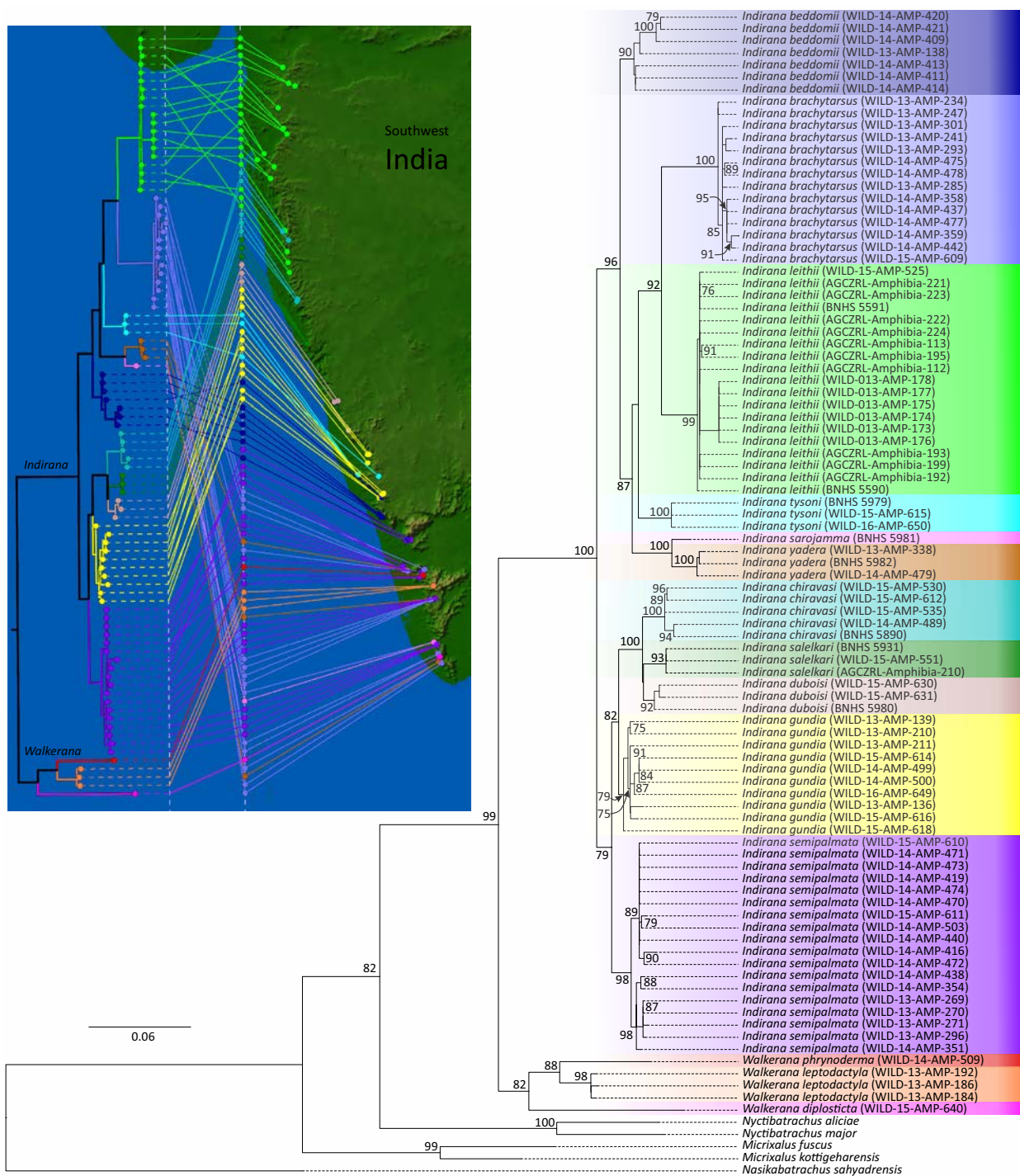


Figure 2. Maximum likelihood tree for concatenated mitochondrial 16S rRNA and nuclear rhodopsin partial gene sequences. Species of *Nyctibatrachus*, *Micrixalus* and *Nasikabatrachus* were used as outgroups with *Nasikabatrachus sahyadrensis* as a root. Values along the nodes are percent bootstraps for 1000 iterations. Phylogeographic analysis using GenGIS is shown in the inset. Color codes for sequences used in phylogeography analysis are shown in the main tree with same color boxes.

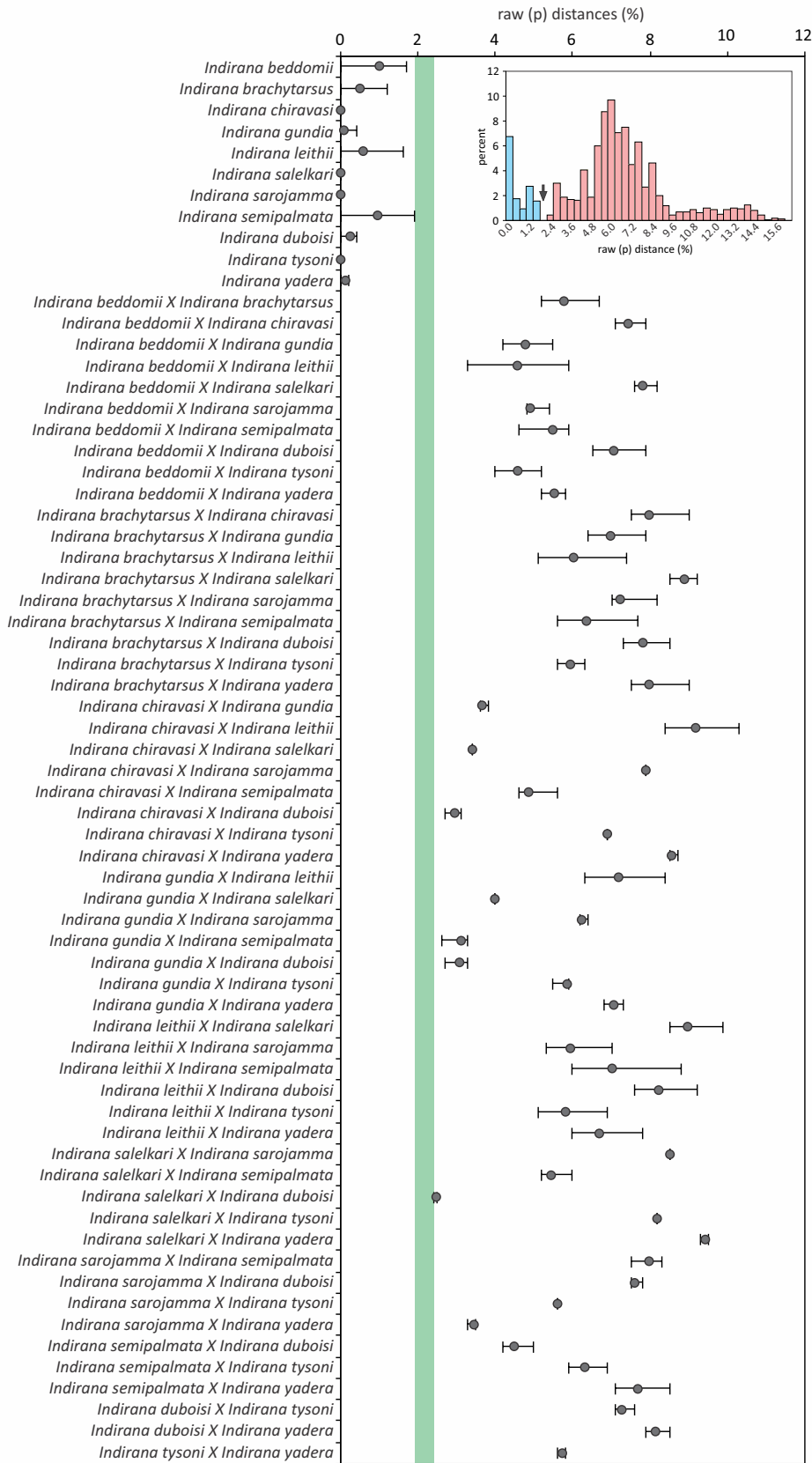


Figure 3. Genetic gap analysis for species of *Indirana*. Mean raw uncorrected p distance values of intra and inter species divergence are plotted with minimum and maximum value as error bars. Green bar shows genetic gap between 1.9 to 2.4% genetic divergence. Frequency distribution of the pairwise distances between all specimens is provided in the inset, where the gap is shown with an arrow.

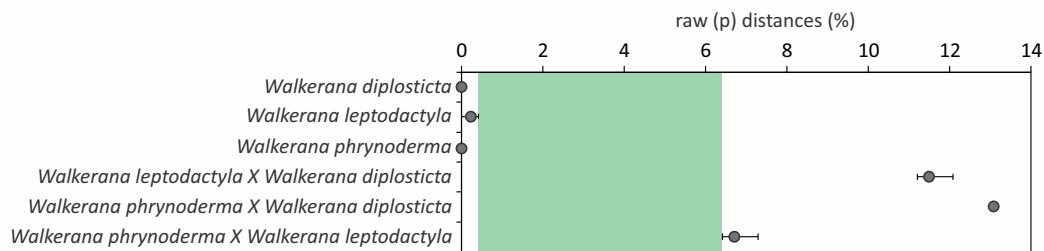


Figure 4. Genetic gap analysis for species of *Walkerana* gen. nov.. Mean raw uncorrected p distance values of intra and inter species divergence are plotted with minimum and maximum value as error bars. Green bar shows genetic gap between 0.4 to 6.4% genetic divergence.

genetic distance is 6.4% between *W. leptodactyla* comb. nov. and *W. phrynoderma* comb. nov. with a clear gap between the two values (Fig. 4). Interspecific distances between the species of *Indirana* and *Walkerana* gen. nov. are >11.0% in all cases.

MORPHOMETRIC ANALYSIS

Fisher's distances between clusters were significantly different after sequential Bonferroni correction at two-tailed level, except in two cases, *Indirana beddomii* vs. *I. brachytarsus* and *I. semipalmata* and *I. chiravasi*, which were only marginally significant at one-tailed level (Table 5). Nevertheless, both these pairs of species had different extent of webbing (see Taxonomy section below). Discriminant analysis of all species of Ranixalidae extracted 13 factors (Fig. 5, inset). Species of *Walkerana* gen. nov. are morphometrically distinct from species of *Indirana* along the first two; and fourth discriminant axes (Fig. 5). This separation occurs largely because of smaller TYL and ENL and longer THL, FOL, TL and TFOL in species of *Walkerana* gen. nov., when all the lengths are corrected for size (Table 6). Species under *Walkerana* gen. nov. form distinct clusters in first two dimensions of PCA (Fig. 6). *Walkerana diplosticta* comb. nov. separated based on higher EL, IOL and T4W; *W. leptodactyla* comb. nov. separated based on higher TYL, F3D, FOL and T5; and *W. phrynoderma* comb. nov. separated based on higher SL, UEW, SNL and INL (Table 6). Discriminant analysis of *Indirana* species extracted 10 factors, of which the first three factors explain 74.45% of the total variation in the data (Fig. 7, inset). *Indirana leithii* forms a distinct cluster in the first two dimensions (Fig. 7a, b), while *I. tysoni* sp. nov. forms a distinct cluster in the third dimension (Fig. 7c). *Indirana leithii* forms a distinct cluster from all other species under *Indirana* (Fig. 7a, b) based on comparatively higher values of ENL, F2 and F3D (Table 6); while *I. tysoni* sp. nov. forms a distinct cluster from other species of *Indirana* based on relatively higher values of characters such as SNL, INL

Table 3. Raw (p) uncorrected genetic distances (%) in 16S rRNA gene between species of *Walkerana* gen. nov. expressed as mean (minimum–maximum). Diagonal values in bold are intra specific distances.

Species	(1)	(2)	(3)
<i>W. diplosticta</i> (1)	0		
<i>W. leptodactyla</i> (2)	11.5 (11.2–12.1)	0.3 (0.0–0.4)	
<i>W. phrynoderma</i> (3)	13.1 (13.1–13.1)	6.7 (6.4–7.3)	0

Table 4. Raw (p) uncorrected genetic distances (%) in 16S rRNA gene between species of *Walkerana* gen. nov. and *Indirana* expressed as mean (minimum–maximum).

Species	<i>W. diplosticta</i>	<i>W. leptodactyla</i>	<i>W. phrynoderma</i>
<i>I. beddomii</i>	13.2 (13.0–13.7)	11.0 (10.6–11.8)	13.9 (13.3–14.2)
<i>I. brachytarsus</i>	14.1 (13.9–14.4)	12.7 (11.8–15.0)	15.1 (14.6–15.9)
<i>I. chiravasi</i>	14.5 (14.5–14.5)	11.8 (11.4–12.5)	13.9 (13.9–13.9)
<i>I. duboisi</i>	14.1 (14.0–14.3)	11.6 (10.8–13.0)	13.4 (13.1–13.8)
<i>I. gundia</i>	14.7 (14.7–14.7)	11.0 (10.5–12.2)	13.4 (13.0–13.7)
<i>I. leithii</i>	13.6 (13.1–14.5)	13.4 (12.3–15.6)	15.1 (14.3–16.2)
<i>I. salelkari</i>	14.1 (14.1–14.1)	12.4 (12.0–13.1)	13.9 (13.9–13.9)
<i>I. sarajamma</i>	15.0 (15.0–15.0)	12.9 (12.6–13.4)	14.6 (14.6–14.6)
<i>I. semipalmata</i>	14.1 (13.9–14.3)	11.2 (10.8–12.0)	13.3 (13.1–13.5)
<i>I. tysoni</i>	14.5 (14.5–14.5)	11.8 (11.4–12.5)	13.8 (13.8–13.8)
<i>I. yadera</i>	14.9 (14.8–15.0)	11.5 (11.2–12.1)	14.4 (14.3–14.5)

and F3D (Table 6). The remaining species of *Indirana* (Fig. 8) and members of 'beddomii group' (Fig. 9) (see Taxonomy section for details) form distinct clusters in DA only in higher dimensions. Factor loading for the first three dimensions in Figs. 8 and 9 are provided in Table 6.

TAXONOMY

Order: Anura Fischer von Waldheim, 1813

Incertae sedis: *Philautus longicrus* Rao, 1937 (= *P. crnri* Dutta, 1985).

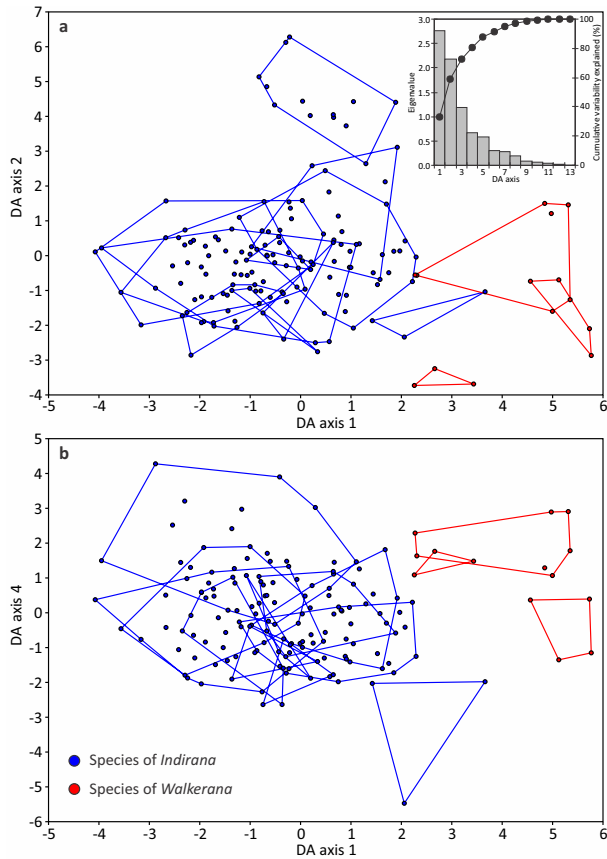


Figure 5. Discriminant analysis of species under the family Ranixalidae. (a) Scatterplot in the first and second axes and (b) scatterplot in first and fourth axes. Scree plot explaining percent variation explained by each axis is provided in the inset. Species under *Walkerana* gen. nov. are morphometrically different from species under *Indirana*.

Philautus longicrus Rao, 1937 (= *P. crnri* Dutta, 1985, a replacement name to avoid homonymy with *Ixalus longicrus* Boulenger, 1894, a species now part of the genus *Philautus*) was transferred to *Indirana* based on the arguments put forth by Bossuyt & Dubois (2001), who suggested that Rao’s (1937) mention of absence of vomerine teeth and a lingual papilla in *P. crnri* were ‘defects of observations’. We disagree with Bossuyt & Dubois (2001) that Rao (1937) made a mistake listing these characters as absent in *P. crnri*, because his descriptions of other species based on these characters are correct. Since we have been unable to identify any species of *Indirana* from the type locality of *P. crnri* that matches the original description, and since the holotype is now lost and the species description and illustration are not adequate to reliably determine whether the species belong to the families Rhacophoridae, Micrixalidae or Ranixalidae (members of the first two families lack vomerine teeth), we treat *Philautus longicrus* Rao, 1937

Table 5. Fisher’s distances (above diagonal blue cells) and associated P values (below diagonal red cells) between clusters of species. P values in bold are significant only at one tailed level.

Species	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]
<i>I. beddomii</i> [1]		1.296	2.234	2.140	2.557	5.844	3.472	1.846	2.388	4.145	3.881	7.376	4.961	13.226
<i>I. brachytrarsus</i> [2]	0.085		2.539	3.639	3.290	4.681	4.305	2.390	2.765	6.692	4.115	8.639	4.830	16.589
<i>I. chiravasi</i> [3]	0.001	0.000		2.608	2.071	6.166	2.507	3.497	1.363	7.470	4.930	11.778	8.031	16.304
<i>I. duboisi</i> [4]	0.002	< 0.0001	0.000		2.513	8.591	3.567	3.131	2.557	5.052	3.975	10.260	8.665	14.025
<i>I. gundia</i> [5]	0.000	< 0.0001	0.004	0.000		5.822	4.249	3.026	1.627	6.530	5.857	11.487	8.274	13.083
<i>I. leithii</i> [6]	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		9.789	6.541	6.394	11.121	10.656	14.448	9.126	20.190
<i>I. salelkari</i> [7]	< 0.0001	< 0.0001	0.000	< 0.0001	< 0.0001	< 0.0001		4.029	3.004	8.775	4.738	12.624	9.233	16.909
<i>I. sarajamma</i> [8]	0.012	0.001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		2.904	7.713	4.309	13.353	7.567	15.571
<i>I. semipalmata</i> [9]	0.001	< 0.0001	0.064	0.000	0.037	< 0.0001	< 0.0001	< 0.0001		7.566	5.050	10.985	6.728	12.796
<i>I. tysoni</i> [10]	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		7.636	6.665	9.371	13.081
<i>I. yadera</i> [11]	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		12.945	10.961	16.205
<i>W. diplosiacta</i> [12]	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		4.316	10.952
<i>W. leptodactyla</i> [13]	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		11.262
<i>W. phrynoderma</i> [14]	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	

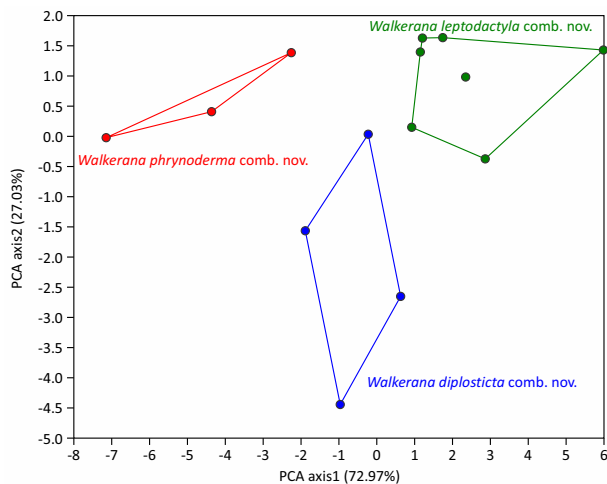


Figure 6. Principle component analysis of species under *Walkerana* gen. nov. showing distinct clusters. Values in parentheses are percent of total variation explained by the axis.

(= *Philautus crnri* Dutta, 1985) as incertae sedis within the Order Anura until further information becomes available.

Family: **Ranixalidae** Dubois, 1987

Type genus: *Indirana* Laurent, 1986

Diagnosis of the family: Y shaped terminal phalanges, digital discs, femoral glands, and semi-terrestrial tadpoles with 3-5/3-4 rows of labial teeth, elongated bodies and low tail fins, with an ability to make long jumps on the ground to escape predators (Dubois 2003).

Included genera: *Indirana* and *Walkerana* gen. nov.

***Walkerana* gen. nov.**

urn:lsid:zoobank.org:act:1A088397-8F05-4339-8696-A50093E88CD5

Type species: *Ixalus diplostictus* Günther, 1876

Diagnosis: *Walkerana* gen. nov. represents a genetically distant clade within the family Ranixalidae and differs from its sister taxon *Indirana* in having extremely reduced webbing with one phalange free on first and second toes (vs. nil), and three phalanges free on the fourth toe (vs. 2–2½). Further, *Walkerana* differs from *Indirana* in consistently having the first finger shorter than second (vs. equal to or longer than second, except in *I. leithii*).

Etymology: The genus is named after Ms. Sally Walker in recognition of her selfless service to the improvement of zoos in South Asia, as well as her contributions to in situ conservation of neglected and non-charismatic wild fauna and flora through the work of Zoo Outreach

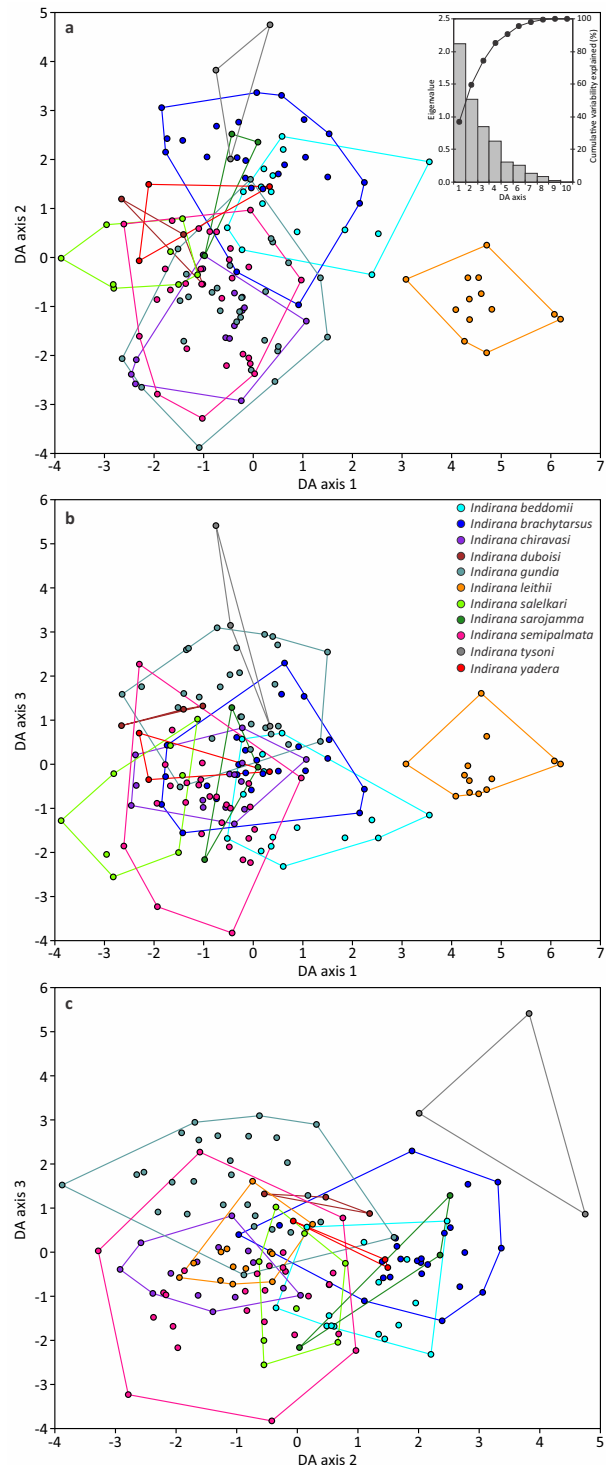


Figure 7. Discriminant analysis of species under the genus *Indirana* in the first three dimensions. Scree plot is provided in the inset. *Indirana leithii* formed a distinct cluster from other *Indirana* species in the first dimension (a, b), while *I. tysoni* sp. nov. formed a distinct cluster from other *Indirana* species in the third dimension (c).

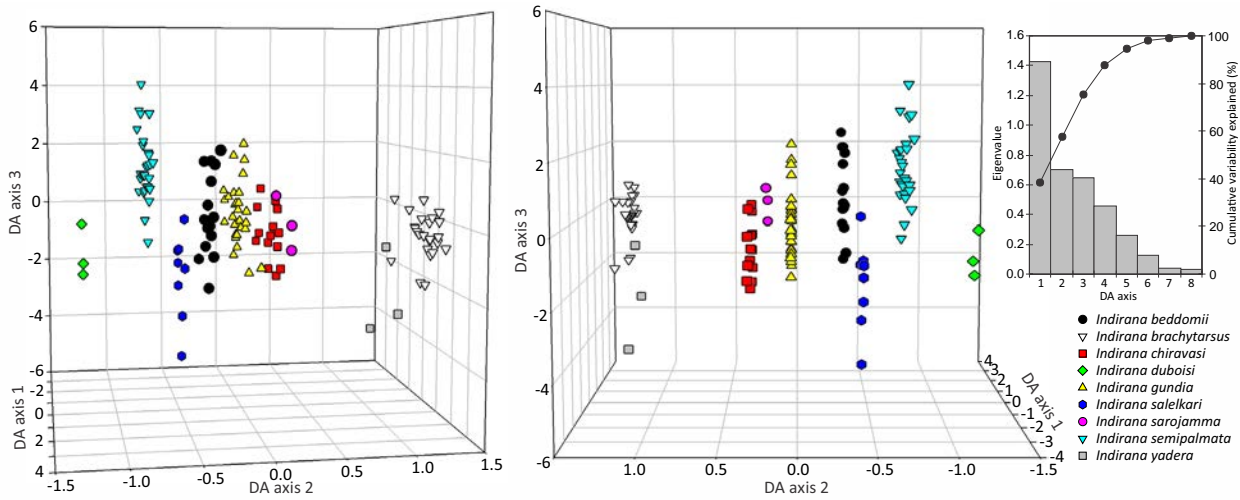


Figure 8. Two projections for discriminant analysis of species under the genus *Indirana* excluding *I. leithii* and *I. tysoni* in the first three dimensions. Scree plot is provided in the far right.

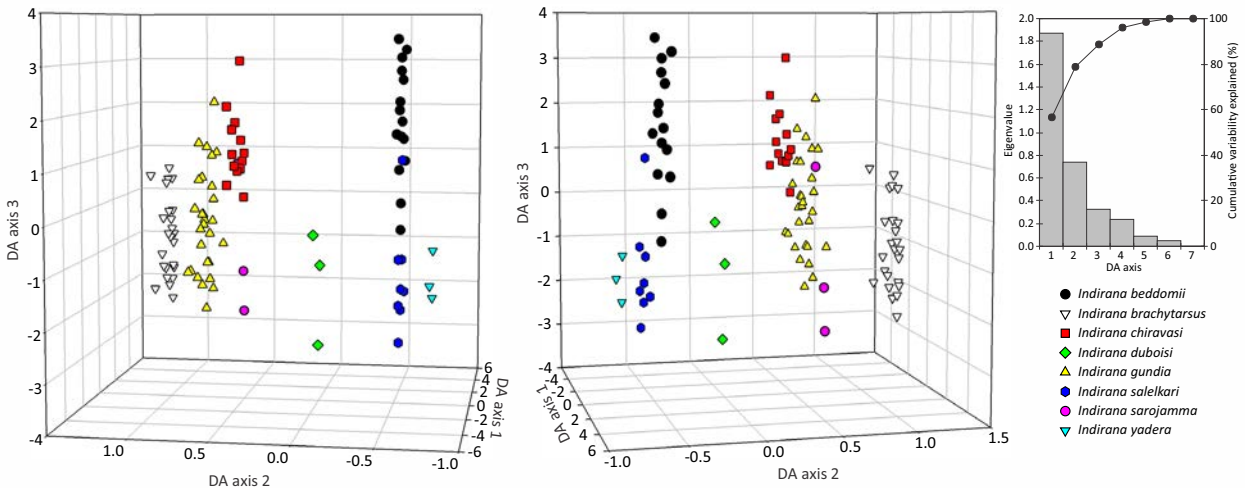


Figure 9. Two projections for discriminant analysis of species under the *beddomii* group in the first three dimensions. Scree plot is provided in the far right.

Key to genera

Extensive webbing with no phalange free on first and second toes, one phalange free on third and fifth toes, and 2–2½ phalanges free on fourth toe *Indirana*

Reduced webbing with one phalange free on first and second toes, two phalanges free on third and fifth toes, and three phalanges free on fourth toe *Walkerana* gen. nov.

Key to species

1a Canthus rostralis indistinct, skin warty *Walkerana phrynoderma* comb. nov.
 1b Canthus rostralis distinct, skin smooth 2

2a Dorsal glandular folds absent, distinct black patch on the loin *Walkerana diplosticta* comb. nov.
 2b Dorsal glandular folds present, black patch on loin absent *Walkerana leptodactyla* comb. nov.

Table 6. Discriminant analysis and principle component analysis factor loadings for scatterplots shown in Figures 5–9.

Character	Figure 5				Figure 6		Figure 7			Figure 8			Figure 9		
	DA axis 1	DA axis 2	DA axis 3	DA axis 4	PC 1	PC 2	DA axis 1	DA axis 2	DA axis 3	DA axis 1	DA axis 2	DA axis 3	DA axis 1	DA axis 2	DA axis 3
HL	-0.5083	-0.3073	0.0049	-0.2545	-0.1959	0.1261	-0.4386	-0.2330	0.2463	-0.4131	0.0980	-0.2773	-0.3900	-0.1204	-0.1097
HW	-0.1944	-0.5058	-0.1087	0.2095	-0.2011	0.1019	-0.4789	-0.2302	-0.1489	-0.3899	-0.3679	-0.1222	-0.2757	-0.4561	0.0589
SL	-0.2673	-0.1845	-0.0415	-0.1798	-0.2087	0.0452	-0.2233	-0.0524	0.0806	-0.2295	-0.2124	-0.1318	-0.1664	-0.2743	-0.1822
EL	-0.3068	-0.0878	-0.311	-0.2185	-0.0906	-0.3108	-0.1399	-0.3566	0.4804	-0.4736	0.3823	-0.0404	-0.4977	0.1956	0.1400
TYL	-0.5302	0.0147	-0.0625	0.0048	0.2105	0.0069	-0.1820	-0.4725	0.2543	-0.4901	0.2709	0.1097	-0.4800	0.1884	0.0000
UEW	-0.0328	-0.2240	-0.1519	-0.1005	-0.2096	-0.0319	-0.1719	-0.0026	0.1106	-0.1390	-0.0959	-0.1476	-0.1118	-0.1564	-0.2071
SNL	0.0760	-0.3363	-0.3266	-0.2277	-0.2083	0.0492	-0.2234	0.0828	0.4499	-0.1255	0.2403	-0.2434	-0.1727	0.0999	-0.3338
ENL	-0.2462	0.1673	-0.0106	-0.0607	-0.1963	0.1242	0.0955	-0.1318	-0.0627	-0.1041	-0.1181	0.0178	-0.0601	-0.1017	-0.0652
INL	0.2376	-0.3202	-0.2366	-0.0094	-0.2094	-0.0356	-0.1793	0.1030	0.2391	-0.0454	0.1179	-0.0641	-0.0589	0.0816	-0.0956
IOL	0.0447	-0.0954	-0.1656	0.1439	0.0011	-0.3444	-0.0628	-0.1640	0.0728	-0.2195	-0.0278	0.1297	-0.1735	0.0031	0.0474
UAL	0.1781	-0.6169	0.365	0.779	-0.0493	0.3348	-0.5541	0.3051	-0.6734	0.2394	-0.6756	0.6668	0.4250	-0.1087	-0.3295
FoAL	-0.1695	-0.3598	0.4829	0.4013	0.2079	0.0537	-0.4707	-0.0105	-0.4949	-0.0064	-0.3996	0.3233	0.0952	-0.2046	0.2120
PAL	0.0633	-0.0165	0.6823	0.4738	0.1816	0.1742	-0.1255	0.1206	-0.8396	0.2239	-0.8301	0.0576	0.3531	-0.6651	0.1319
F1	-0.2275	-0.0612	0.3231	-0.024	0.0350	0.3396	-0.1677	0.0977	-0.2151	0.1173	-0.1569	-0.0298	0.1283	-0.1248	-0.0968
F2	0.1337	0.1686	0.138	0.2067	0.1358	0.2632	0.1672	0.0922	-0.2292	0.2278	-0.0570	0.1654	0.2201	0.0545	0.1187
F3	0.1037	0.0321	0.4276	0.1141	0.1763	0.1881	-0.0240	0.2476	-0.3207	0.2978	-0.2536	-0.0152	0.3082	-0.1796	0.0100
F4	0.0969	0.0813	0.2662	0.2036	0.1699	0.2034	0.0449	0.1184	-0.2902	0.1626	-0.2982	0.0949	0.2062	-0.1811	0.0074
F3D	0.0412	0.1460	-0.026	-0.0273	0.2105	-0.0049	0.1418	-0.0325	0.0081	0.0246	0.0363	-0.1071	0.0031	-0.0201	-0.0574
F3W	-0.0174	-0.0006	-0.006	0.0484	-0.1639	0.2160	-0.0024	-0.0344	-0.0462	-0.0148	-0.0299	0.0029	-0.0077	-0.0284	0.0071
THL	0.9599	-0.7458	1.2332	0.5433	0.2039	-0.0855	-0.5451	1.2666	-1.4280	1.1672	-1.5334	0.1284	1.3803	-0.9460	-0.3257
TL	1.1996	-0.9355	1.5794	0.3351	0.2097	-0.0306	-0.7145	1.7987	-1.2717	1.6929	-1.0835	0.1576	1.7705	-0.4545	-0.3056
ACL	0.5316	-0.4917	0.8599	0.608	0.2067	0.0651	-0.4431	0.6330	-0.9645	0.6513	-0.8960	0.1327	0.7936	-0.4833	-0.4786
FOL	1.0579	-0.5468	2.1292	0.0758	0.2097	-0.0294	-0.5242	1.8692	-1.4821	1.9131	-1.1738	-0.2367	1.9059	-0.7339	-0.1946
TFOL	1.5871	-0.6552	2.917	-0.7623	0.1894	-0.1502	-0.5526	2.9486	-1.7168	2.9057	-1.4964	-1.0509	2.7945	-1.1144	-0.9991
T1	0.0371	0.0408	0.3474	0.0203	0.1810	0.1757	0.0040	0.2404	-0.2897	0.3235	-0.1405	0.0361	0.3147	-0.0523	0.0598
T2	0.1310	-0.1167	0.448	0.0094	0.2036	0.0876	-0.1425	0.3243	-0.2816	0.3443	-0.1767	-0.0729	0.3265	-0.1490	0.0986
T3	0.3091	-0.1683	0.7121	0.0148	0.2068	-0.0644	-0.1779	0.5271	-0.5371	0.5571	-0.4517	-0.2073	0.5516	-0.4042	0.0284
T4	0.6272	-0.2011	1.3235	-0.1212	0.2090	-0.0411	-0.2133	1.1939	-0.7769	1.2433	-0.5484	-0.2001	1.1891	-0.3147	-0.1558
T5	0.2865	0.0393	0.8238	-0.2516	0.2105	-0.0034	-0.0220	0.6055	-0.4012	0.6667	-0.2621	-0.4526	0.5915	-0.3598	0.1223
T4D	0.0655	0.0181	0.106	-0.0933	0.1106	-0.2930	0.0176	0.0679	-0.0742	0.0506	-0.1531	-0.1677	0.0578	-0.1984	-0.0700
T4W	0.0177	-0.0599	0.0808	0.0346	0.0261	-0.3417	-0.0612	0.0201	-0.1156	0.0029	-0.1717	-0.0575	0.0304	-0.1670	-0.0491

Organization. An unsung hero, this is also in recognition of her voluntary service to conservation in India and South Asia for well over 35 years. The generic name is a combination of Sally Walker's last name and the Latin name for frogs, *Rana*, and is used as a noun.

Included species: *Walkerana diplosticta* (Günther, 1876), *W. leptodactyla* (Boulenger, 1882), *W. phrynoderma* (Boulenger, 1882).

Distribution: The new genus *Walkerana* is endemic to the Western Ghats of India and is currently known from south of the Palghat gap (Fig. 10). All records of the species under *Walkerana* gen. nov. from north of the Palghat gap need genetic confirmation.

SPECIES ACCOUNTS

Walkerana diplosticta (Günther, 1876) comb. nov.

(Images 1–3)

Ixalus diplostictus Günther, 1876: 574, Pl. 63 fig. C

Rana diplosticta — Boulenger (1882: 55)

Rana (Discodeles) diplosticta — Boulenger (1920: 120)

Indirana diplosticta — Laurent (1986: 761)

Ranixalus diplostictus — Dubois (1987a: 69)

Common name: Spotted Leaping Frog

Type locality: Malabar, India.

Putative type locality: Bonacaud (8.686°N & 77.183°E, elevation 877m), Peppara Wildlife Sanctuary, Kerala, India.

Material examined: Lectotype: BMNH 1947.2.2.21 (female), India: Malabar, coll. Col. Beddome

Paralectotype: BMNH 1947.2.2.23 (female) and BMNH 1947.2.2.22 (male), same data as lectotype.

Comparative: WILD-15-AMP-640 (male), 13.x.2015, Bonacaud, Peppara Wildlife Sanctuary, Kerala, India (8.686°N & 77.183°E, elevation 877m), coll. S. Das.

Diagnosis and comparison: *Walkerana diplosticta* comb. nov. differs from its congeners in having distinct canthus rostralis (vs. indistinct in *W. phrynoderma* comb. nov.), webbing formula I2-2½II2-3III2-4IV4-2½V (vs. I2-2½II2-3III3-4IV4-3V in *W. leptodactyla* comb. nov. and I2-2½II2-3III3-4IV4-2½V in *W. phrynoderma*), dorsal skin smooth without glandular folds (vs. warty in *W. phrynoderma* and smooth with glandular folds in *W. leptodactyla*), a distinct black patch/es on the loin (vs. no such patch in *W. leptodactyla* and *W. phrynoderma*), narrower head (HW/SUL ratio 0.34–0.36 vs. broader 0.38–0.41 in *W. phrynoderma*) and total foot length

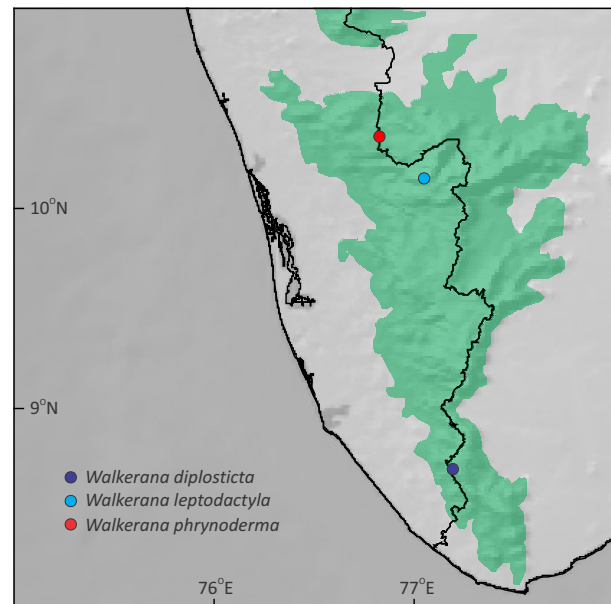


Figure 10. Distribution of species under *Walkerana* gen. nov. examined in the current study.

more than ¾ of SUL (vs. less than ¾ in *W. phrynoderma*).

Description of Lectotype BMNH 1947.2.2.21 (Image 1), female (all measurements in mm): Medium-sized frog (SUL 25.8); head longer than wide (HL 10.2 > HW 9.1); snout slightly longer than horizontal diameter of eye (SL 3.8 > EL 3.5); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils equidistant from snout and eye (SNL 2.1 = ENL 2.1); tympanum slightly less than half the diameter of eye (TYL = 1.6), separated from the eye with a distance equal to ¾ of TYL; supratympanic fold distinct; UEW slightly more than half EL (UEW = 1.9); upper eyelids smooth; IOL less than INL (IOL 3.0 < INL 3.5); canthus rostralis obtuse; loreal region slightly concave and oblique; buccal cavity narrow, deep, vomerine teeth in two slightly oblique rows at the posterior border of choanae; tongue thin, bifid; bear a mid ventral papilla.

Upper arm shorter than forearm (UAL 4.7 < FoAL 5.7); hand longer than forearm length (PAL 6.1); finger lengths from shortest to longest – F1 (1.4) < F2 (1.8) < F4 (2.6) < F3 (3.0); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate, supernumerary tubercles present, single; finger discs moderate in size, about 1.5 times the width of finger (F3D = 0.8, F3W = 0.5), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 13.6 < TL 14.2); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 20.1); toe lengths from shortest

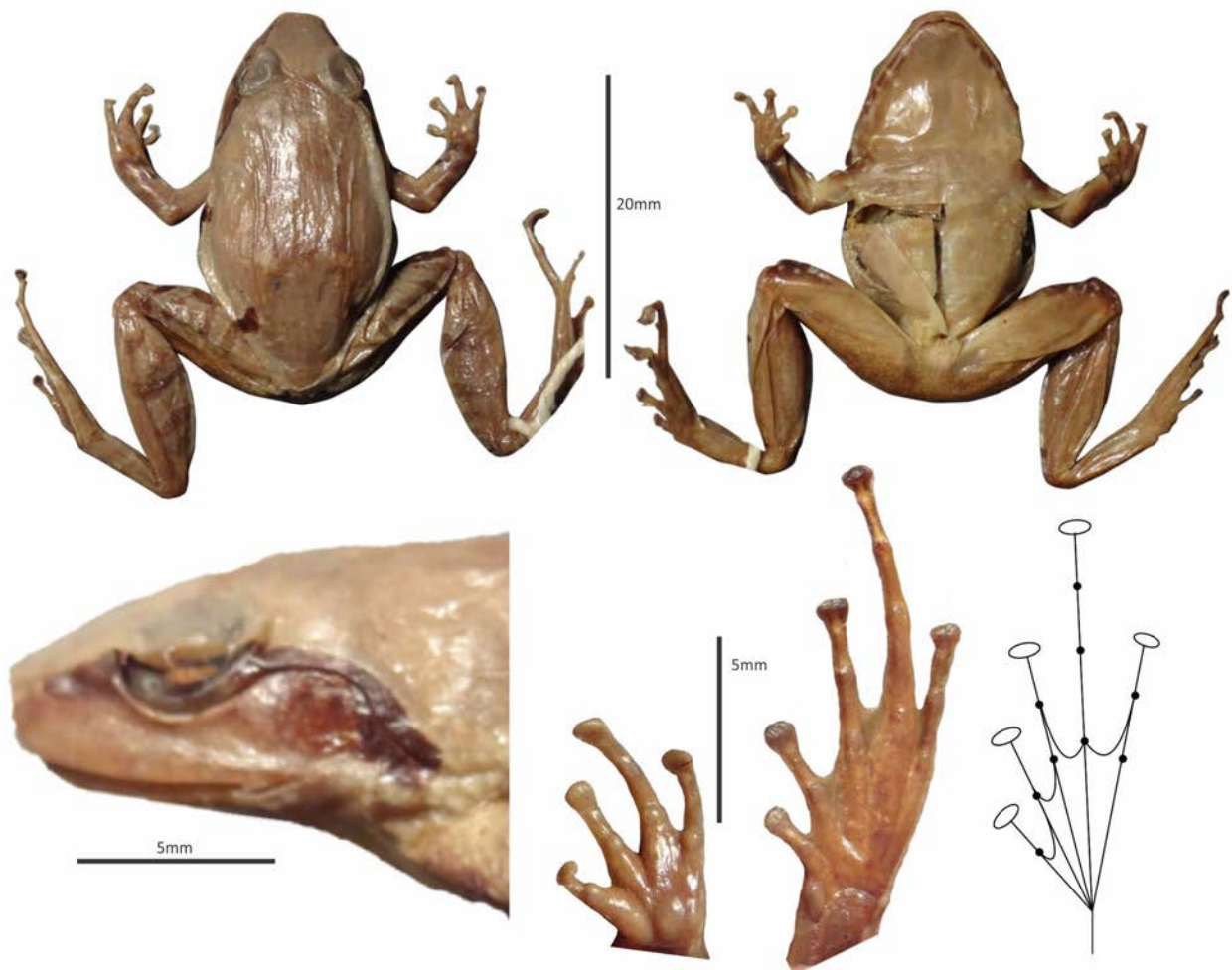


Image 1. *Walkerana diplosticta* comb. nov. lectotype BMNH 1947.2.2.21 (female, 25.8mm SUL) from Malabar. © Nikhil Modak

to longest are- T1 (1.8) < T2 (2.6) < T3 (4.2) < T5 (4.3) < T4 (7.3); toe discs slightly larger than finger discs, its diameter about 1.6 times width of finger (T4D = 0.9, T4W = 0.6); bear semicircular groove; inner metatarsal tubercle thin and elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles small; tarsal fold and outer phalangeal fringe absent; webbing formula I2-2½II2-3III3-4IV4-3V.

Dorsal and ventral skin smooth; very few longitudinal folds on dorsal side; lateral side granular.

Coloration: In alcohol preservation, dorsal reddish-brown, dark band between the two upper eyelids; lower mandible barred with brown stripes inconspicuous on upper mandible; dark brown stripe running from tip of snout to shoulder through eye and tympanum visible; symmetrical black spots on the flanks – one just posterior to the axil, another on the middle of the flank, a third anterior to the loin; forelimbs and hindlimbs barred with dark brown stripes; lateral margin of forelimbs and hind

limbs densely spotted with dark brown or black; sole and foot pale brown dorsally, dark brown ventrally.

Variation: Morphometric variation provided in Table 7. Color in life as in Image 2. Some of the symmetrical black spots on the flanks (except those on the loin) may not be present or could be very small in size, or may be lost in preservation.

Distribution: In the current study, the species was collected only from Bonacaud (8.686°N & 77.183°E, elevation 877m), Kerala Western Ghats, south of the Palghat gap (Fig. 10). In our surveys we could record *W. diplosticta* only from south of Shencottah. Except Athiramala (Biju et al. 2004h), Ponmudi (Inger et al. 1984; Nair et al. 2012b), Kalakkad-Mundanthurai Tiger Reserve (Johnsingh 2001; Vasudevan et al. 2001, 2008; Kumar et al. 2002), all other previous records of this species, including Ranipuram (Andrews et al. 2005), Anamalai Hills (Boulenger 1920), Indira Gandhi National Park (Biju et al. 2004h), Idukki Wildlife Sanctuary (Andrews et al.



Image 2. *Walkerana diplosticta* comb. nov. from Bonacaud (WILD-15-AMP-640, male, 28mm SUL) in life.



Image 3. *Walkerana diplosticta* comb. nov. collected by T.C. Jerdon (BMNH 72.4.17.268 – 269, old numbers) from Malabar.

2005), Srivilliputtur (Daniel & Sekar 1989; Biju et al. 2004h), and Kochupamba (9.421°N & 77.160°E) (Nair et al. 2012b) need genetic confirmation.

Remarks: During the study of types of *Walkerana diplosticta*, two specimens of the species collected by T.C. Jerdon from Malabar were also photographed (Image 3) but as they were not types they were not considered for morphometric study.

***Walkerana leptodactyla* (Boulenger, 1882) comb. nov.**
(Images 4–7)

Polypedates brevipalmatus Günther, 1876: 572

Rana leptodactyla Boulenger, 1882: 57

Rana (Discodeles) leptodactyla — Boulenger (1920: 118)

Indirana leptodactyla — Laurent (1986: 761)

Ranixalus leptodactylus — Dubois (1987a: 69)

Common name: Slender-toed Leaping Frog

Type locality: Malabar and Anamallays (= Anamalai), India.

Putative type locality: Eravikulam National Park (10.145°N & 77.038°E, elevation 1940m), Kerala, India.

Material examined: Lectotypes: BMNH 1947.2.29.39 (female), India: Malabar, coll. Col. R.C. Beddome.

Paralectotype: BMNH 1947.2.29.40 (female) and BMNH 1947.2.29.41 (male), same data as lectotype.

Comparative: BMNH 1897.1.10.11 (female), India: Devicolum (= Devikulam), Travancore, 1200–2100 m, coll. Fergusson; WILD-13-AMP-184 (female), WILD-13-AMP-186 (unsexed), India: Kerala: Eravikulam National Park (10.145°N & 77.038°E, elevation 1940m), coll. K. Krutha, A. Kanagavel & R. Hadlee, 2.ix.2013; WILD-13-

AMP-192 (female), India: Kerala: Eravikulam (10.144°N & 77.037°E, elevation 1899m), coll. K. Krutha, A. Kanagavel & R. Hadlee, 1.ix.2013.

Diagnosis: *Walkerana leptodactyla* comb. nov. differs from its congeners in having distinct canthus rostralis (vs. indistinct in *W. phrynoderma*), webbing formula I2-2½II2-3III3-4IV4-3V (vs. I2-2½II2-3III2-4IV4-2¼V in *W. diplosticta* and I2-2½II2-3III3-4IV4-2¾V in *W. phrynoderma*), dorsal skin smooth with glandular folds (vs. warty in *W. phrynoderma* and smooth without glandular folds in *W. leptodactyla*), absence of any distinct black patch on the loin (vs. present in *W. diplosticta*).

Description of Lectotype BMNH 1947.2.29.39 (Image 4), female (all measurements in mm): Medium-sized frog (SUL 31.4); head longer than wide (HL 13.0 > HW 11.4); snout longer than horizontal diameter of eye (SL 5.7 > EL 4.0); pupil horizontal; outline of snout suboval dorsally, truncated laterally; ventrally snout slightly protruding beyond the mouth; nostrils closer to snout than to eye (SNL 2.6 < ENL 3.5); tympanum three-fourth of the diameter of eye (TYL = 2.9), separated from eye with a distance about half of TYL; supra-tympanic fold distinct; UEW two-third of EL (UEW = 2.7); upper eyelids smooth; IOL less than INL (IOL 3.6 < INL 4.0); canthus rostralis obtuse; loreal region slightly concave and oblique; buccal cavity narrow, deep, vomerine teeth in two slightly oblique rows at the posterior border of choanae; tongue thin, bifid; bear a mid ventral papilla.

Upper arm shorter than forearm (UAL 6.9 < FoAL 8.1); hand longer than forearm (PAL 8.6); fingers from shortest to longest – F1 (2.8) < F2 (3.1) < F4 (3.2) < F3 (4.2); Palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate, supernumerary

Table 7. Raw morphometric data (mm) for species of *Walkerana* gen. nov. Abbreviations: F, female; M, male; L, lectotype; PL, paralectotype*; used for genetic analysis. Character abbreviations as per Materials and methods.

Species/ Locality	Voucher (Gender) [Type status]	SUL	HL	HW	SL	EL	TYL	UEW	SNL	ENL	INL	IOD	UAL	FOAL	PAL	F1	F2	F3	F4	F3D	F3W	THL	TL	ACL	FOL	TFOL	T1	T2	T3	T4	T5	T4D	T4W		
<i>Walkerana diplosticta</i>																																			
Malabar	BMNH 1947.2.2.21 (F)[L]	25.8	10.2	9.1	3.8	3.5	1.6	1.9	2.1	2.1	3.5	3.0	4.7	5.7	6.1	1.4	1.8	3.0	2.6	0.8	0.5	13.6	14.2	7.2	12.7	20.1	1.8	2.6	4.2	7.3	4.3	0.9	0.6		
Malabar	BMNH 1947.2.3.22 (M) [PL]	23.9	9.5	8.6	4.4	2.7	1.6	2.3	2.0	1.9	2.9	2.7	6.2	5.3	6.6	1.5	2.1	3.3	2.1	0.8	0.4	14.4	16.0	6.5	14.2	20.2	1.5	2.2	4.1	7.5	3.7	1.0	0.4		
Malabar	BMNH 1947.2.3.23(F)[PL]	23.2	9.1	8.0	4.0	3.2	1.7	2.0	1.7	2.5	2.5	2.9	3.6	4.8	4.8	1.1	1.6	2.4	1.9	0.9	0.3	12.2	14.4	7.0	12.3	18.0	1.5	2.3	4.3	6.6	3.5	1.2	0.7		
Bonacaud	WILD-15-AMP- 640(M)*	28.0	10.6	10.2	4.4	3.3	1.6	2.3	2.1	2.1	3.6	3.6	5.0	5.5	6.7	1.7	2.0	3.5	3.0	1.0	0.6	17.5	19.5	8.9	15.2	23.9	1.6	2.8	5.5	8.7	5.0	1.3	0.7		
<i>Walkerana leptodactyla</i>																																			
Malabar	BMNH 1947.2.29.39(F)[L]	31.4	13.0	11.4	5.7	4.0	2.9	2.7	2.6	3.5	4.0	3.6	6.9	8.1	8.6	2.8	3.1	4.2	3.2	1.2	0.6	18.5	21.7	10.2	18.2	26.0	2.3	3.5	5.7	9.7	6.4	1.1	0.6		
Malabar	BMNH 1947.2.29.40(F) [PL]	28.6	11.0	9.7	4.7	3.9	1.8	2.7	2.5	2.3	3.7	2.2	6.5	6.5	7.7	2.3	2.9	4.8	3.8	0.8	0.5	15.8	17.5	8.6	16.0	22.8	2.0	3.4	5.7	9.0	5.3	1.1	0.6		
Malabar	BMNH 1947.2.29.41(M) [PL]	28.5	12.4	10.0	4.7	3.1	2.0	2.0	2.1	2.7	3.1	3.2	5.2	6.0	7.9	1.9	2.9	3.7	3.4	0.9	0.5	15.3	17.9	8.4	15.9	23.4	2.1	3.6	5.5	9.2	5.2	0.9	0.5		
Devicolum, Travancore	BMNH 1897.1.10.11(F)	34.0	11.9	11.7	4.6	3.9	2.4	2.2	1.6	2.6	3.2	2.8	7.1	7.9	9.9	2.7	3.5	5.8	5.1	1.2	0.5	21.0	23.9	10.7	21.0	30.5	2.5	3.8	6.7	12.2	6.2	1.2	0.7		
Eravikulam	WILD-13-AMP- 184(F)*	34.2	13.9	13.1	5.6	4.0	2.5	2.1	2.4	2.5	3.5	3.6	6.0	7.6	9.5	2.8	3.1	5.4	3.9	1.5	0.7	19.7	21.4	10.9	20.0	23.8	2.5	3.6	6.3	10.5	6.2	1.5	0.7		
Eravikulam	WILD-13-AMP- 186(U)*	23.2	8.1	7.3	3.6	1.7	1.4	1.9	1.7	1.9	2.8	3.0	6.3	4.7	6.1	1.1	1.6	3.1	2.5	1.0	0.5	13.7	16.0	8.3	13.2	21.4	1.8	2.6	4.3	7.8	4.0	0.8	0.6		
Eravikulam	WILD-13-AMP- 192(F)*	20.0	7.8	7.0	3.0	1.4	1.3	0.9	1.1	1.6	2.4	3.0	4.6	3.7	4.9	1.1	1.7	2.9	2.0	0.7	0.4	11.4	12.5	5.8	11.3	14.3	1.7	1.9	3.4	6.0	3.5	0.6	0.5		
<i>Walkerana phrynoderma</i>																																			
Anamalai	BMNH 1947.2.3.8(M)[L]	32.3	13.2	12.6	5.5	3.7	2.2	2.8	2.9	2.8	4.1	3.3	6.8	7.3	7.7	2.6	2.7	4.3	3.3	1.0	0.7	16.8	20.9	9.8	16.5	24.1	2.0	3.4	5.4	8.9	4.6	1.0	0.6		
Anamalai	BMNH 1947.2.3.9(M)[PL]	30.0	11.5	11.3	5.0	3.6	1.4	2.9	2.7	2.7	3.9	3.0	6.9	6.0	7.0	2.2	2.4	3.3	2.8	1.0	0.6	16.3	17.3	8.5	13.3	21.4	1.8	2.8	5.0	7.1	3.7	0.9	0.6		
Anamalai	WILD-14-AMP- 509(U)*	12.2	5.1	5.0	2.4	1.4	0.7	1.3	1.4	1.2	1.7	1.6	2.7	2.3	2.9	0.6	0.9	1.4	1.1	0.4	0.3	7.0	6.9	3.0	5.6	7.0	0.8	0.9	1.6	2.8	1.7	0.3	0.3		

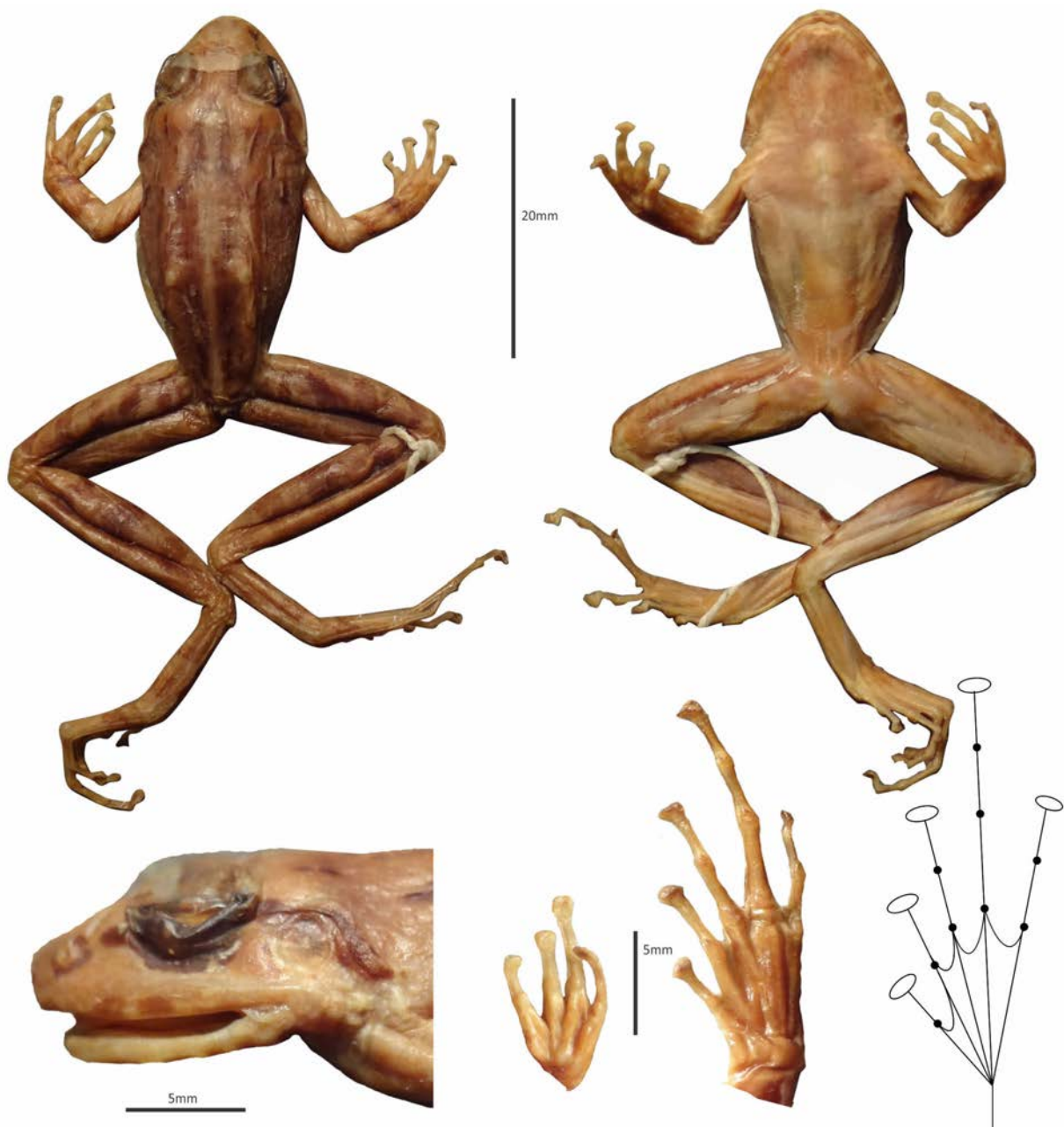


Image 4. *Walkerana leptodactyla* comb. nov. lectotype BMNH 1947.2.29.39 (female, 31.4mm SUL) from Malabar. © Nikhil Modak

tubercles present, single; finger discs moderate in size, twice the width of finger ($F3D = 0.6$, $F3W = 1.2$), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) ($THL 18.5 < TL 21.7$); total foot length (including astragalus-calcaneum) longer than tibia ($TFOL 26.0$); toe lengths from shortest to longest are – $T1 (2.3) < T2 (3.5) < T3 (5.7) < T5 (6.4) < T4 (9.7)$; toe discs slightly smaller than finger discs, its diameter about twice the width of finger ($T4D = 1.1$, $T4W = 0.6$); bearing a semicircular groove; inner metatarsal

tubercle thin and elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate; tarsal fold and outer phalangeal fringe absent; webbing formula $I2-2\frac{1}{2}II2-3III3-4IV4-3V$.

Dorsal and ventral skin smooth; longitudinal folds on dorsal side; lateral side granular.

Coloration: In alcohol preservation, dorsal dark brown; white band between the two upper eyelids followed by a dark band posterior; upper and lower mandible barred with brown stripes; narrow dark brown stripe running from tip of snout to shoulder through eye



Image 5. *Walkerana leptodactyla* comb. nov. from Eravikulam (WILD-13-AMP-192, female, 20.0mm SUL) in life.

and tympanum visible; forelimbs and hind limbs barred with dark brown stripes; lateral margin of forelimbs and hind limbs densely spotted with dark brown or black; foot and sole pale brown dorsally, dark brown ventrally.

Variation: Morphometric variation is provided in Table 7. Color in life as in Image 5. Dorsal side sometimes with a white middorsal line; ventral side creamy white mottled with brown or brown with white dots; anterior

and posterior sides of the thigh and tibia mottled with brown.

Distribution: One of the original type locality 'Malabar' is an imprecise area (see Biju 2001) the second locality 'Anamallays' is relatively more precise but we could not study the syntype from Anamalais (see Remarks below). In the current study, we could only examine specimens from Eravikulam (10.145°N & 77.038°E, elevation 1940m) (Fig. 10), which is within the Anamalais. Other records of the species are from Parambikulam (Satyamurti 1967; Biju & Dutta 2004; Andrews et al. 2005), Indira Gandhi National Park (Biju & Dutta 2004), Vellikulam (Satyamurti 1967), Trichur (Satyamurti 1967), Devikulam (Boulenger 1920, Satyamurti 1967), Eravikulam National Park (Andrews et al. 2005), Kodaikanal (Daniel & Sekar 1989), Palni Hills (Daniel & Sekar 1989), Idukki Wildlife Sanctuary (Andrews et al. 2005), Periyar (Biju & Dutta 2004), Athiramala (Biju & Dutta 2004), Agasthyamala Hills (Biju & Dutta 2004), Tenmalai (Annandale 1909; Satyamurti 1967), Thirumala (Dutta 1997), Kalakkad-Mundanthurai (Johnsingh 2001; Vasudevan et al. 2001, 2006, 2008). Records of the species from Shimoga and Coorg (Rao 1920; Satyamurti 1967) need genetic validation.

Remarks: In his description of *Walkerana*



Image 6. *Walkerana leptodactyla* comb. nov. non-types collected by Col. R.C. Beddome (BMNH 1874.4.28.503–509, old numbers) from Malabar. © Nikhil Modak



Image 7. *Walkerana leptodactyla* comb. nov. collected by T.C. Jerdon (BMNH 72.4.17.200–202, old numbers). © Nikhil Modak

leptodactyla, Boulenger (1882) mentioned several specimens from Malabar collected by Col. Beddome; types of *Polypedates brevipalmatus* consisting of several specimens from Malabar and one female from Anamallays all collected by Col. Beddome; and specimen/s from an unknown locality collected by T.C. Jerdon. Boulenger (1882) did not indicate types for *W. leptodactyla*, however, as this is just a replacement name for *P. brevipalmatus* we consider only syntypes of *P. brevipalmatus* as syntypes of *W. leptodactyla*. We were able to study types of *P. brevipalmatus* from Malabar; however, we could not locate syntypes from Anamalais within the type collection at BMNH. Some additional specimens of *Walkerana leptodactyla* from Malabar collected by Col. Beddome were photographed (Image 6) but as they were not types they were not considered for morphometric study. The specimens collected by T.C. Jerdon are in bad condition (Image 7) and therefore they were also not considered for morphometric study.

***Walkerana phrynoderma* (Boulenger, 1882) comb. nov.**
(Images 8–9)

Rana phrynoderma Boulenger, 1882: 462

Rana (Discodeles) phrynoderma — Boulenger (1920: 121)

Indirana phrynoderma — Laurent (1986: 761)

Ranixalus phrynoderma — Dubois (1987: 69)

Common name: Warty-skinned Leaping Frog

Type locality: Anamallays (= Anamalai), India

Material Examined: Lectotype: BMNH 1947.2.3.8 (male), India: Anamallays (= Anamalai), coll. Col. R.C. Beddome.

Paralectotype: BMNH 1947.2.3.9 (male), same data as lectotype.

Comparative: WILD-14-AMP-509 (unsexed), India: Kerala: Anamalai (Parambikulam Tiger Reserve), (10.354°N & 76.815°E, elevation 928m), coll. P.O. Nameer, 25.v.2011.

Diagnosis: *Walkerana phrynoderma* comb. nov. differs from its congeners in having indistinct canthus rostralis (vs. distinct in *W. diplosticta* and *W. leptodactyla*), webbing formula I2-2½II2-3III3-4IV4-2½V (vs. I2-2½II2-3III2-4IV4-2½V in *W. diplosticta* and I2-2½II2-3III3-4IV4-3V in *W. leptodactyla*), dorsal skin warty (vs. smooth in *W. diplosticta* and *W. leptodactyla*).

Description of Lectotype BMNH 1947.2.3.8 (Image 8), male (all measurements in mm): Medium-sized frog (SUL 32.3); head longer than wide (HL 13.2 > HW 12.6);

snout longer than horizontal diameter of eye (SL 5.5 > EL 3.7); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils almost equidistant from snout and eye (SNL 2.9 ≈ ENL 2.8); tympanum indistinct, covered with skin, about 60% of the diameter of eye (TYL = 2.2), separated from eye with a distance about half of the TYL; supra-tympanic fold distinct; UEW three-fourth of EL (UEW = 2.8); upper eyelids densely tuberculated; IOL less than INL (IOL 3.3 < INL 4.1); canthus rostralis indistinct; loreal region slightly concave and oblique; buccal cavity narrow, deep, vomerine teeth in slightly oblique rows at the posterior border of choanae; tongue thin, bifid; bear a mid ventral papilla.

Upper arm shorter than forearm (UAL 6.8 < FoAL 7.3); hand longer than forearm length (PAL 7.7); finger lengths from shortest to longest – F1 (2.6) < F2 (2.7) < F4 (3.3) < F3 (4.3); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate, supernumerary tubercles present, single; finger discs moderate in size, about 1.5 times the width of finger (F3D = 0.7, F3W = 1.0), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 16.8 < TL 20.9); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 24.1); toe lengths from shortest to longest are – T1 (2.0) < T2 (3.4) < T5 (4.6) < T3 (5.4) < T4 (8.9); toe discs equal to finger discs, its diameter slightly less than twice the width of finger (T4D = 1.0, T4W = 0.6); bear semicircular groove; inner metatarsal tubercle thin and elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate; tarsal fold and outer phalangeal fringe absent; webbing formula I2-2½II2-3III3-4IV4-2½V.

Dorsal skin warty; few longitudinal folds on dorsal side; W shaped skin fold on the posterior side of head; lateral side granular; ventral side smooth.

Coloration: In alcohol preservation, dorsal brown with few scattered dark brown spots; dark band between the two upper eyelids; upper and lower mandible barred with brown stripes; indistinct narrow dark brown stripe running from tip of snout to shoulder through eye and tympanum; forelimbs and hindlimbs barred with dark brown stripes; sole and foot dark brown; ventrally cream.

Variation: Morphometric variation is provided in Table 7. Live coloration as in Image 9. Ventrally sometimes dotted with whitish W-shaped fold sometimes dark brown.

Distribution: We recorded the species from Anamalai (10.354°N & 76.815°E, elevation 928m; Fig. 10). Other

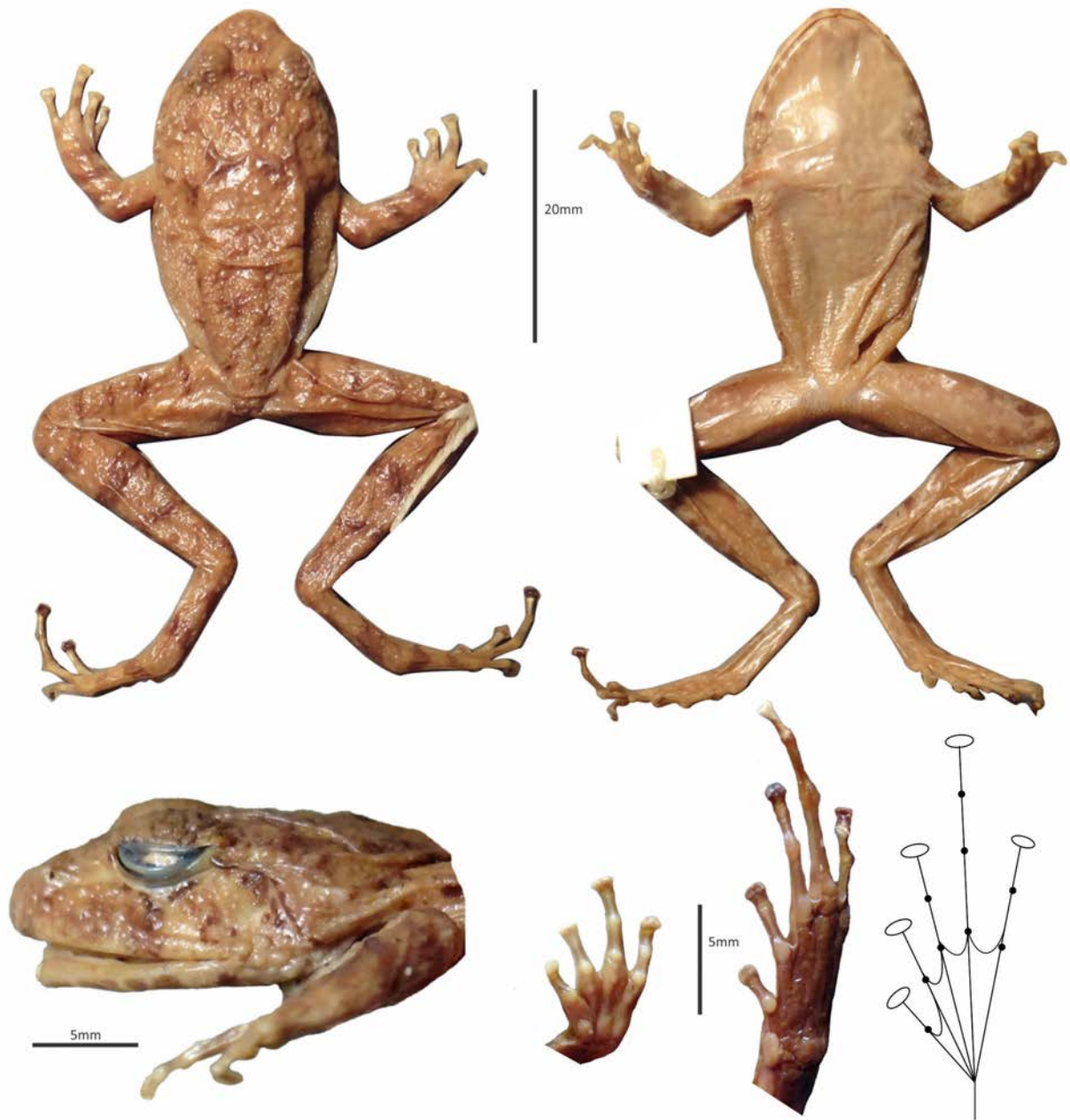


Image 8. *Walkerana phrynoderma* comb. nov. lectotype BMNH 1947.2.3.8 (male, 32.3mm SUL) from Anamallays (= Anamalai). © Nikhil Modak



Image 9. *Walkerana phrynoderma* comb. nov. in life from (a) Munnar (specimen not collected) and (b) Anamalai (WILD-14-AMP-509, 12.2mm SUL).

records from Anamalais are by Thurston (1888), Boulenger (1890), Boulenger (1920), Chanda & Deuti (1997), Biju (2001), Chanda (2002), and Dinesh et al. (2009). Padhye & Ghate (2012) suggested a need for genetic confirmation of previous records (Padhye & Ghate 2002; Padhye et al. 2002) of this species from Mulshi (approx. 18.440°N & 73.466°E), Maharashtra. During the current study, we collected specimens from same locality (i.e. Mulshi) and we confirm that they were misidentifications of *Indirana leithii*.

***Indirana* Laurent, 1986**

Ranixalus Dubois, 1986: p. 114

Type species: *Polypedates beddomii* Günther, 1876, by original designation.

Diagnosis: *Indirana* forms a genetically distinct clade within the family Ranixalidae and differs from its sister taxon *Walkerana* in having more extensive webbing with no phalange free on first and second toe (vs. one) and 2–2½ phalanges free on fourth toe (vs. three). Further, *Indirana* differs from *Walkerana* in consistently having first finger equal to or longer than second, except *I. leithii* (vs. shorter than second).

Species recognized: *Indirana beddomii* (Günther, 1876); *I. brachytarsus* (Günther, 1876); *I. chiravasi* Padhye et al., 2014; *I. duboisi* sp. nov.; *I. gundia* (Dubois, 1986); *I. leithii* (Boulenger, 1888); *I. salelkari* Modak et al., 2015; *I. sarojamma* sp. nov.; *I. semipalmata* (Boulenger, 1882); *I. tysoni* sp. nov.; *I. yadera* sp. nov.

Incertae sedis: '*Indirana*' *tenuilingua* (Rao, 1937)

There are no known surviving types of *I. tenuilingua* as they have been considered lost by Dubois (1984). The original description of *I. tenuilingua* is not adequate to diagnose it from other known species in *Indirana*, further; there are several discrepancies in the description, morphometry and the illustration. For instance, in the original description, Rao (1937) mentions head wider than long; however, the figure provided by Rao (1937) suggests that head should be longer than wide. Further, Rao (1937) mentions inter-orbital distance more than twice the internarial distance; however the measurement data provided by the author does not reflect this. From the type locality mentioned by Rao (1937) as Kemppholey ghats, we could only collect *I. gundia* despite extensive and repeated surveys for three consecutive years (2013–2016). Due to lack of comparative type material for phylogenetic analysis and unavailability of similar specimens from the type locality and discrepancies between the description, morphometry table and figure

in the original publication, we consider *I. tenuilingua* incertae sedis under the genus *Indirana* as the correct generic status cannot be ascertained.

Distribution: The genus *Indirana* is endemic to the Western Ghats of India distributed from 8°N to 21°N latitudes (Fig. 11). Records of this genus from the Eastern Ghats (Srinivasulu et al. 2007; Srinivasulu & Das 2008) and from Madhya Pradesh (Inger & Dutta 1986) need genetic confirmation and are disregarded until further information is available (see Modak et al. 2014).

Groups: We identify three morphological groups, namely the '*leithii* group' (includes only *I. leithii*), the '*semipalmata* group' (includes species *I. semipalmata* and *I. tysoni* sp. nov.) and the '*beddomii* group' (includes species *I. beddomii*, *I. brachytarsus*, *I. chiravasi*, *I. duboisi* sp. nov., *I. gundia*, *I. salelkari*, *I. sarojamma* sp. nov., and *I. yadera* sp. nov.).

Remarks: Although we provide a key to separate the species of the *beddomii* group, it is essential to note that some of these characters are subjective. Nevertheless, the species of the *beddomii* group are well separated in both genetic and multivariate morphometric analyses. A more reliable method to diagnose the species within the *beddomii* group is the use of an integrated approach with separation based on morphological, genetic and geographic distribution information. Western Ghats mountain ranges have three geographical gaps (see Robin et al. 2010; Van Bocxlaer et al. 2012): the Goa gap, the Palghat gap and the Shencottah gap (see Fig. 1). From the *beddomii* group, *Indirana chiravasi* and *I. salelkari* are distributed north of the Goa gap (Fig. 11a); *I. beddomii*, *I. gundia* and *I. duboisi* sp. nov. are distributed between the Goa and Palghat gaps (Figure 11b); and *I. brachytarsus*, *I. sarojamma* sp. nov. and *I. yadera* sp. nov. are distributed south of the Palghat gap (Fig. 11c). Taxonomically informative sites that can be used in combination for identification of species based on 16S rRNA gene sequence are provided in Table 8. Based on these data, we provide an alternate key for the separation of species in the *beddomii* group.

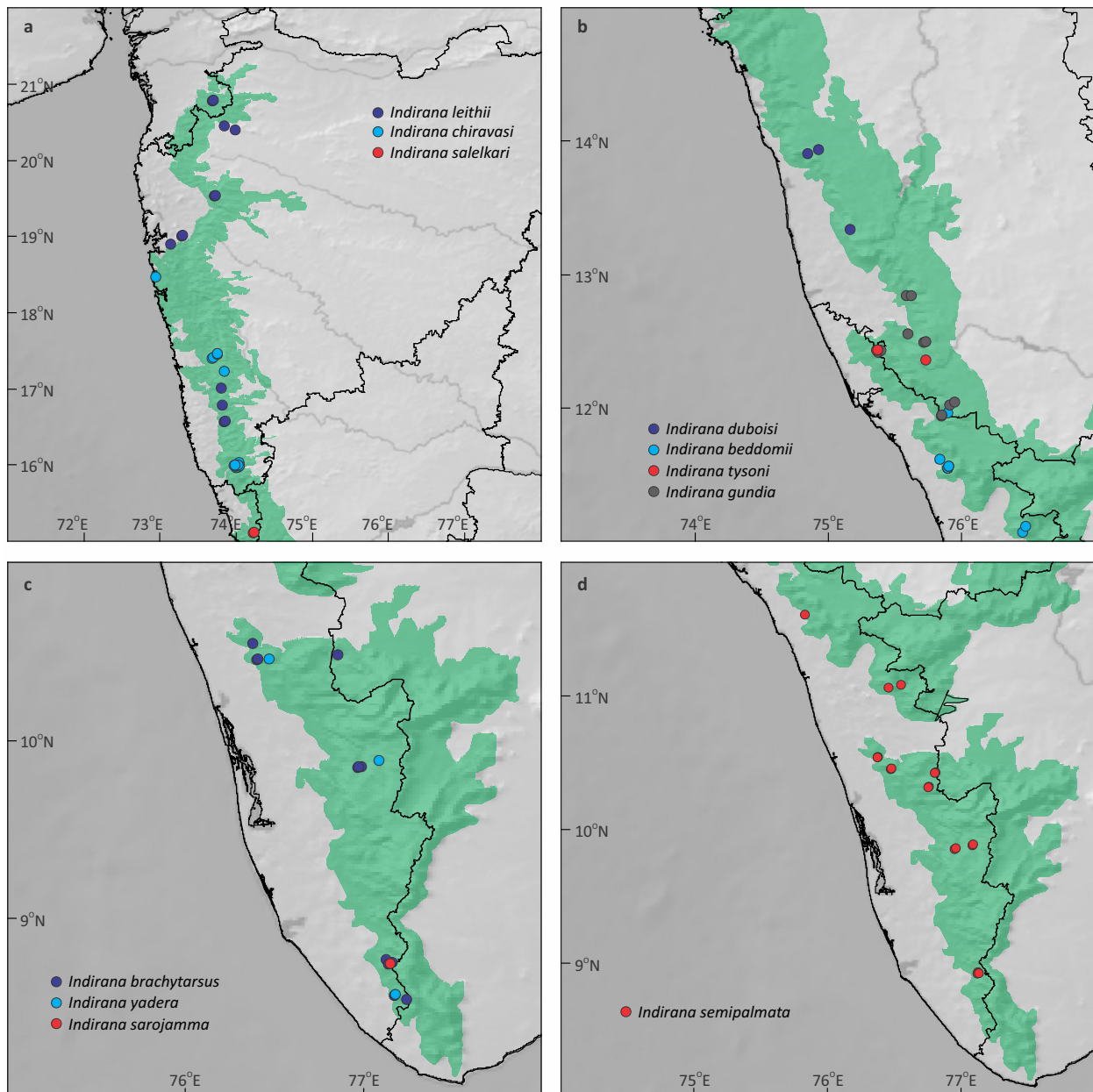


Figure 11. Distribution of species under *Indirana* examined in the current study. Species (a) distributed north of Goa gap, (b) distributed between the Palghat and Goa gaps, (c) distributed south of the Palghat gap, and (e) distribution of *I. semipalmata* found both north and south of the Palghat gap.

SPECIES ACCOUNTS

leithii group

Indirana leithii (Boulenger, 1888)

(Images 10–12)

Rana leithii Boulenger, 1888: 506

Rana (Discodeles) leithii — Boulenger (1918: 238)

Ranixalus leithii — Dubois (1987a: 69).

Common name: Matheran Leaping Frog

Type Locality: Matheran, Bombay (= Mumbai), India.

Material examined: Holotype: BMNH 1869.8.28.50 (female), India: Maharashtra: Matheran, coll. Leith (only photographs examined, Image 10).

Comparative: WILD-15-AMP-525 (female), India: Maharashtra: Karnala, Mumbai Highway (18.878°N & 73.11°E, elevation 25m), coll. K. Krutha, U. Katwate

Key to groups

- 1a First finger including metacarpal shorter than second, single outer palmar tubercle *leithii* group
 1b First finger including metacarpal equal to or longer than second, double outer palmar tubercle 2
- 2a Reduced webbing with at least ½ phalange free on 3rd and 5th toe and 2¼ phalanges free on 4th toe *semipalmata* group
 2b Extensive webbing with no phalange free on 3rd and 5th toe and not more than two phalanges free on 4th toe
 *beddomii* group

Key to species

- 1a First finger including metacarpal shorter than second, single outer palmar tubercle *I. leithii*
 1b First finger including metacarpal equal to or longer than second, double outer palmar tubercle 2
- 2a Reduced webbing with at least ½ phalange free on 3rd and 5th toe and 2¼ phalanges free on 4th toe 3
 2b Extensive webbing 4
- 3a Tympanum diameter >50% of eye diameter *I. semipalmata*
 3b Tympanum diameter <50% of eye diameter *I. tysoni* sp. nov.
- 4a 1½ phalanges free on inner side of third toe, loreal region more oblique resulting into the protruding appearance of tympanum in the dorsal view *I. gundia*
 4b 1 phalange free on inner side of third toe 5
 4c 1¼ phalange free on inner side of third toe 6
 4d 1¾ phalange free on inner side of third toe 8
- 5a Heels just overlap when thighs are held at right angles to body axis, loreal region more oblique *I. beddomii*
 5b Heels strongly overlap when thighs are held at right angles to body axis, loreal region less oblique *I. duboisi* sp. nov.
- 6a Buccal cavity deep, 26.3–30.5% HL *I. salelkari*
 6b Buccal cavity shallow, 8.4–19.2% HL 7
- 7a Heels just overlap when thighs are held at right angles to body axis *I. chiravasi*
 7b Heels strongly overlap when thighs are held at right angles to body axis *I. brachytarsus*
- 8a Buccal cavity deeper 18.2% HL, vomerine teeth series length 9.0% HL and vomerine teeth series separated by larger distance from each other 9.1% HL *I. sarojamma* sp. nov.
 8b Buccal cavity shallow 13.3–16.3% HL, vomerine teeth series length 10.0–12.8% HL and vomerine teeth series separated by smaller distance from each other 5.7–6.7% HL *I. yadera* sp. nov.

Alternate key for separation of species of *beddomii* group

- 4a Unique character position 946: T, 980: A, 1154: T; distributed between the Palghat and Goa gaps *I. beddomii*
 4b Unique character position 942: G, 952: A, 959: C, 960: T, 973: C, 978: G, 980: G, 1055: T, 1057: C; south of the Palghat gap
 *I. brachytarsus*
 4c Unique character position 898: C, 950: G, 1151: C; distributed north of the Goa gap *I. chiravasi*
 4d Unique character position 1057: T, 1161: C; distributed between the Palghat and Goa gaps *I. duboisi* sp. nov.
 4e Character combination 838: T & 873: C, 890: G & 893: T, 1067: T & 1079: G; distributed between the Palghat and Goa gaps
 *I. gundia*
 4f Unique character position 935: T, 985: A, 1023: G, 1089: C, 1092: C; distributed north of the Goa gap *I. salelkari*
 4g Unique character position 926: C, Character combination 960: C & 970: T & 971: G, 981: G & 982: A, 1173: G & 1230: T; south of the Palghat gap *I. sarojamma* sp. nov.
 4h Unique character position 894: T, 897: A, 956: G, 982: C, 1084: T, 1112: T; distributed south of the Palghat gap
 *I. yadera* sp. nov.

& S. Gawas, 28.xi.2014; BNHS 5590 (female), India: Maharashtra: Matheran (18.989°N & 73.268°E, elevation 801m), coll. N. Modak, 30.ix.2012; BNHS 5589 (male), Matheran (18.989°N & 73.268°E, elevation 801m), coll. N. Modak & A. Bayani, 25.viii.2012; AGCZRL-Amphibia-549 (unsexed), India: Maharashtra: Jalvalya fort (20.374°N & 73.960°E, elevation 1221m), coll. N. Modak, 04.x.2014; AGCZRL-Amphibia-548 (unsexed), India: Maharashtra:

Achala fort (20.432°N & 73.814°E, elevation 1106m), coll. N. Modak, 03.x.2014; AGCZRL-Amphibia-552 and 555 (females), India: Gujrat: Ahwa Dang (20.764°N & 73.676°E, elevation 395m), coll. N. Modak, R. Mirza & Y. Vasaikar, 20.ix.2014; AGCZRL-Amphibia-112 & 113 (females), India: Maharashtra: Ratangad (19.509°N & 73.700°E, elevation 1101 m), coll. N. Modak and S. Thatte, 30.iii.2013; AGCZRL-Amphibia-194 & 195

Table 8. Taxonomically informative sites in 16S rRNA gene sequence of species belonging to *beddomii* group. Character numbers are relative to the alignment with complete 16S rRNA gene of *Fejervarya cancrivora* extracted from the complete mitochondrial sequence EU652694. Characters in dark blue cells are species specific.

Species	804	807	821	838	873	890	893	894	895	897	898	926	935	938	942	943	946	950	952	956	959	
<i>I. beddomii</i>	A	G	T	T	T	A	T	A	A	C	T	T	C	A	C	T	T	A	A	T	A	A
<i>I. brachytarsus</i>	A	G	C	T	T	A	T	A	A	C	T	T	C	A	G	T	A	A	A	A	A	C
<i>I. chiravasi</i>	T	A	C	C	C	G	A	A	T	C	C	T	C	G	C	T	G	G	G	C	A	A
<i>I. duboisi</i>	T	A	C	C	C	G	A	A	T	C	T	T	C	G	C	T	G	A	A	C	A	A
<i>I. gundia</i>	A	G	T	T	C	G	T	A	T	C	T	T	C	G	C	T	G	A	A	C	A	A
<i>I. salelkari</i>	T	A	C	C	C	G	A	A	T	C	T	T	T	G	C	T	G	A	C	A	A	A
<i>I. sarajamma</i>	A	G	T	T	T	A	T	A	A	C	T	C	C	G	C	C	A	A	A	T	A	A
<i>I. yadera</i>	A	G	T	T	T	A	A	T	A	A	T	T	C	G	C	C	A	A	T	G	A	A

Table 8: contd....

Species	960	970	971	972	973	974	977	978	979	980	981	982	983	985	1016	1018	1021	1023	1051	1053	1055
<i>I. beddomii</i>	C	C	G	A	G	A	C	T	G	A	A	A	T	G	C	A	T	A	T	T	C
<i>I. brachytarsus</i>	T	T	G	A	C	A	T	G	G	-	A	A	C	G	T	A	T	A	T	T	T
<i>I. chiravasi</i>	C	T	T	G	A	G	C	T	G	T	A	A	T	G	T	G	A	A	A	A	C
<i>I. duboisi</i>	C	T	T	G	A	G	C	T	G	T	A	A	T	G	C	G	A	A	A	A	C
<i>I. gundia</i>	C	T	T	G	A	G	C	T	G	T	A	A	T	G	T	A	T	A	A	A	C
<i>I. salelkari</i>	C	T	T	G	A	G	C	T	G	T	A	A	T	A	C	G	A	G	A	T	C
<i>I. sarajamma</i>	C	T	G	A	G	A	T	T	A	T	G	A	C	G	C	G	T	A	T	C	C
<i>I. yadera</i>	C	C	G	A	G	A	T	T	A	T	G	C	T	G	T	G	T	A	T	C	C

Table 8: contd....

Species	1056	1057	1060	1066	1067	1079	1082	1084	1089	1092	1103	1112	1117	1151	1154	1155	1161	1173	1230		
<i>I. beddomii</i>	A	A	A	A	C	G	T	C	T	T	C	C	G	T	T	G	T	A	A	A	
<i>I. brachytarsus</i>	A	C	G	G	C	G	C	C	T	T	T	C	A	T	C	A	T	A	A	A	
<i>I. chiravasi</i>	A	A	G	A	C	A	C	C	T	T	C	C	A	C	C	A	T	G	A	A	
<i>I. duboisi</i>	A	T	A	G	T	A	C	C	T	T	T	C	G	T	C	A	C	A	A	A	
<i>I. gundia</i>	A	A	A	A	T	G	C	C	T	T	C	C	G	T	C	G	T	A	A	A	
<i>I. salelkari</i>	A	A	A	G	T	A	C	C	C	C	C	C	A	T	C	A	T	A	A	A	
<i>I. sarajamma</i>	G	A	A	A	T	A	T	C	T	T	C	C	G	T	C	A	T	G	T	T	
<i>I. yadera</i>	G	A	A	G	T	A	T	T	T	T	C	T	G	T	C	G	T	A	A	T	T



Image 10. *Indirana leithii* holotype BMNH 1869.8.28.50 (female, 33.0mm SUL) from Matheran. © Jefferey Streicher

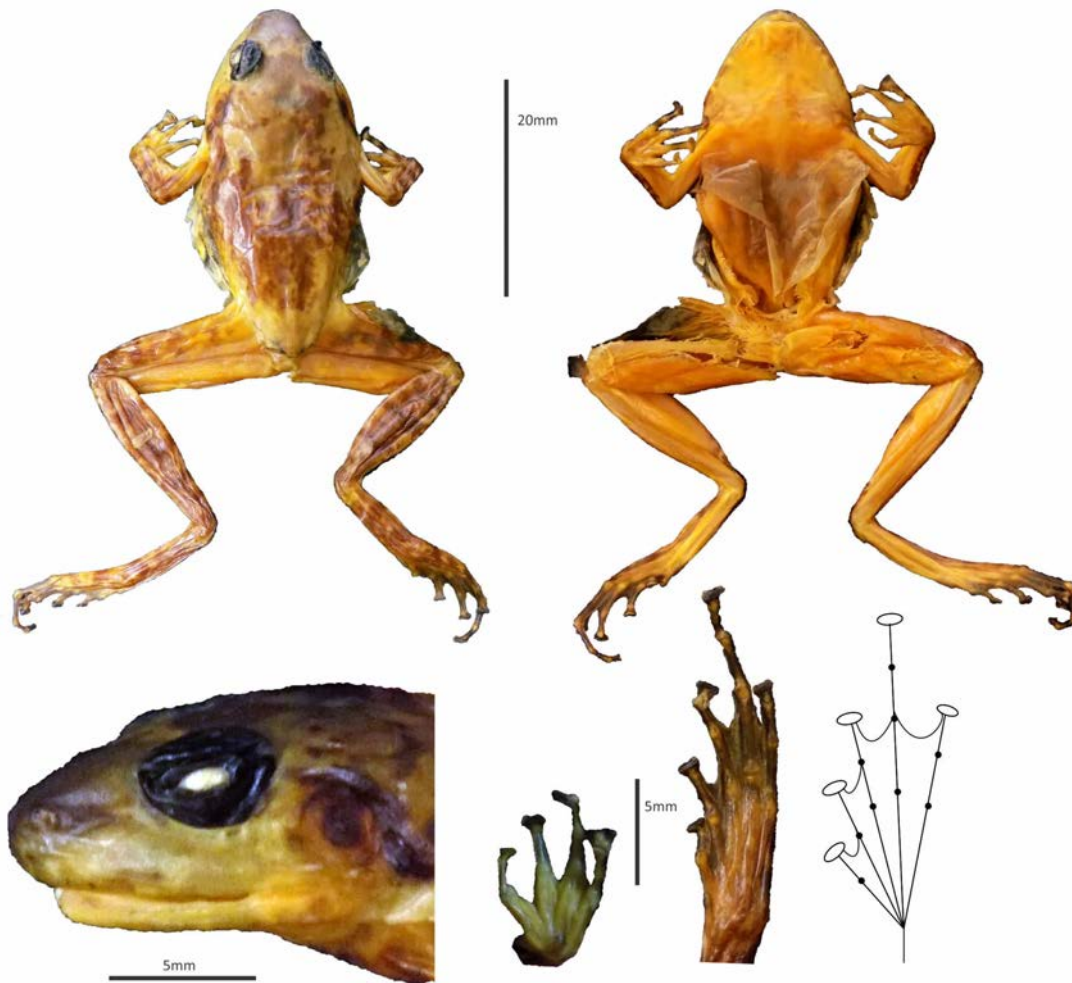


Image 11. *Indirana leithii* topotype (BNHS 5590, female, 33.4mm SUL) from Matheran. © Nikhil Modak

(unsexed), India: Maharashtra: Gaganbawda (16.550°N & 73.831°E, elevation 609m), coll. N. Modak & A.D. Padhye, 20.ix.2013; AGCZRL-Amphibia-193 (unsexed), India: Maharashtra: Anuskura ghat (16.761°N & 73.795°E, elevation 597m), coll. N. Modak & A.D. Padhye, 20.ix.2013; AGCZRL-Amphibia-192 (unsexed), India: Maharashtra: Amba Ghat (16.982°N & 73.781°E, elevation 608m), coll. N. Modak & A.D. Padhye, 22.ix.2013.

Diagnosis: *Indirana leithii* can be diagnosed from all other members of the genus *Indirana* based on following combination of characters: (i) first finger shorter than second, (ii) single outer palmar tubercle, (iii) webbing extensive with webbing formula I1-2II1-2III1-3IV3-1V, (4) TYL > 50% of EL. Geographically, the species is restricted to the Western Ghats in the States of Maharashtra and Gujarat.

Description of Holotype BMNH 1869.8.28.50 (Image 10), female: Description is provided in Boulenger (1888). We could only examine photograph of the specimen (see Remarks below) and therefore detailed description is not possible. Since the original description is not in detail for comparison of the species with its congeners, we provide description of topotypic female (BNHS 5590, Image 11), which is of comparable size to the holotype.

Description of Topotype BNHS 5590 (Image 11), female (all measurements in mm): Medium-sized frog (SUL 33.4); head longer than wide (HL 13.3 > HW 12.7); snout longer than horizontal diameter of eye (SL 5.5 > EL 3.8); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils closer to snout than to eye (SNL 1.8 < ENL 3.0); tympanum distinct, more than $\frac{3}{4}$ of ED (TYL = 3.0), separated from eye with a distance about $\frac{2}{3}$ of TYL; supratympanic fold distinct; UEW slightly less than half of EL (UEW = 1.8); upper eyelids sparsely tuberculated; IOL more than IND (IOL 4.0 > INL 3.3); canthus rostralis distinct; loreal region slightly concave and oblique; buccal cavity wide, slightly deep, vomerine teeth in slightly oblique rows positioned at the anterior margin of choanae; tongue thin, bifid; bear a mid-ventral papilla.

Upper arm smaller than forearm (UAL 5.3 < FoAL 6.5); hand longer than forearm (PAL 8.8); fingers from shortest to longest – F1 (2.2) < F2 (2.8) < F4 (4.3) < F3 (4.6); palmar tubercles present, outer palmar tubercle single, subarticular tubercles moderate to large, supernumerary tubercles present, single; finger discs moderate in size, more than twice the width of finger (F3D = 1.3, F3W = 0.6), broad, truncate, bearing semicircular groove; fingers without web or fringe of



Image 12. *Indirana leithii* from Matheran (BNHS 5590, female, 33.4mm SUL) in life.

skin.

Thigh shorter than shank (tibia) (THL 18.2 < TL 19.2); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 25.9); toe lengths from shortest to longest are – T1 (2.2) < T2 (2.8) < T5 (5.5) < T3 (5.7) < T4 (9.8); toe discs slightly smaller than finger discs, its diameter twice the width of toe (T4D = 1.2, T4W = 0.6); bear semicircular groove; inner metatarsal tubercle thin, elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate to large; tarsal fold and outer phalangeal fringe absent; webbing formula I1-2II1-2III1-3IV3-1V.

Dorsal skin smooth with dense glandular longitudinal folds arranged in irregular rows; lateral side granular with sparse granulation below the tympanum; ventral side smooth; glandular W-shaped mark at the posterior margin of head.

Coloration: In life (Image 12a), dorsal uniform pinkish-brown; dark band between upper eyelids; upper and lower mandible barred with brown stripes; distinct dark brown stripe running from tip of snout to shoulder through eye and tympanum; forelimbs and hindlimbs barred with brown stripes; sole and foot dark brown; ventrally cream to light brown. In preservation, color as above but faded.

Variation: Morphometric variation is provided in Table 9 and 10. Coloration in life varies as in Image 12. Dorsum coloration ranges from golden brown to dark brown. Darker brown spots and W-shaped mark on dorsum sometimes absent. Throat sometimes mottled with brown.

Distribution: The species is distributed in the

northern Western Ghats between 16°N to 21°N latitudes (Fig. 11a, and Fig. 6 in Modak et al. 2014).

Remarks: We could not examine the type of the species during a visit to BMNH as the specimen was misplaced; however, the specimen was traced later and photographs of the same have been examined.

semipalmata group

Indirana semipalmata (Boulenger, 1882)

(Images 13–14)

Rana semipalmata Boulenger, 1882: 56

Rana (Discodeles) semipalmata — Boulenger (1918: 238)

Indirana semipalmata — Laurent (1986: 761)

Ranixalus semipalmatus — Dubois (1987a: 69)

Common name: Half-webbed Leaping Frog

Type locality: Malabar, India

Putative type locality: Painavu, Idukki Wildlife Sanctuary (10.308°N & 76.742°E, elevation 803m), Kerala, India.

Material examined: Lectotype: BMNH 1947.2.29.50 (female), India: Malabar, coll. Col. R.C. Beddome

Paralectotype: BMNH 1947.2.29.51 (male) same data as lectotype.

Comparative: WILD-15-AMP-610, 611, 637 & 638 (females), India: Tamil Nadu: Sholayar (10.308°N & 76.742°E, elevation 722m), coll. S. Sulakhe, 25.xii.2014; WILD-14-AMP-419 (female), India: Kerala: Peruvannamuzhi, Malabar Wildlife Sanctuary (11.599°N

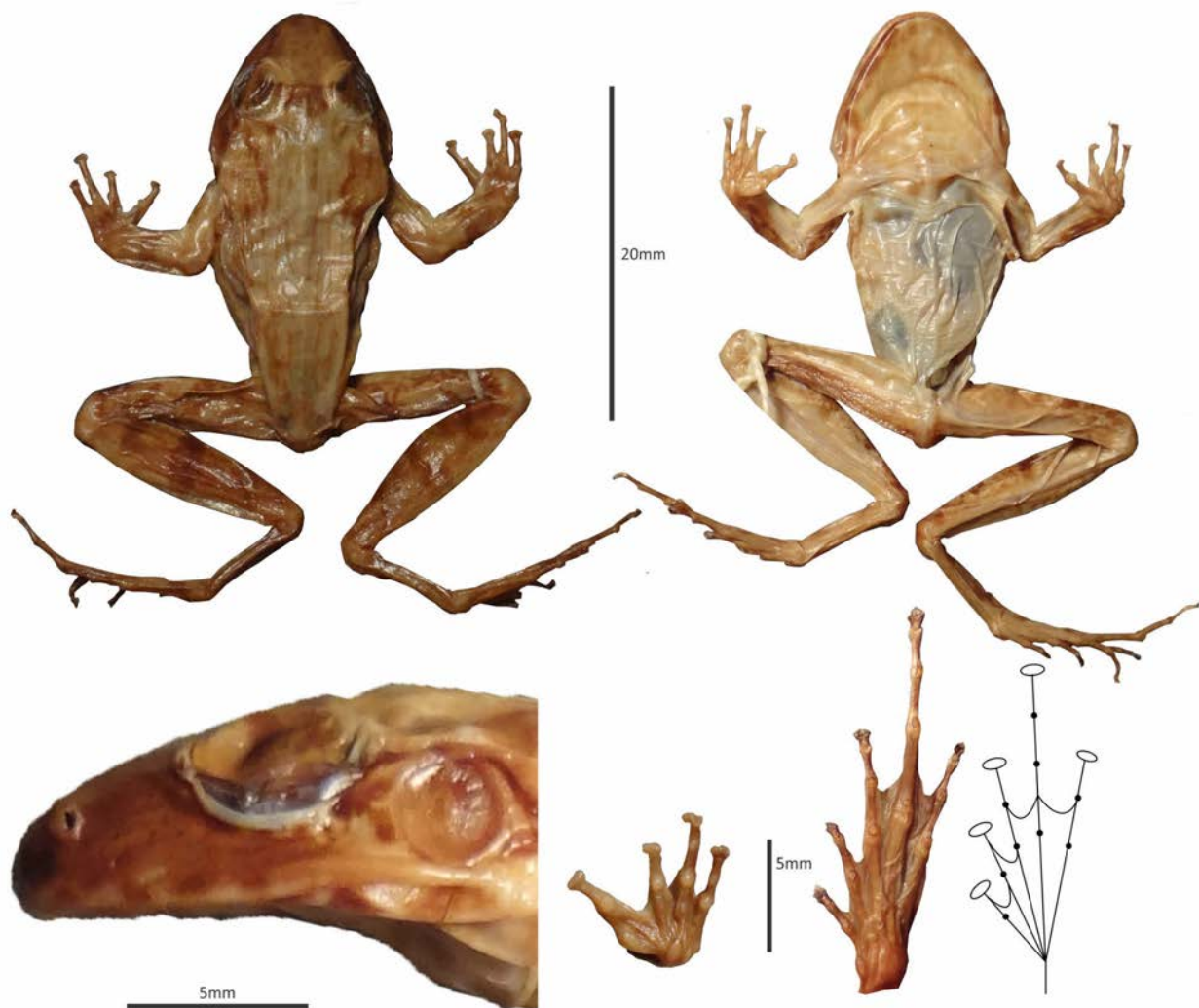


Image 13. *Indirana semipalmata* lectotype (BMNH 1947.2.29.50, female, 33.5mm SUL) from Malabar. © Nikhil Modak

Table 9. Raw morphometric data (mm) for species under *Indirana* for first 16 characters. Abbreviations: F, female; M, male; H, holotype; P, paratype; L, lectotype; PL, paralectotype; *, used for genetic analysis. Character abbreviations as per Materials and methods.

Species/Locality	Voucher (gender)[type status]	SUL	HL	HW	SL	EL	TYL	UEW	SNL	ENL	INL	IOD	UAL	FoAL	PAL	F1	F2
<i>Indirana beddomii</i>																	
Malabar	NHM 1947.2.27.72 (F)[L]	53.9	21.6	19.5	9.5	5.6	4.1	3.2	3.0	4.9	5.2	5.8	7.3	13.1	14.6	6.5	5.1
Malabar	NHM 1947.2.27.82 (F)[PL]	39.2	14.6	12.9	6.9	4.1	3.2	3.1	3.1	3.9	3.7	4.4	7.7	7.9	9.5	3.5	3.4
Malabar	NHM 1947.2.27.85 (F)[PL]	25.4	11.0	8.9	4.6	4.0	2.4	1.9	1.4	2.7	2.5	3.0	4.9	5.7	6.4	2.0	2.4
Peruvannamuzhi	WILD-14-AMP-411 (F)*	32.0	12.6	10.9	5.6	3.2	2.2	2.8	1.8	3.2	3.1	3.0	7.2	7.7	7.7	2.6	2.6
Peruvannamuzhi	WILD-14-AMP-412 (F)	32.9	12.9	11.8	5.4	3.9	2.6	2.8	1.6	3.4	3.1	3.5	6.2	7.0	8.3	2.4	2.9
Peruvannamuzhi	WILD-14-AMP-414 (F)*	39.8	15.8	14.6	6.5	4.6	3.0	3.1	2.0	3.8	3.9	4.1	8.0	9.7	10.4	3.4	3.2
Peruvannamuzhi	WILD-14-AMP-417 (F)	35.5	13.9	13.0	5.5	3.9	3.0	2.4	1.8	3.4	3.3	3.1	7.8	7.8	8.6	2.3	2.6
Peruvannamuzhi	WILD-14-AMP-418 (F)	25.6	10.9	9.2	4.3	3.1	1.8	2.2	1.6	2.3	2.5	2.5	4.8	6.3	6.9	2.0	2.2
Peruvannamuzhi	WILD-14-AMP-420 (F)*	37.5	16.6	13.1	6.2	5.1	3.5	2.7	1.8	3.8	3.7	3.9	8.4	7.4	9.9	2.7	3.4
Kunthipuzha	WILD-14-AMP-421 (F)*	25.1	11.0	8.8	3.9	3.0	1.9	1.9	1.8	2.3	2.5	2.9	4.4	6.0	6.4	1.7	1.8
Aralam WS	WILD-13-AMP-138 (F)*	36.9	14.9	12.7	6.1	4.0	2.6	2.9	2.5	3.9	3.9	3.4	6.7	8.6	9.1	3.0	2.8
Kakkayam	WILD-14-AMP-415 (F)	27.9	11.6	10.3	4.9	3.5	2.2	1.3	1.3	2.7	2.6	2.8	4.9	5.3	7.1	2.2	2.1
Malabar	NHM 1947.2.27.83 (M)[PL]	24.7	10.0	8.6	4.4	3.8	2.6	2.3	2.1	2.6	2.7	2.6	4.7	6.0	6.5	2.2	2.3
Sairandhri	WILD-14-AMP-409 (M)*	24.1	10.0	9.1	4.2	3.3	1.9	1.9	1.3	2.3	2.7	2.5	5.6	5.5	6.5	1.9	2.0
Kakkayam	WILD-14-AMP-413 (M)*	29.7	12.5	10.9	4.7	4.1	2.5	1.9	1.9	3.1	3.5	2.7	7.1	6.8	8.0	2.3	2.4
<i>Indirana brachytarsus</i>																	
Anamallays (=Anamalais)	NHM 1947.2.27.92 (F)[L]	36.4	15.4	12.6	6.0	4.6	3.4	3.2	2.1	3.8	3.2	4.0	5.9	7.6	8.2	2.7	2.7
Sevagherry (=Sivagiri)	NHM 1947.2.2.85 (F)[PL]	52.4	20.4	17.3	10.0	5.0	4.2	3.4	3.5	5.5	4.7	5.3	8.4	11.3	13.0	4.5	4.4
Sevagherry (=Sivagiri)	NHM 1947.2.4.86 (F)[PL]	44.8	16.0	14.3	7.3	6.2	3.1	3.8	4.0	4.2	4.7	4.1	8.7	9.9	12.7	4.3	4.3
Sevagherry (=Sivagiri)	NHM 1947.2.4.87 (F)[PL]	39.6	14.9	12.4	6.6	4.3	3.0	2.8	2.5	4.2	3.7	3.5	6.7	8.1	10.3	3.3	3.3
Anamalai	NHM 1947.2.27.89 (F)[PL]	42.6	16.3	14.2	7.6	4.7	3.3	3.3	3.6	4.0	4.2	3.7	7.9	9.3	10.4	4.3	4.5
Anamalai	NHM 1947.2.27.90 (F)[PL]	35.8	14.3	12.6	6.3	4.2	3.2	3.1	2.5	3.7	3.9	3.2	7.5	8.8	9.7	3.8	3.5
Anamalai	NHM 1947.2.27.91 (F)[PL]	32.0	14.4	11.3	5.5	4.2	3.2	2.5	2.0	3.6	3.7	3.1	6.4	7.1	8.2	3.3	2.9
Neyyar	WILD-13-AMP-234 (F)*	29.3	12.3	10.8	5.0	3.3	2.2	1.9	2.1	3.0	3.0	3.1	5.7	6.3	7.5	2.1	2.5
Ponmudi	WILD-13-AMP-301 (F)*	27.6	11.5	9.4	4.9	3.0	2.0	2.0	1.9	2.9	2.8	2.6	5.3	5.8	6.9	2.3	2.2
Painavu/Idukki	WILD-14-AMP-358 (F)*	26.7	10.6	8.7	5.0	3.0	2.0	2.0	1.9	2.3	2.6	2.3	5.4	5.2	6.7	2.3	2.2
Vellakkamaly/Idukki	WILD-14-AMP-437 (F)*	29.1	12.0	10.2	5.5	4.2	2.3	2.2	2.0	2.9	3.4	2.5	6.5	6.8	7.6	2.6	2.5
Vellakkamaly/Idukki	WILD-14-AMP-441 (F)	29.5	11.9	9.9	5.0	3.2	2.4	2.1	2.2	3.0	3.0	2.5	5.3	6.1	7.4	2.3	2.2
Chimmony	WILD-14-AMP-475 (F)*	24.0	9.8	8.2	4.3	2.9	2.0	1.8	1.7	2.4	2.6	2.3	5.6	5.2	5.7	2.3	2.2
Topslip	WILD-15-AMP-609 (F)*	24.6	10.9	9.1	4.9	3.1	1.9	2.0	2.2	2.7	2.8	2.7	5.5	5.5	6.8	2.4	2.2
Ponmudi	WILD-13-AMP-241 (F)*	27.5	11.6	9.3	5.3	2.8	2.3	2.1	1.8	3.0	2.9	3.4	6.6	6.0	7.7	2.5	2.2
Neyyar	WILD-13-AMP-247 (F)*	20.7	8.2	7.1	3.4	2.2	1.7	1.5	1.2	1.7	2.2	2.2	4.4	4.5	4.9	1.5	1.5
Ponmudi	WILD-13-AMP-285 (F)*	29.1	11.3	11.0	5.3	2.7	1.9	1.6	2.3	2.9	3.2	2.8	5.3	6.6	7.9	2.1	2.3
Ponmudi	WILD-13-AMP-293 (F)*	29.7	12.1	10.4	5.0	3.0	2.2	2.1	2.2	2.8	3.1	3.0	5.6	5.4	7.5	2.1	2.4
Painavu/Idukki	WILD-14-AMP-359 (F)*	32.7	12.3	11.3	6.3	3.7	2.2	2.2	2.4	3.2	3.4	3.4	6.6	7.0	8.7	2.8	2.6
Vellakkamaly	WILD-14-AMP-442 (F)*	24.6	11.5	9.1	4.1	2.5	2.1	1.9	1.6	2.1	2.6	3.1	4.7	5.5	6.6	2.0	1.9

Species/Locality	Voucher (gender)[type status]	SUL	HL	HW	SL	EL	TYL	UEW	SNL	ENL	INL	IOD	UAL	FoAL	PAL	F1	F2
Painavu	WILD-14-AMP-353 (F)	27.0	11.3	10.0	4.7	3.3	2.7	2.0	2.1	2.7	2.9	2.5	5.6	5.8	6.7	2.2	2.3
Sevagherry	NHM 1947.2.4.88 (M) [PL]	31.8	11.9	10.8	4.9	3.6	2.6	3.0	2.4	3.0	3.0	3.2	5.2	7.2	7.4	3.2	2.6
Chimmony	WILD-14-AMP-477 (M)*	19.6	8.2	7.1	3.6	2.6	1.6	1.6	1.6	2.1	2.2	1.9	4.3	4.3	4.5	1.4	1.5
Peechi-Vazhani	WILD-14-AMP-478 (M)*	20.5	8.7	7.1	3.2	2.0	1.6	1.3	1.3	1.7	2.3	2.9	4.2	4.1	4.5	1.2	1.4
<i>Indirana chiravasi</i>																	
Amboli	BNHS 5888 (M)[H]	27.3	11.4	9.8	4.8	3.7	2.8	2.0	2.0	2.7	2.6	2.6	5.3	6.0	6.6	2.4	1.9
Amboli	WILD-14-AMP-489 (M)[P]*	24.7	10.5	8.9	4.8	3.3	2.5	2.1	1.6	2.9	2.5	3.1	3.7	5.7	6.3	1.9	1.8
Amboli	BNHS 5890 (M)[P]*	25.0	10.8	9.0	4.7	3.1	2.3	1.8	1.7	2.7	2.0	2.9	3.3	5.4	6.7	1.9	1.9
Amboli	ZSI-WRC A/1541 (M)[P]	25.2	11.0	9.2	4.8	3.2	2.4	2.1	1.9	2.9	2.4	2.5	4.7	5.5	6.3	2.0	2.0
Amboli	WILD-14-AMP-491 (M)[P]	25.6	11.5	9.3	5.0	3.1	2.6	1.7	1.7	2.7	2.7	2.9	4.0	5.3	6.9	2.0	1.8
Amboli	WILD-14-AMP-490 (F)[P]	31.7	12.7	11.1	5.3	3.3	3.0	1.8	2.0	3.3	3.6	3.2	4.7	6.6	7.5	2.2	2.2
Amboli	BNHS 5889 (F)[P]	39.2	14.9	13.9	6.5	5.0	3.1	2.9	2.6	3.9	4.1	4.2	7.1	8.4	10.7	3.5	3.1
Phansad	WILD-15-AMP-528 (F)	24.8	10.6	9.5	4.2	3.2	2.2	2.2	1.5	2.5	2.8	2.5	5.3	5.0	6.9	2.4	2.4
Koyna	WILD-15-AMP-529 (F)	28.5	11.7	11.1	5.6	3.3	2.5	2.4	2.2	2.9	3.3	3.0	5.6	7.3	7.3	2.6	2.6
Koyna	WILD-15-AMP-530 (F)*	20.9	8.9	8.1	4.2	3.2	1.9	1.8	1.5	2.0	2.4	2.5	4.4	4.6	5.8	1.8	1.8
Chandoli	WILD-15-AMP-535 (F)	21.0	8.9	7.5	3.9	3.0	1.6	1.7	1.4	2.0	2.1	2.2	4.3	4.7	5.1	1.5	1.4
Koyna	WILD-15-AMP-544 (F)	25.7	10.6	9.4	4.6	3.4	2.3	1.9	1.7	2.5	2.4	2.8	4.4	5.7	6.7	2.1	2.1
Kitawade Plateau	WILD-15-AMP-612 (F)*	29.5	12.6	10.3	5.5	3.4	2.9	1.9	2.1	3.1	2.9	2.9	4.6	6.9	7.0	2.2	2.3
Nawja	WILD-15-AMP-613 (F)	30.3	13.3	11.9	6.3	4.3	2.8	2.7	2.5	3.2	3.4	3.4	5.7	7.1	8.4	2.9	2.6
<i>Indirana duboisi</i>																	
Kerekatte	BNHS 5980 (F)[H]*	30.3	12.9	11.0	6.1	3.8	3.0	2.5	2.5	4.0	3.3	3.3	5.7	6.6	7.9	3.3	2.8
Mookambika	WILD-15-AMP-631 (F)[P]*	25.3	11.0	9.5	4.6	3.2	2.2	2.0	2.0	2.5	2.7	2.8	5.3	5.7	6.3	1.7	1.7
Mookambika	WILD-15-AMP-630 (M)[P]*	22.7	9.5	8.3	4.1	3.2	1.8	1.9	1.8	2.3	2.7	2.9	4.6	5.4	5.8	1.5	1.3
<i>Indirana gundia</i>																	
Gundia, Inde	MNHN 1985.0633 (M)[H]	28.8	12.4	10.7	5.5	4.2	3.3	2.8	2.2	3.1	3.4	2.2	6.0	6.0	7.1	2.2	2.2
Gundia, Inde	MNHN 1985.0628 (M)[P]	25.5	10.7	9.0	4.7	3.8	3.4	2.3	2.2	2.5	3.1	2.4	5.6	5.5	5.7	1.8	1.9
Gundia, Inde	MNHN 1985.0596 (M) [P]	25.6	10.7	8.1	4.8	3.6	3.1	1.9	1.9	2.6	3.2	2.7	4.1	5.9	5.6	1.6	1.8
Gundia, Inde	MNHN 1985.0608 (M) [P]	25.1	11.2	9.2	4.5	3.6	2.9	2.3	1.9	2.5	2.7	2.9	4.6	5.2	5.6	1.8	1.8
Gundia, Inde	MNHN 1985.0605 (M) [P]	25.3	11.3	9.1	4.5	4.2	3.0	1.8	1.8	2.4	3.1	2.8	3.0	5.1	5.8	1.9	1.8
Gundia, Inde	MNHN 1985.0610 (M) [P]	23.6	9.9	7.8	4.2	3.5	2.9	1.9	1.9	2.5	2.5	2.4	4.6	5.4	5.6	1.8	1.8
Gundia, Inde	MNHN 1985.0603 (M) [P]	26.2	11.2	9.2	4.6	3.6	2.9	1.9	2.1	2.5	2.3	2.9	4.7	6.1	6.3	2.2	1.9
Gundia, Inde	MNHN 1985.0599 (M) [P]	26.5	11.5	9.6	4.6	3.7	3.2	2.1	2.1	2.4	2.9	2.7	4.6	5.9	5.8	1.9	1.9
Kutta	WILD-13-AMP-211 (M)*	16.1	8.0	7.1	3.2	2.2	1.2	1.5	1.0	2.0	1.4	2.0	3.3	3.9	4.1	1.3	1.4
Gundia	WILD-14-AMP-499 (M)*	26.8	11.6	10.1	5.1	4.1	3.1	2.1	2.0	3.0	3.3	3.0	5.1	5.6	6.4	2.0	1.7
Gundia, Inde	MNHN 1985.0622 (F) [P]	33.6	14.1	11.8	5.5	4.3	3.5	2.2	2.4	3.2	3.4	3.7	5.9	6.8	7.5	2.5	2.6
Gundia, Inde	MNHN 1985.0620 (F) [P]	31.9	12.6	10.8	4.9	4.3	3.5	2.3	2.4	3.0	2.8	2.8	5.7	6.7	7.7	2.9	2.4
Gundia, Inde	MNHN 1985.0617 (F) [P]	33.6	13.9	11.8	5.8	4.9	3.2	2.5	2.6	3.3	3.3	3.4	6.4	7.7	7.6	3.2	2.5
Gundia, Inde	MNHN 1985.0611 (F) [P]	34.3	14.1	11.8	5.8	4.4	2.8	2.6	2.4	3.1	3.1	3.5	6.5	7.9	8.1	2.7	2.8

Species/Locality	Voucher (gender)[type status]	SUL	HL	HW	SL	EL	TYL	UEW	SNL	ENL	INL	IOD	UAL	FoAL	PAL	F1	F2
Gundia, Inde	MNHN 1985.0618 (F) [P]	35.3	14.0	11.6	5.9	4.6	3.3	2.4	2.4	3.2	3.1	3.7	6.2	7.3	8.2	2.6	2.4
Gundia, Inde	MNHN 1985.0619 (F) [P]	30.5	12.6	11.3	5.3	3.9	2.6	2.5	2.1	3.3	3.3	3.2	5.1	6.6	7.4	2.5	2.3
Gundia, Inde	MNHN 1985.0637 (F) [P]	31.0	12.1	10.3	4.7	3.8	3.3	2.4	2.2	2.7	2.5	3.3	5.1	7.0	6.9	2.7	2.5
Gundia, Inde	MNHN 1985.0638 (F) [P]	32.0	13.1	11.5	5.2	4.4	3.1	2.8	2.3	3.1	3.0	3.2	5.8	6.5	6.6	2.3	2.2
Aralam WS	WILD-13-AMP-136 (F)*	25.3	11.4	9.3	5.1	3.4	2.9	1.8	2.1	3.1	2.7	3.0	5.2	5.2	6.0	1.8	1.8
Ranipuram	WILD-15-AMP-614 (F)*	18.5	7.7	6.2	3.9	2.9	1.6	1.6	1.3	1.9	2.1	2.4	2.9	3.8	4.3	1.5	1.4
Ranipuram	WILD-15-AMP-616 (F)*	17.6	7.6	6.7	3.4	3.0	1.7	1.7	1.6	1.7	2.3	2.1	4.0	3.5	4.7	1.2	1.5
Ranipuram	WILD-15-AMP-618 (F)*	19.0	8.6	6.7	3.1	2.7	1.6	1.6	1.4	2.0	2.2	2.6	3.2	4.0	4.4	1.5	1.4
Gundia	WILD-14-AMP-500 (F)*	36.4	14.8	13.3	6.6	5.0	3.5	2.9	2.9	4.1	4.2	4.0	7.1	8.3	9.2	3.1	3.0
Coorg	WILD-13-AMP-012 (F)	54.2	21.2	19.0	9.0	5.6	4.3	4.1	3.8	5.1	5.8	5.2	10.5	11.3	13.3	4.9	4.6
Coorg	WILD-13-AMP-013 (F)	32.9	13.5	11.4	5.5	4.4	2.7	2.6	2.6	2.8	3.2	3.0	7.0	6.4	8.1	2.5	2.5
Aralam WS	WILD-13-AMP-139 (F)*	27.1	13.2	10.9	4.8	3.8	2.7	2.3	1.9	2.7	2.6	2.9	4.7	5.5	5.8	1.9	1.9
Coorg	WILD-13-AMP-210 (F)*	35.3	14.5	13.1	6.0	4.0	3.0	2.7	2.5	3.8	3.9	3.9	7.0	7.6	8.6	2.9	2.7
Subramanya-Sullya	WILD-16-AMP-649(F)*	34.3	12.8	11.4	5.6	4.8	2.7	2.7	2.4	3.3	3.1	3.7	5.5	7.3	8.1	2.9	2.7
<i>Indirana leithii</i>																	
Matheran	BNHS 5590 (F)*	33.4	13.3	12.7	5.5	3.8	3.0	1.8	1.8	3.0	3.3	4.0	5.3	6.5	8.8	2.2	2.8
Karnala	WILD-15-AMP-525 (F)*	26.4	10.6	8.4	4.7	3.0	2.3	2.0	1.7	2.9	2.5	2.4	4.7	5.6	6.8	1.6	2.3
Matheran	BNHS 5589 (M)	25.2	10.3	8.1	4.1	3.1	2.1	1.9	1.7	2.6	2.8	2.8	4.6	5.0	6.2	1.8	2.3
Javalya fort	AGCZRL-Amphibia-221 (U)*	28.3	10.3	9.0	4.5	3.1	2.0	1.8	1.5	3.1	2.2	3.1	4.5	5.4	7.0	2.0	2.1
Achala fort	AGCZRL-Amphibia-222 (U)*	27.6	10.3	9.0	4.6	2.9	1.9	1.8	1.5	3.1	2.6	3.2	4.8	5.7	6.9	2.0	2.3
Ahwa Dang	AGCZRL-Amphibia-223 (U)*	26.6	10.5	8.5	4.6	3.2	2.3	2.0	1.5	3.4	2.0	2.7	4.2	5.8	6.7	2.1	2.5
Ahwa Dang	AGCZRL-Amphibia-224 (U)*	29.6	11.3	9.6	5.2	3.4	2.6	1.9	1.9	3.5	2.4	3.4	5.0	6.3	7.6	2.4	2.6
Ratangad	AGCZRL-Amphibia-112 (U)*	35.1	13.0	11.8	5.4	3.8	3.1	2.3	1.5	3.7	2.8	3.1	4.4	5.8	8.4	2.6	2.8
Ratangad	AGCZRL-Amphibia-113 (U)*	36.0	13.3	12.0	5.5	3.9	3.1	2.5	1.9	3.8	3.2	3.1	4.9	5.9	8.7	3.1	3.3
Gaganbawda	AGCZRL-Amphibia-194 (U)*	25.0	9.8	8.5	4.6	3.3	2.2	1.9	1.6	2.5	2.6	2.5	4.5	4.9	6.0	1.9	2.3
Gaganbawda	AGCZRL-Amphibia-195 (U)	19.6	8.8	7.1	3.9	2.9	1.6	1.8	1.1	2.4	2.0	2.1	3.6	4.0	5.0	1.1	1.5
Anuskura ghat	AGCZRL-Amphibia-193 (U)*	19.8	8.4	7.3	3.8	2.8	1.7	1.4	1.3	2.1	2.0	2.4	3.2	3.2	4.7	1.2	1.7
Amba ghat	AGCZRL-Amphibia-192 (U)*	21.6	9.1	7.5	3.6	2.7	1.5	2.2	1.3	2.9	2.0	2.0	3.8	4.0	4.9	1.7	1.9
<i>Indirana salelkari</i>																	
Netravali	BNHS 5931 (M)[H]*	27.7	11.6	9.5	4.8	3.4	2.7	2.5	2.0	2.5	2.6	2.6	5.0	5.7	6.0	2.1	1.6
Netravali	WILD-15-AMP-552 (M)[P]	24.7	10.7	9.1	4.6	3.0	2.7	2.4	2.1	2.6	2.1	2.9	6.1	6.2	6.6	2.0	1.9
Netravali	BNHS 5932 (M) [P]	26.2	11.6	9.5	5.0	3.1	2.8	2.7	1.8	2.5	2.6	2.7	5.8	5.6	6.9	2.1	1.9
Netravali	AGCZRL-Amphibia-209 (M) [P]	26.0	10.5	9.9	4.9	3.2	1.9	2.4	1.7	3.1	2.4	3.0	4.5	5.3	7.4	2.0	1.9
Netravali	ZSI-WRC A/1457 (F) [P]	30.0	12.7	11.2	5.3	3.7	2.8	2.8	2.1	2.9	3.0	3.0	6.4	6.6	8.3	2.5	2.1
Netravali	WILD-15-AMP-551 (F) [P]*	30.8	12.9	11.4	5.7	3.7	2.6	2.4	1.9	3.5	3.4	3.1	5.5	7.4	8.7	3.3	3.0
Netravali	AGCZRL-Amphibia-210 (F) [P]*	30.9	12.3	11.1	5.4	4.6	2.4	2.6	2.3	3.2	3.3	3.2	5.3	7.2	7.5	3.0	2.5
Netravali	BNHS 5933 (F) [P]	30.2	11.8	11.2	5.6	3.5	2.4	2.3	2.5	2.8	3.2	2.8	7.3	6.8	8.3	2.8	2.2

Species/Locality	Voucher (gender)[type status]	SUL	HL	HW	SL	EL	TYL	UEW	SNL	ENL	INL	IOD	UAL	FoAL	PAL	F1	F2
<i>Indirana sarojamma</i>																	
Ponmudi	BNHS 5981 (F)[H]*	34.5	14.3	12.9	6.3	3.2	2.9	2.5	2.0	3.6	3.4	3.9	7.9	8.8	9.3	3.0	2.8
Travancore	NHM 1947.2.27.87 (F)	33.0	13.5	11.3	6.3	3.9	2.9	3.1	2.4	3.8	3.0	3.2	7.1	7.2	8.8	3.3	3.2
Travancore	NHM 1947.2.27.88 (M)	31.0	12.9	10.6	5.4	4.2	2.7	2.8	2.5	3.1	3.0	2.5	5.9	6.6	8.0	3.2	2.9
<i>Indirana semipalmata</i>																	
Malabar	NHM 1947.2.29.50 (F)[L]	33.5	13.7	11.3	5.3	4.4	2.9	2.4	2.6	2.8	3.5	3.4	7.0	8.5	7.0	2.5	2.3
Sholayar	WILD-15-AMP-610 (F)*	25.4	11.3	9.5	4.8	3.7	2.3	2.0	1.9	2.6	2.6	2.7	4.9	6.4	6.8	2.4	2.4
Sholayar	WILD-15-AMP-611 (F)*	21.5	9.1	7.6	3.6	2.8	1.9	2.0	1.6	2.2	2.2	2.4	5.0	5.0	5.6	2.0	1.9
Peruvannamuzhi	WILD-14-AMP-419 (F)*	26.7	10.6	10.4	4.4	3.3	2.3	1.7	1.3	2.9	2.3	3.0	6.2	6.4	7.1	2.5	2.3
Kizhukanam	WILD-14-AMP-438 (F)*	23.0	9.7	8.3	4.6	3.1	2.2	1.7	1.5	2.7	2.4	2.6	4.2	4.8	6.3	1.9	1.9
Shendurney	WILD-13-AMP-269 (F)*	26.4	10.0	9.3	4.8	3.1	2.2	2.0	1.6	2.9	3.0	2.9	6.1	6.3	7.2	2.1	2.1
Shendurney	WILD-13-AMP-270 (F)*	24.3	9.3	8.7	4.1	3.1	1.9	1.9	1.6	2.2	2.7	2.5	4.7	5.1	6.0	1.8	2.0
Shendurney	WILD-13-AMP-271 (F)*	25.3	10.5	9.7	4.5	3.0	2.0	2.4	1.8	2.7	2.6	2.4	5.6	5.7	6.2	2.0	1.7
Shendurney	WILD-13-AMP-273 (F)	23.1	9.5	8.7	4.2	2.7	2.0	2.1	1.3	2.4	2.3	2.4	5.4	5.3	5.6	1.6	1.6
Shendurney	WILD-13-AMP-296 (F)*	26.3	10.6	10.1	4.9	3.1	2.1	2.2	1.6	2.8	2.6	2.7	5.3	5.8	6.7	2.2	2.0
Idukki	WILD-14-AMP-351 (F)*	22.1	9.9	8.3	3.8	2.4	2.1	1.6	1.3	2.3	2.0	2.3	5.3	5.4	5.8	1.8	1.6
Painavu/Idukki	WILD-14-AMP-354 (F)*	24.4	10.7	8.8	4.6	3.6	3.4	1.7	1.5	2.4	2.4	2.3	4.9	5.1	5.6	1.5	1.5
Painavu/Idukki	WILD-14-AMP-356 (F)	20.0	8.5	7.0	3.5	2.5	1.7	1.8	1.2	2.1	1.9	2.1	4.5	4.6	5.3	1.6	1.6
Silent Valley	WILD-14-AMP-410 (F)	23.1	9.4	8.1	4.2	2.5	2.0	1.6	1.3	2.3	2.2	2.8	6.1	5.5	6.0	2.0	1.9
Silent Valley	WILD-14-AMP-416 (F)*	20.6	9.1	7.9	3.7	2.4	1.8	1.5	1.4	2.2	2.3	2.5	4.0	4.1	5.8	1.8	1.8
Idukki	WILD-14-AMP-440 (F)*	24.9	9.5	8.7	4.7	3.1	2.1	2.0	1.5	2.8	2.2	2.5	5.6	6.3	7.1	2.2	2.2
Peechi-Vazhani	WILD-14-AMP-470 (F)*	22.1	9.5	8.1	4.0	2.6	2.2	1.5	1.4	2.2	2.3	2.2	5.0	5.2	5.9	1.9	1.9
Chimmony	WILD-14-AMP-471 (F)*	21.1	8.6	7.7	3.7	2.5	2.2	1.3	1.2	2.6	2.2	2.5	5.3	5.0	5.6	1.8	1.7
Peechi-Vazhani	WILD-14-AMP-472 (F)*	23.3	9.3	8.2	3.7	2.7	2.2	1.8	1.3	2.3	2.1	2.6	4.3	5.2	6.2	2.0	2.0
Chimmony	WILD-14-AMP-473 (F)*	21.6	9.5	8.2	3.6	2.9	1.6	1.9	1.2	2.2	2.1	2.4	4.9	5.1	5.4	1.9	1.9
Chimmony	WILD-14-AMP-474 (F)*	21.3	9.1	8.1	4.1	2.6	2.2	1.9	1.4	2.4	2.4	2.7	4.5	4.5	5.6	1.6	1.6
Sholayar	WILD-15-AMP-637 (F)	26.0	11.5	9.4	5.2	3.7	2.5	2.2	1.8	3.0	2.6	2.7	5.4	6.0	7.1	2.4	2.4
Sholayar	WILD-15-AMP-638 (F)	21.8	9.3	7.8	4.4	3.1	1.9	1.9	1.4	2.2	2.3	2.4	4.5	5.2	5.5	2.1	1.7
Malabar	NHM 1947.2.29.51 (M)[PL]	25.2	9.5	8.5	4.9	3.2	3.0	2.1	2.3	2.5	3.0	2.6	4.4	5.8	5.3	1.6	1.6
Parambikulam	WILD-14-AMP-503 (M)*	19.3	7.8	7.1	3.5	2.4	1.8	1.6	1.4	1.8	2.2	2.3	3.5	3.6	4.8	1.5	1.6
Parambikulam	WILD-14-AMP-504 (M)	21.6	9.1	8.2	4.0	2.5	1.8	1.7	1.2	2.3	2.2	2.9	4.5	5.0	6.1	1.6	1.9
Chimmony	WILD-15-AMP-596 (U)	16.0	7.0	5.6	3.0	1.6	1.4	1.1	1.2	1.8	1.8	1.8	3.6	3.8	4.4	1.3	1.3
<i>Indirana tysoni</i>																	
Ranipuram	BNHS 5979 (M)[H]*	20.0	8.4	7.1	3.9	3.3	1.5	1.7	1.7	2.0	2.5	2.1	4.3	3.9	4.6	1.2	1.3
Ranipuram	WILD-15-AMP-615 (F)[P]*	16.8	7.1	6.1	3.5	2.3	1.0	1.9	1.6	1.8	2.2	2.1	2.6	2.9	3.7	1.1	1.1
Wattakole	WILD-16-AMP-650 (F)[P]*	50.9	19.8	17.7	9.2	7.0	3.3	3.7	4.0	4.7	5.1	5.4	9.4	11.7	12.7	3.9	4.2
<i>Indirana yadera</i>																	
Vagamalai	BNHS 5982 (F)[H]*	23.7	11.3	9.5	4.5	4.0	2.0	2.3	1.6	2.4	2.6	2.3	4.4	4.9	5.9	1.7	1.5
Neyyar	WILD-13-AMP-338 (F)[P]*	23.4	10.9	8.5	4.4	2.3	1.9	1.5	1.6	2.7	2.6	2.6	4.6	4.6	5.7	1.9	1.9
Chimmony	WILD-14-AMP-479 (F)[P]*	26.7	11.3	10.8	4.9	3.2	1.9	2.6	1.5	2.8	3.0	2.7	4.9	5.9	6.6	1.9	1.6

& 75.819°E, elevation 95m), coll. K. Krutha & B. Kumar, 30.xii.2013; WILD-14-AMP-438 (female), India: Kerala: Kizhukanam, Idukki Wildlife Sanctuary (9.874°N & 77.076°E, elevation 797m), coll. K. Krutha & B. Kumar, 17.xii.2013; WILD-13-AMP-269 (female), India: Kerala: Shendurney Wildlife Sanctuary (8.920°N & 77.110°E, elevation 174m), coll. K. Krutha, Nisha & Sivakumar, 26.x.2013; WILD-13-AMP-270 (female), India: Kerala: Shendurney Wildlife Sanctuary (8.910°N & 77.119°E, elevation 230m), coll. K. Krutha, Nisha & Sivakumar, 26.x.2013; WILD-13-AMP-271 & 273 (females), India: Kerala: Shendurney Wildlife Sanctuary (8.909°N & 77.119°E, elevation 281m), coll. K. Krutha, Nisha & Sivakumar, 26.x.2013; WILD-13-AMP-296 (female), India: Kerala: Shendurney Wildlife Sanctuary (8.909°N & 77.119°E, elevation 222m), coll. K. Krutha, Nisha & Sivakumar, 27.x.2013; WILD-14-AMP-351 (female), India: Kerala: Idukki (9.874°N & 77.076°E, elevation 797m), coll. K. Krutha & B. Kumar, 17.xii.2013; WILD-14-AMP-354 & 356 (females), India: Kerala: Painavu, Idukki Wildlife Sanctuary (9.849°N & 76.949°E, elevation 803m), coll. K. Krutha & B. Kumar, 18.xii.2013; WILD-14-AMP-410 (female), India: Kerala: near Silent Valley National Park (11.049°N & 76.440°E, elevation 95m), coll. K. Krutha & B. Kumar, 31.xii.2013; WILD-14-AMP-416 (female), India: Kerala: near Silent Valley National Park (11.0720°N & 76.535°E, elevation 556m), coll. K. Krutha & B. Kumar, 31.xii.2013; WILD-14-AMP-440 (female), India: Kerala: Idukki Wildlife Sanctuary (9.874°N & 77.076°E, elevation 797m), coll. K. Krutha & B. Kumar, 17.xii.2013; WILD-14-AMP-470 (female), India: Kerala: Peechi-Vazhani Wildlife Sanctuary (10.532°N & 76.366°E, elevation 96m), coll. K. Krutha & V.K. Jayanandan, 5.xii.2013; WILD-14-AMP-471 (female), India: Kerala: Chimmony Wildlife Sanctuary (10.447°N & 76.462°E, elevation 61m), coll. K. Krutha & V.K. Jayanandan, 3.xii.2013; WILD-14-AMP-472 (female), India: Kerala: Peechi-Vazhani Wildlife Sanctuary (10.532°N & 76.366°E, elevation 96m), coll. K. Krutha & V.K. Jayanandan, 2.xii.2013; WILD-14-AMP-473 (female), India: Kerala: Chimmony Wildlife Sanctuary (10.447°N & 76.462°E, elevation 61m), coll. K. Krutha & V. K. Jayanandan, 3.xii.2013; WILD-14-AMP-474 (female), India: Kerala: Chimmony Wildlife Sanctuary (10.447°N & 76.462°E, elevation 61m), coll. K. Krutha & V.K. Jayanandan, 3.xii.2013; WILD-14-AMP-503 (male), India: Kerala: Parambikulam Tiger Reserve (10.418°N & 76.793°E, elevation 661m), coll. K. Krutha, 1.xii.2013; WILD-14-AMP-504 (male), India: Kerala: Parambikulam Tiger Reserve (10.418°N & 76.793°E, elevation 661m), coll. K. Krutha, 1.xii.2013; WILD-15-AMP-596 (unsexed), India: Kerala: Chimmony Wildlife Sanctuary (10.447°N

& 76.462°E, elevation 61m), coll. K. Krutha & V.K. Jayanandan, 3.xii.2013.

Diagnosis and comparison: *Indirana semipalmata* can be diagnosed from all other members of the genus *Indirana* based on the following combination of characters: (i) first finger longer than or equal to second, (ii) double outer palmar tubercle, and (iii) reduced webbing with two phalange free on 3rd and 5th toe and 3½ phalanges free on 4th toe. From its morphological closest congener *I. tysoni*, *I. semipalmata* differs in the webbing formula $I1\frac{1}{4}-2\frac{1}{4}II1\frac{1}{4}-3III2-3\frac{1}{2}IV3\frac{1}{2}-2V$ (vs. $I1-2II1-2\frac{1}{2}III1\frac{1}{2}-3\frac{1}{4}IV3\frac{1}{4}-1\frac{1}{2}V$) and TYL more than 50% of EL (vs. less than 50% of EL).

Description of Lectotype, BMNH 1947.2.29.50 (Image 13), Female (all measurements in mm): Medium-sized frog (SUL 33.5); head longer than wide (HL 13.7 > HW 11.3); snout longer than horizontal diameter of eye (SL 5.3 > EL 4.4); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils slightly closer to snout than to eye (SNL 2.6 < ENL 2.8); tympanum distinct, about 2/3rd of the diameter of eye (TYL = 2.9), separated from eye with a distance about 1/3rd of the TYL; supra-tympanic fold distinct; UEW slightly more than half of EL (UEW = 2.4); upper eyelids sparsely tuberculated; IOL slightly less than INL (IOL 3.4 < INL 3.5); canthus rostralis distinct; loreal region slightly concave and oblique; buccal cavity narrow, slightly deep, vomerine teeth in slightly oblique rows positioned at the anterior margin of choanae; tongue thin, bifid; bear a mid ventral papilla.

Upper arm smaller than forearm (UAL 7.0 < FoAL 8.5); hand smaller than forearm (PAL 7.0); fingers from shortest to longest – F2 (2.3) < F1 (2.5) < F4 (2.7) < F3 (3.2); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate to large, supernumerary tubercles present, single; finger discs small in size, less than twice the width of finger (F3D = 0.7, F3W = 0.4), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 17.2 < TL 18.2); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 23.0); toe lengths from shortest to longest are – T1 (2.0) < T2 (3.2) < T3 (4.8) ≈ T5 (4.8) < T4 (8.3); toe discs equal to finger discs, its diameter 1.4 times the width of toe (T4D = 0.7, T4W = 0.5); bear semicircular groove; inner metatarsal tubercle thin, elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate to large; tarsal fold and outer phalangeal fringe absent; webbing formula $I1\frac{1}{4}-2\frac{1}{4}II1\frac{1}{4}-3III2-3\frac{1}{2}IV3\frac{1}{2}-2V$.

Dorsal skin smooth with few glandular longitudinal



Image 14. *Indirana semipalmata* in life. (a) Chimmony (WILD-14-AMP-473, female, 21.6mm SUL), (b) Peechi (WILD-14-AMP-472, female, 23.3mm SUL), (c) Shendurney (WILD-13-AMP-269, female, 26.4mm SUL) and (d) Silent Valley (WILD-14-AMP-416, female, 20.6mm SUL).

folds arranged in irregular rows; lateral side smooth; ventral side smooth.

Coloration: In alcohol preservation, dorsal brown with irregular dark brown spots; white band followed posteriorly by dark band between upper eyelids; upper and lower mandible barred with brown stripes; distinct dark brown stripe running from tip of snout to shoulder through eye and tympanum; forelimbs and hindlimbs barred with dark brown stripes; sole and foot dark brown; ventrally cream with light brown throat.

Variation: Morphometric variation is provided in Table 9 and 10. Variation in life as in Image 14. Dorsum coloration ranges from pale to dark brown with pinkish tinge. Ventral side sometimes brown. Lateral side often granular. Dark brown spots and W-shaped mark on dorsum often present. Throat sometimes mottled with brown. Middorsal white stripe running from the tip of snout till vent sometimes present, interrupted by dark band between upper eyelids.

Distribution: We report *I. semipalmata* from Sholayar (10.308°N & 76.742°E, elevation 722m), Peruvannamuzhi, Malabar Wildlife Sanctuary (11.599°N & 75.819°E, elevation 95m), Kizhukanam, Idukki Wildlife Sanctuary (9.874°N & 77.076°E, elevation 797m), Shendurney Wildlife Sanctuary (8.916°N & 77.110°E, elevation 174m), Idukki Wildlife Sanctuary (9.874°N & 77.076°E, elevation 797m), Painavu, Idukki Wildlife Sanctuary (9.849°N & 76.949°E, elevation 803m), near Silent Valley National Park (11.072°N & 76.535°E, elevation 556m), Peechi-Vazhani Wildlife Sanctuary (10.532°N & 76.366°E, elevation 96m), Chimmomy Wildlife Sanctuary (10.447°N & 76.462°E, elevation 61m) and Parambikulam Tiger Reserve (10.418°N & 76.793°E, elevation 661m) (Fig. 11d). Other records include Pulloorampara (Daniel & Sekar 1989), Wayanad Wildlife Sanctuary (Andrews et al. 2005b), Anamalai Hills (Fischer 1915; Daniel & Sekar 1989), Cochin (Satyamurti 1967), Thattakkad (Andrews et al. 2005), Poombarai (Daniel & Sekar 1989), Kodaikanal (Daniel & Sekar 1989), Idukki Wildlife Sanctuary (Andrews et al. 2005), Ponmudi (Inger et al. 1984), North Kanara (Gururaja et al. 2008), Sringeri (Krishnamurthy & Katre 1993), Kudremukh (Krishnamurthy 2003), Gundia (Gururaja et al. 2007), Madikeri (Kuramoto & Joshy 2001), Athirapally (10.293°N & 76.565°E) and Kochupamba (9.421°N & 77.160°E) (Nair et al. 2012b), and Periyar Tiger Reserve (9.491°N & 77.136°E, elevation 896m) (Gopalan et al. 2012).

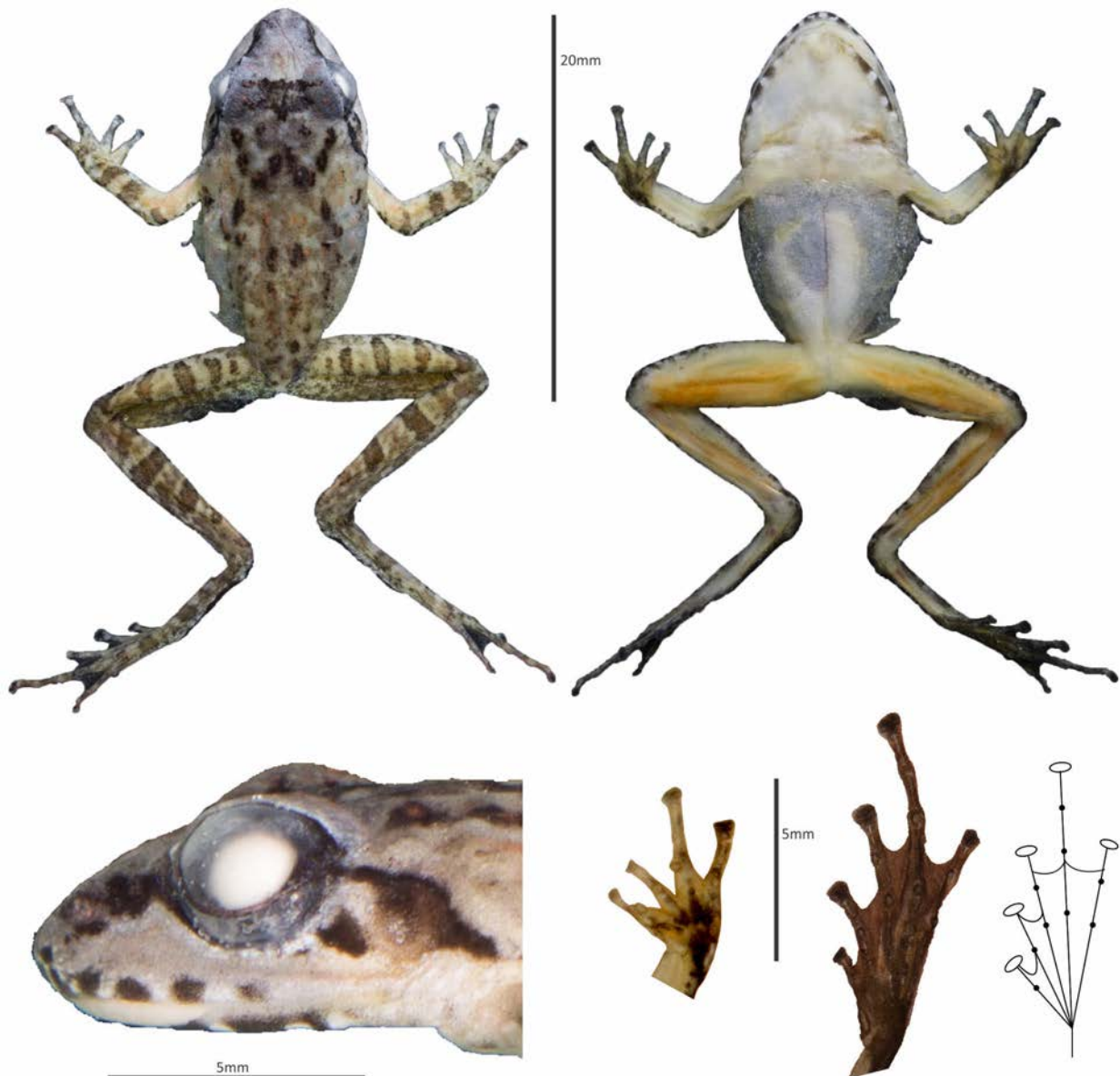
***Indirana tysoni* sp. nov.**

(Image 15)

urn:lsid:zoobank.org:act:B9624C9D-789F-49FD-85AF-43C7E310F107

Common name: Tyson's Leaping Frog**Material examined:** Holotype: BNHS 5979 (male), India: Kerala: Ranipuram Vested Forest (12.419°N & 75.353°E, elevation 932m), coll. K. Krutha & H. Tripathi, 1.ix.2015.

Paratypes: WILD-15-AMP-615 (female), same data as holotype; WILD-16-AMP-650 (female), India: Karnataka: Wattakole, Coorg (12.380°N & 75.822°E, elevation 1051m), coll. A.D. Padhye, R. Patil, C. Risbud & S. Sulakhe, 01.vii.2016.

Diagnosis: *Indirana tysoni* sp. nov. can be diagnosed from all other members of the genus *Indirana* based on following combination of characters: (i) first finger including metacarpel longer than second, (ii) double outer palmar tubercle, and (iii) reduced webbing with 1½ phalange free on 3rd and 5th toe and ¾ phalanges free on 4th toe. From its morphologically closest congener *I. semipalmata*, *I. tysoni* differs in the webbing formula I1-2II1-2½III1½-3¼IV3¼-1½V (vs. I1¼-2¼II1¼-3III2-3½IV3½-2V) and TYL less than 50% of EL (vs. more than 50% EL).**Description of Holotype, BNHS 5979 (Image 15), male (all measurements in mm):** Small-sized frog (SUL 20.0); head longer than wide (HL 8.4 > HW 7.1); snout longer than horizontal diameter of eye (SL 3.9 > EL 3.3); pupilImage 15. *Indirana tysoni* sp. nov. holotype BNHS 5979 (male, 20.0mm SUL) from Ranipuram. © Neelesh Dahanukar

horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils slightly closer to snout than to eye (SNL 1.7 < ENL 2.0); tympanum distinct, small, less than half of the diameter of eye (TYL = 1.5), separated from eye with a distance less than half of the TYL; supra-tympanic fold distinct; UEW slightly less than half of EL (UEW = 1.7); upper eyelids sparsely tuberculated; IOL slightly less than INL (IOL 2.1 < INL 2.5); canthus rostralis distinct; loreal region slightly concave and oblique; buccal cavity narrow, slightly deep, vomerine teeth in slightly oblique rows positioned between the two margins of choanae; tongue thin, bifid; bear a mid ventral papilla.

Upper arm longer than forearm (UAL 4.3 > FoAL 3.9); hand longer than forearm (PAL 4.6); fingers from shortest to longest – F1 (1.2) < F2 (1.3) < F4 (1.8) < F3 (2.3); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate to large, supernumerary tubercles present, single; finger discs small in size, less than twice the width of finger (F3D = 0.5, F3W = 0.3), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 10.1 < TL 10.8); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 13.0); toe lengths from shortest to longest are – T1 (0.9) < T2 (1.7) < T3 (2.9) ≈ T5 (2.9) < T4 (5.3); toe discs larger than finger discs, its diameter 1.8 times the width of toe (T4D = 0.7, T4W = 0.4); bear semicircular groove; inner metatarsal tubercle thin, elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate to large; tarsal fold and outer phalangeal fringe absent; webbing formula I1-2II1-2½III1½-3¼IV3¼-1½V.

Dorsal skin smooth with dense glandular longitudinal folds arranged in irregular rows; lateral side granular; ventral side smooth.

Coloration: In alcohol preservation, dorsal greyish-brown with irregular dark brown spots; W-shaped mark at the posterior border of head; two dorso-lateral brown streaks posterior to W-shaped mark; white band followed posteriorly by dark band between upper eyelids; upper and lower mandible barred with brown stripes; distinct dark brown stripe running from tip of snout to shoulder through eye and tympanum; forelimbs and hindlimbs barred with dark brown stripes; sole and foot dark brown; ventrally cream; thighs and tibia orange.

Variation: Morphometric variation is provided in Table 9 and 10. Dorsum sometimes with pinkish tinge. Thighs and tibia may not be orange.

Etymology: The species is named after the famous

Dr. Neil deGrasse Tyson, Director of the Hayden Planetarium in New York, for his effective, innovative, witty and entertaining contributions to popularizing and communicating science to the general public.

Distribution: Currently the species is known from Ranipuram (12.419°N & 75.353°E, elevation 932m), Kerala, and Wattakole, Coorg (12.380°N & 75.822°E, elevation 1051m), Karnataka (Fig. 11b).

beddomii group

Indirana beddomii (Günther, 1876)

(Image 16)

Polypedates beddomii Günther, 1876: p.571, Pl. 63 fig.B

Rana beddomii — Boulenger (1882, p. 55)

Rana (Discodeles) beddomii — Boulenger (1918, p. 238)

Ranixalus beddomii — Dubois (1987a, p. 69)

Common name: Beddome's Leaping Frog

Type locality: Malabar, India

Putative type locality: Peruvannamuzhi, Malabar Wildlife Sanctuary (11.599°N & 75.819°E, elevation 38m), Kerala, India.

Material examined: Lectotype: BMNH 1947.2.27.72, female, India: Malabar, coll. Col. R.C. Beddome.

Paralectotypes: BMNH 1947.2.27.82 & 85 (females) and BMNH 1947.2.27.83 (male), same data as lectotype.

Comparative: WILD-14-AMP-411, 412 & 414 (females), India: Kerala: Peruvannamuzhi, Malabar Wildlife Sanctuary (11.599°N & 75.819°E, elevation 38m), coll. K. Krutha & B. Kumar, 26.xii.2013; WILD-14-AMP-417, 418 & 420 (females), India: Kerala: Peruvannamuzhi, Malabar Wildlife Sanctuary (11.535°N & 75.880°E, elevation 63m), coll. K. Krutha & B. Kumar, 27.xii.2013; WILD.14.AMP.421 (female), India: Kerala: Kunthipuzha near Silent Valley National Park (11.049°N & 76.440°E, elevation 95m), coll. K. Krutha & B. Kumar, 30.xii.2013; WILD-13-AMP-138 (female), India: Kerala: Aralam Wildlife Sanctuary (11.946°N & 75.878°E, elevation 546m), coll. K. Krutha, S. Kudalkar & A. Raj, 18.vii.2013; WILD-14-AMP-409 (male), India: Kerala: Sairandhri, Silent Valley National Park (11.093°N & 76.464°E, elevation 1001m), coll. K. Krutha and B. Kumar, 31.xii.2013; WILD-14-AMP-413 (male) and WILD-14-AMP-415 (female), India: Kerala: Kakkayam, Malabar Wildlife Sanctuary (11.548°N & 75.889°E, elevation 60m), coll. K. Krutha & B. Kumar, 28.xii.2013.

Diagnosis: *Indirana beddomii* can be diagnosed

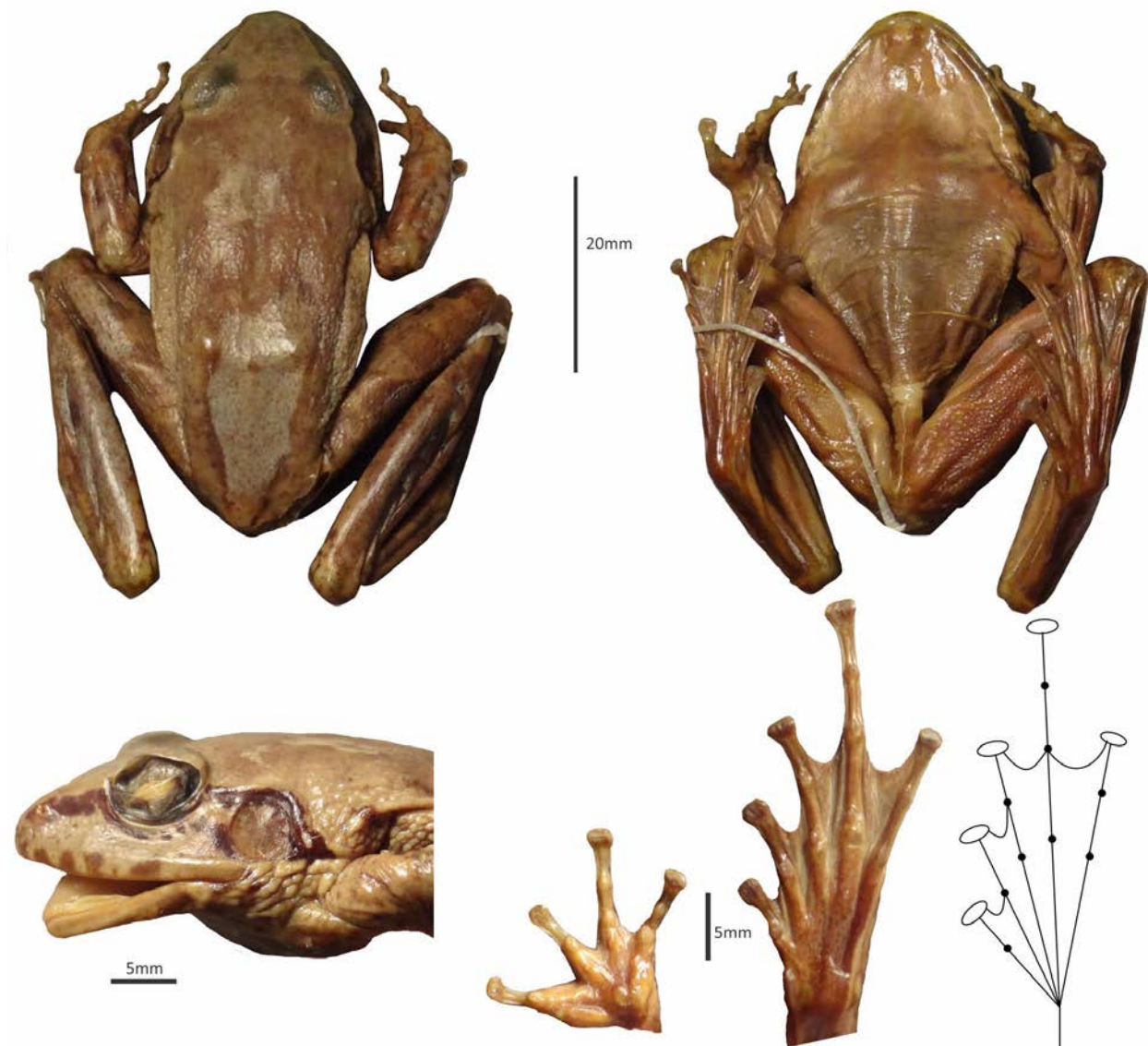


Image 16. *Indirana beddomii* lectotype BMNH 1947.2.27.72 (female, 53.9mm SUL) from Malabar. © Nikhil Modak

based on following combination of characters: (i) first finger equal to or longer than second, (ii) double outer palmar tubercle, (iii) extensive webbing with a webbing formula I1-2II1-2III1-3IV3-1V, (iv) tibio-tarsal articulation reaching beyond the snout, (v) vomerine teeth in slightly oblique rows (length 9.0–12.0% HL), (vi) choanae round to slightly oblong its maximum to minimum ratio 1.0 - 1.4, and (vii) buccal cavity shallow (depth 13.0–20.0% HL). Genetically, the species can be diagnosed from other species of *beddomii* group with 16S rRNA gene unique character position 946: T, 980: A, 1154: T (see Table 8). Geographically, the species is distributed in the Western Ghats, between the Palghat and Goa gaps.

Comparison: *Indirana beddomii* differs from *I. brachytarsus* in having nostrils closer to snout (SNL/ENL

0.61 ± 0.12 vs. 0.73 ± 0.10 , $t = 3.48$, $df = 37$, $P = 0.001$; SNL/SUL 0.06 ± 0.01 vs. 0.07 ± 0.01 , $t = 3.72$, $df = 37$, $P = 0.001$) and toe 3 shorter than toe 5 ($T3/T5$ 0.97 ± 0.08 vs. toe 3 and toe 5 about the equal length 1.05 ± 0.09 , $t = 2.64$, $df = 37$, $P = 0.012$), distribution north of the Palghat gap (vs. south of the Palghat gap); from *I. chiravasi* in having toe 3 shorter than toe 5 ($T3/T5$ 0.97 ± 0.08 vs. toe 3 and toe 5 about the equal length 1.06 ± 0.09 , $t = 2.79$, $df = 27$, $P = 0.009$), slightly shorter snout (SL/SUL 0.17 ± 0.001 vs. 0.19 ± 0.001 , $t = 4.35$, $df = 27$, $P < 0.0001$), forearm slightly longer (FoAL/SUL 0.55 ± 0.04 vs. 0.50 ± 0.03 , $t = 3.36$, $df = 27$, $P = 0.002$) and tibio-tarsal articulation reaching beyond the snout ((THL+TL)/SUL 1.16 ± 0.04 vs. reaches snout or very slightly beyond it 1.09 ± 0.07 , $t = 3.21$, $df = 27$, $P = 0.003$); from *I. duboisi*

in having shorter snout (SL/SUL 0.17 ± 0.001 vs. 0.19 ± 0.001 , $t = 3.38$, $df = 16$, $P = 0.004$) and nostrils closer to snout (SNL/SUL 0.06 ± 0.01 vs. 0.08 ± 0.003 , $t = 2.71$, $df = 16$, $P = 0.015$); from *I. gundia* in having longer palm (PAL/SUL 0.26 ± 0.01 vs. shorter palm 0.23 ± 0.01 , $t = 5.57$, $df = 40$, $P < 0.0001$), longer thigh (THL/SUL 0.54 ± 0.02 vs. 0.48 ± 0.04 , $t = 5.71$, $df = 40$, $P < 0.0001$), longer foot (FOL/SUL 0.55 ± 0.04 vs. 0.47 ± 0.03 , $t = 6.74$, $df = 40$, $P < 0.0001$), the tibio-tarsal articulation reaching beyond snout ((THL+TL)/SUL 1.16 ± 0.05 vs. barely reaches till snout 1.03 ± 0.07 , $t = 8.51$, $df = 40$, $P < 0.0001$); from *I. salelkari* in having shallow buccal cavity (depth of buccal cavity/HL $0.13-0.20$ vs. deep buccal cavity $0.22-0.25$); from *I. sarojamma* in having longer vomerine teeth series length (vomerine teeth series length/HL $0.09-0.12$ vs. shorter vomerine teeth series length 0.08) and tibio-tarsal articulation reaches slightly beyond snout ((THL+TL)/SUL 1.16 ± 0.04 vs. reaches far beyond snout 1.22 ± 0.02 , $t = 2.156$, $df = 16$, $P = 0.047$); from *I. yadava* in having shorter head length (HL/SUL 0.41 ± 0.02 vs. 0.47 ± 0.03 , $t = 3.38$, $df = 16$, $P = 0.004$), shorter head width (HW/SUL 0.36 ± 0.01 vs. 0.39 ± 0.02 , $t = 3.69$, $df = 16$, $P = 0.002$), shorter snout (SL/SUL 0.17 ± 0.01 vs. 0.19 ± 0.00 , $t = 3.96$, $df = 16$, $P = 0.001$) and larger ratio of maximum distance between vomers and head length (max distance between vomers/HL $0.26-0.35$ vs. $0.22-0.25$).

Description of Lectotype BMNH 1947.2.27.72 (Image 16), female (all measurements in mm): Medium-sized frog (SUL 53.9); head longer than wide (HL 21.6 > HW 19.5); snout longer than horizontal diameter of eye (SL 9.5 > EL 5.6); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils closer to snout than to eye (SNL 3.0 < ENL 4.9); tympanum indistinct, about 3/4th of the diameter of eye (TYL = 4.1), separated from eye with a distance about 3/4th of the TYL; supra-tympanic fold distinct; UEW slightly more than half of EL (UEW = 3.2); upper eyelids densely tuberculated; IOL more than INL (IOL 5.8 > INL 5.2); canthus rostralis distinct; loreal region slightly concave and oblique; buccal cavity wide, shallow, vomerine teeth in slightly oblique rows between the two margins of choanae; tongue thin, bifid; bear a mid ventral papilla.

Upper arm shorter than forearm (UAL 7.3 < FoAL 13.1); hand longer than forearm (PAL 14.6); fingers from shortest to longest – F2 (5.1) < F1 (6.4) < F4 (6.9) < F3 (8.5); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate to large, supernumerary tubercles present, single; finger discs moderate in size, more than 1.5 times the width of

finger (F3D = 1.8, F3W = 1.0), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 30.4 < TL 35.5); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 43.5); toe lengths from shortest to longest are – T1 (5.5) < T2 (6.6) < T3 (9.6) < T5 (10.6) < T4 (18.3); toe discs slightly wider than finger discs, its diameter slightly less than twice the width of toe (T4D = 2.0, T4W = 1.1); bear semicircular groove; inner metatarsal tubercle thin and elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate to large; tarsal fold and outer phalangeal fringe absent; webbing formula I1-2II1-2III1-3IV3-1V.

Dorsal skin smooth with dense glandular longitudinal folds arranged in irregular rows; lateral side granular with dense granulation below the tympanum; ventral side smooth; posteroventral side of femur dense granular.

Coloration: In alcohol preservation, dorsal uniformly pale brown; white band followed posteriorly by dark band between the two upper eyelids; upper and lower mandible barred with brown stripes; distinct narrow dark brown stripe running from tip of snout to shoulder through eye and tympanum; forelimbs and hindlimbs barred with dark brown stripes; sole and foot dark brown; ventrally brown.

Variation: Morphometric variation is provided in Table 9 and 10. Mid-dorsal broad white stripe interrupted by dark brown band between eyelids sometimes present. Ventrally throat sometimes mottled with brown.

Distribution: The species is known from Peruvannamuzhi, Malabar Wildlife Sanctuary (11.599°N & 75.819°E, elevation 38m), Kunthipuzha near Silent Valley National Park (11.049°N & 76.440°E, elevation 95m), Aralam Wildlife Sanctuary (11.946°N & 75.878°E, elevation 546m), Sairandhri, Silent Valley National Park (11.093°N & 76.464°E, elevation 1001m) and Kakkayam, Malabar Wildlife Sanctuary (11.548°N & 75.889°E, elevation 60m) (Fig. 11b). Because the species is a part of a complex, we do not consider any previous distribution records as valid until further genetic analyses of specimens from those localities are done.

Remarks: Fourteen syntypes of *I. beddomii* originate from Malabar, Travancore, Anamalais and Sivagiri. Of these syntypes, Inger et al. (1984) designated BMNH 1947.2.27.92 as lectotype of *I. brachytarsus*. Other seven specimens from Anamalais and Sivagiri are conspecific to the lectotype of *I. brachytarsus* and therefore we consider them as paralectotypes of *I. brachytarsus*. Of the remaining six specimens, four

from Malabar are not conspecific with the two from Travancore. To stabilize taxonomy, we designate BMNH 1947.2.27.72, a specimen originating from Malabar pictured in the original publication as *I. beddomii*, as lectotype and other three specimens from Malabar as paralectotypes of *I. beddomii*. Malabar is not a specific locality; however, since the lectotype closely resembles with the population we studied from Peruvannamuzhi, Malabar Wildlife Sanctuary (11.599°N & 75.819°E, elevation 38m) north of the Palghat gap, we consider this locality as putative type locality of the species. Further, Peruvannamuzhi also falls into the larger Malabar region of the British era. The remaining two syntypes BMNH 1947.2.27.87 and 1947.2.27.88 originating from Travancore are conspecific to *I. sarojamma* described below.

***Indirana brachytarsus* (Günther, 1876)**

(Images 17 & 18)

Polypedates brachytarsus Günther, 1876: p. 572

Rana brachytarsus — Inger et al. (1984, p. 423)

Ranixalus brachytarsus — Dubois (1987a, p. 69)

Common name: Günther's Leaping Frog

Type locality: Lectotype of the species originates from the Anamalais, India.

Material examined: Lectotype: BMNH 1947.2.27.92 (female), India: Anamallays (=Anamalai), coll. Col. R.C. Beddome.

Paralectotypes: BMNH 1947.2.27.89, 90 & 91 (females), same data as lectotype; BMNH 1947.2.2.85 (female), BMNH 1947.2.4.86 & 87 (females), and BMNH 1947.2.4.88 (male), India: Tamil Nadu: Sevagherry (= Sivagiri), coll. Col. R.C. Beddome.

Comparative: WILD-13-AMP-234 (female), India: Kerala: Neyyar Wildlife Sanctuary (8.534°N & 77.232°E, elevation 109m), coll. K. Krutha, Sivakumar & Nisha, 04.xi.2013; WILD-13-AMP-301 (female), India: Kerala: Ponmudi Reserve Forest (8.737°N & 77.145°E, elevation 903m), coll. K. Krutha, Sivakumar & Nisha, 29.x.2013; WILD-14-AMP-358 (female), India: Kerala: Painavu, Idukki Wildlife Sanctuary (9.844°N & 76.959°E, elevation 743m), coll. K. Krutha & B. Kumar, 18.xii.2013; WILD-14-AMP-437 & 441 (females), India: Kerala: Vellakkamaly, Idukki Wildlife Sanctuary (9.843°N & 76.979°E, elevation 704m), coll. K. Krutha & B. Kumar, 16.xii.2013; WILD-14-AMP-475 (female) and WILD-14-AMP-477 (male), India: Kerala: Chimmony Wildlife Sanctuary (10.447°N & 76.395°E, elevation 48m), coll.

K. Krutha & B. Kumar, 03.xii.2013; WILD-14-AMP-478 (male), India: Kerala: Peechi-Vazhani Wildlife Sanctuary (10.426°N & 76.466°E, elevation 61m), coll. K. Krutha and V.K. Jayanandan, 02.xii.2013; WILD-15-AMP-609 (female), India: Tamil Nadu: Topslip, Anamalai Tiger Reserve (10.471°N & 76.842°E, elevation 748m), coll. S. Sulakhe, 24.xii.2014; WILD-13-AMP-241 (female), India: Kerala: Ponmudi Reserve Forest (8.967°N & 77.052°E, elevation 91m), coll. K. Krutha, Sivakumar & Nisha, 29.x.2013; WILD-13-AMP-247 (female), India: Kerala: Neyyar Wildlife Sanctuary (8.559°N & 77.159°E, elevation 104m), coll. K. Krutha, Sivakumar & Nisha, 04.xi.2013; WILD-13-AMP-285 (female), India: Kerala: Ponmudi Reserve Forest (8.735°N & 77.138°E, elevation 794m), coll. K. Krutha, Sivakumar & Nisha, 29.x.2013; WILD-13-AMP-293 (female), India: Kerala: Ponmudi Reserve Forest (8.735°N & 77.140°E, elevation 837m), coll. K. Krutha, Sivakumar & Nisha, 29.x.2013; WILD-14-AMP-359 (female), India: Kerala: Idukki (9.844°N & 76.959°E, elevation 743m), coll. K. Krutha & B. Kumar, 18.xii.2013; WILD-14-AMP-442 (female), India: Kerala: Idukki Wildlife Sanctuary (9.843°N & 76.979°E, elevation 704m), coll. K. Krutha & B. Kumar, 16.xii.2013; WILD-14-AMP-353 (female), India: Kerala: Idukki Wildlife Sanctuary (9.844°N & 76.959°E, elevation 743m), coll. K. Krutha & B. Kumar, 18.xii.2013.

Diagnosis: *Indirana brachytarsus* can be diagnosed based on following combination of characters: (i) first finger equal to or longer than second, (ii) double outer palmar tubercle, (iii) extensive webbing with a webbing formula I1-2II1-2½III1-3IV3-1V, (iv) tibio-tarsal articulation reaching beyond the snout, (v) vomerine teeth in slightly oblique rows its length about 7.5–12.0% of HL, (vi) choanae round to slightly oblong its maximum to minimum ratio 1.0–1.4, and (vii) buccal cavity shallow 5.5–17.0% of HL. Genetically, the species can be diagnosed from other members of *beddomii* group with 16S rRNA gene unique character position 942: G, 952: A, 959: C, 960: T, 973: C, 978: G, 980: gap, 1055: T, 1057: C (see Table 8). Geographically, the species is distributed in the southern Western Ghats, south of the Palghat gap.

Comparison: *Indirana brachytarsus* differs from *I. chiravasi* in having, slightly narrower head (HW/SUL 0.35 ± 0.02 vs. 0.37 ± 0.02, t = 3.81, df = 36, P = 0.004), slightly less eye diameter (EL/SUL 0.11 ± 0.01 vs. 0.13 ± 0.01, t = 3.13, df = 36, P = 0.003), slightly less tympanum diameter (TyL/SUL 0.08 ± 0.01 vs. 0.09 ± 0.01, t = 3.96, df = 36, P < 0.0001), larger ratio of upper arm and fore arm (UAL/FoAL 0.92 ± 0.11 vs. 0.80 ± 0.13, t = 3.01, df = 36, P = 0.005), longer tibia (TL/SUL 0.62 ± 0.05 vs. 0.57 ± 0.04, t = 3.10, df = 36, P = 0.004), longer tarsus (ACL/SUL

Table 10. Morphometric data (mm) for species under *Indirana* for last 16 characters. Abbreviations: F, female; M, male; H, holotype; P, paratype; L, lectotype; PL, paralectotype;*, used for genetic analysis. Character abbreviations as per Materials and methods.

Species/Locality	Voucher (gender) [type status]	F3	F4	F3D	F3W	THL	TL	ACL	FOL	TFOL	T1	T2	T3	T4	T5	T4D	T4W
<i>Indirana beddomii</i>																	
Malabar	NHM 1947.2.27.72 (F)[L]	8.6	6.9	1.8	1.0	30.4	35.5	16.3	30.7	43.5	5.5	6.6	9.6	18.3	10.6	2.0	1.1
Malabar	NHM 1947.2.27.82 (F)[PL]	5.1	3.5	1.3	0.7	21.9	25.6	10.5	21.0	31.7	3.2	4.6	6.7	11.6	7.7	1.2	0.7
Malabar	NHM 1947.2.27.85 (F)[PL]	3.7	2.8	0.8	0.4	14.1	14.9	7.4	13.2	19.6	1.9	2.3	4.2	7.2	4.5	0.7	0.5
Peruvannamuzhi	WILD-14-AMP-411 (F)*	3.9	3.4	0.9	0.5	18.4	19.8	9.5	17.8	22.3	2.3	3.2	5.1	9.3	5.8	1.0	0.6
Peruvannamuzhi	WILD-14-AMP-412 (F)	4.3	3.5	1.1	0.7	18.1	21.2	9.6	17.1	23.6	2.5	3.4	5.7	9.8	6.0	1.2	0.7
Peruvannamuzhi	WILD-14-AMP-414 (F)*	5.5	4.4	1.4	0.6	20.5	25.7	11.2	22.6	31.6	3.4	4.4	7.1	12.4	7.8	1.5	0.8
Peruvannamuzhi	WILD-14-AMP-417 (F)	4.5	3.4	1.0	0.6	18.2	20.3	8.6	18.8	26.0	2.8	3.4	5.9	9.8	6.3	1.1	0.6
Peruvannamuzhi	WILD-14-AMP-418 (F)	3.7	2.8	0.8	0.6	13.6	15.0	7.0	14.8	22.7	2.2	3.0	5.0	8.4	4.2	0.8	0.6
Peruvannamuzhi	WILD-14-AMP-420 (F)*	5.5	4.2	1.2	0.6	20.3	23.2	9.8	20.2	29.5	2.7	3.8	5.7	10.8	6.0	1.3	0.7
Kunthipuzha	WILD-14-AMP-421 (F)*	3.1	2.5	0.8	0.4	14.0	14.5	6.0	11.2	17.6	1.9	2.1	4.0	6.8	3.9	0.8	0.5
Aralam WS	WILD-13-AMP-138 (F)*	4.8	3.7	1.3	0.6	18.7	21.6	10.1	19.2	28.8	2.8	4.1	6.7	11.3	6.7	1.4	0.8
Kakkayam	WILD-14-AMP-415 (F)	3.6	2.3	0.7	0.5	14.6	17.2	7.9	16.2	22.6	1.9	2.9	4.8	8.5	4.9	0.9	0.6
Malabar	NHM 1947.2.27.83 (M)[PL]	3.6	2.7	0.9	0.8	13.0	15.3	6.3	13.8	20.8	1.9	2.9	4.9	8.7	4.9	1.0	0.7
Sairandhri	WILD-14-AMP-409 (M)*	3.5	2.8	0.8	0.5	13.9	15.3	7.1	14.4	21.1	2.0	2.6	4.9	8.1	4.7	0.9	0.5
Kakkayam	WILD-14-AMP-413 (M)*	4.0	3.2	0.8	0.5	15.9	19.3	8.6	16.8	24.5	2.2	3.3	5.8	9.4	5.6	1.0	0.6
<i>Indirana brachytarsus</i>																	
Anamallays (=Anamalais)	NHM 1947.2.27.92 (F)[L]	4.2	2.8	1.3	0.6	17.1	19.3	8.5	16.4	24.1	2.5	3.5	5.6	9.2	4.9	1.2	0.7
Sevagherry (=Sivagiri)	NHM 1947.2.2.85 (F)[PL]	7.4	5.9	1.2	0.9	28.1	29.9	13.6	26.5	39.2	4.2	4.6	8.8	15.6	9.4	1.6	0.9
Sevagherry (=Sivagiri)	NHM 1947.2.4.86 (F)[PL]	6.6	5.7	1.5	0.8	23.3	27.1	12.4	25.8	36.9	3.8	5.7	8.7	14.4	8.8	1.6	0.8
Sevagherry (=Sivagiri)	NHM 1947.2.4.87 (F)[PL]	5.6	4.2	1.3	0.9	21.2	23.8	11.3	20.9	30.2	3.4	4.5	7.6	12.4	7.6	1.6	0.8
Anamalai	NHM 1947.2.27.89 (F)[PL]	6.5	4.1	1.5	0.9	22.9	27.3	11.8	24.6	34.1	3.3	4.9	8.9	14.6	8.0	1.4	0.5
Anamalai	NHM 1947.2.27.90 (F)[PL]	5.7	4.5	1.0	0.6	20.1	23.6	10.7	20.8	30.3	3.4	4.4	7.1	12.0	6.9	1.5	0.8
Anamalai	NHM 1947.2.27.91 (F)[PL]	4.5	3.6	0.8	0.4	18.4	21.1	9.0	18.0	25.2	2.7	3.2	5.4	10.0	6.0	1.0	0.6
Neyyar	WILD-13-AMP-234 (F)*	3.7	2.9	1.2	0.6	16.7	17.9	9.4	17.5	26.5	2.9	3.3	5.6	10.0	5.5	0.8	0.6
Ponmudi	WILD-13-AMP-301 (F)*	3.6	3.2	1.0	0.5	15.2	17.0	8.0	15.1	22.9	2.5	2.9	5.2	8.5	4.9	1.0	0.5
Painavu/Idukki	WILD-14-AMP-358 (F)*	3.6	2.7	1.0	0.5	13.9	15.0	7.2	13.3	19.3	1.8	3.0	4.6	7.6	4.0	1.1	0.5
Vellakkamaly/ Idukki	WILD-14-AMP-437 (F)*	4.4	2.2	0.9	0.6	16.9	19.7	8.9	17.5	26.3	2.3	3.7	6.2	10.2	5.4	1.0	0.6
Vellakkamaly/ Idukki	WILD-14-AMP-441 (F)	3.7	2.2	0.9	0.5	16.6	17.6	7.6	15.4	22.0	2.3	3.1	6.0	9.1	5.2	1.1	0.6
Chimmony	WILD-14-AMP-475 (F)*	3.6	2.6	0.8	0.4	13.5	15.0	6.8	12.3	19.6	1.8	2.6	4.0	7.2	4.3	1.0	0.6
Topslip	WILD-15-AMP-609 (F)*	3.9	3.0	0.9	0.5	15.3	17.4	8.2	15.3	19.5	2.1	2.9	4.3	7.8	4.4	1.1	0.5
Ponmudi	WILD-13-AMP-241 (F)*	3.9	3.2	1.0	0.5	15.3	18.1	8.0	16.3	24.0	2.3	3.1	5.3	9.3	5.2	1.2	0.6

Species/Locality	Voucher (gender) [type status]	F3	F4	F3D	F3W	THL	TL	ACL	FOL	TFOL	T1	T2	T3	T4	T5	T4D	T4W
Neyyar	WILD-13-AMP-247 (F)*	2.3	1.8	0.8	0.4	10.6	12.3	5.5	10.7	16.2	1.5	2.3	3.8	6.0	3.2	0.8	0.4
Ponmudi	WILD-13-AMP-285 (F)*	4.1	3.2	1.0	0.6	16.4	18.7	8.8	16.8	23.7	2.2	3.1	5.3	9.0	4.8	1.1	0.6
Ponmudi	WILD-13-AMP-293 (F)*	4.1	2.9	1.0	0.6	16.4	17.8	9.4	16.6	24.7	2.5	3.3	5.4	8.9	5.0	1.1	0.6
Painavu/Idukki	WILD-14-AMP-359 (F)*	4.8	3.2	1.3	0.7	18.6	21.6	8.9	19.4	27.4	2.9	3.8	6.8	11.3	6.1	1.1	0.7
Vellakkamaly	WILD-14-AMP-442 (F)*	3.2	2.4	0.8	0.5	13.1	15.7	7.0	14.2	21.6	2.2	2.9	5.0	8.3	4.4	0.9	0.5
Painavu	WILD-14-AMP-353 (F)*	3.9	3.0	0.8	0.5	14.4	16.3	8.7	15.5	23.1	2.2	3.0	4.3	8.6	4.7	1.0	0.6
Sevagherry	NHM 1947.2.4.88 (M)[PL]	4.5	4.1	1.2	0.5	16.4	16.6	7.8	15.6	21.6	2.1	2.7	4.7	8.1	5.1	1.3	0.6
Chimmony	WILD-14-AMP-477 (M)*	2.4	2.2	0.6	0.4	9.8	11.7	5.1	9.9	15.4	1.3	2.0	3.0	5.3	2.9	0.7	0.5
Peechi-Vazhani	WILD-14-AMP-478 (M)*	2.7	1.9	0.7	0.4	11.3	12.4	6.3	11.3	17.4	1.4	1.9	3.3	6.2	3.2	0.6	0.4
<i>Indirana chiravasi</i>																	
Amboli	BNHS 5888 (M)[H]	3.5	2.6	0.8	0.5	13.4	13.9	6.4	12.4	18.0	1.6	2.7	4.2	6.5	4.2	0.9	0.5
Amboli	WILD-14-AMP-489 (M)[P]*	3.1	2.3	0.8	0.4	12.0	13.3	5.9	12.1	16.8	1.9	2.3	3.8	6.1	3.2	0.9	0.5
Amboli	BNHS 5890 (M) [P]*	3.3	1.9	0.6	0.4	12.6	13.0	5.9	12.2	18.2	1.8	2.1	4.3	6.8	3.7	0.9	0.5
Amboli	ZSI-WRC A/1541 (M)[P]	3.6	2.6	0.8	0.5	11.2	13.3	6.3	12.5	17.2	2.1	2.9	4.5	7.3	4.3	0.9	0.5
Amboli	WILD-14-AMP-491 (M)[P]	3.4	2.6	0.9	0.5	13.5	15.0	6.4	13.5	20.1	2.1	2.7	4.3	7.5	4.4	0.8	0.5
Amboli	WILD-14-AMP-490 (F)[P]	4.1	3.7	1.1	0.5	17.0	17.6	9.6	15.2	21.1	1.7	4.6	5.4	8.6	5.5	1.0	0.6
Amboli	BNHS 5889 (F)[P]	5.6	4.1	1.7	0.6	20.0	23.2	11.4	20.7	30.7	2.9	4.7	7.4	12.8	7.4	1.7	0.9
Phansad	WILD-15-AMP-528 (F)	3.7	2.8	0.9	0.6	14.2	15.9	6.5	12.7	19.9	2.0	2.7	4.7	6.5	3.7	0.8	0.5
Koyna	WILD-15-AMP-529 (F)	3.8	3.3	1.0	0.6	15.9	17.2	7.8	15.7	21.7	2.2	2.9	5.2	8.6	5.2	1.1	0.6
Koyna	WILD-15-AMP-530 (F)*	2.8	2.1	0.7	0.5	10.5	12.6	5.6	11.2	14.6	1.4	2.2	4.0	6.1	3.6	0.7	0.5
Chandoli	WILD-15-AMP-535 (F)*	2.7	1.9	0.6	0.5	11.1	11.6	5.6	10.3	15.0	1.5	1.9	3.4	5.4	3.4	0.7	0.4
Koyna	WILD-15-AMP-544 (F)	3.6	2.5	0.7	0.5	12.7	14.7	6.8	13.0	18.3	2.2	2.9	4.4	7.3	4.5	1.0	0.5
Kitawade Plateau	WILD-15-AMP-612 (F)*	3.6	2.8	1.1	0.6	15.2	15.6	7.3	13.4	19.9	2.0	2.6	5.0	7.5	4.7	1.3	0.5
Nawja	WILD-15-AMP-613 (F)	4.2	4.0	1.3	0.8	17.4	19.5	8.5	16.1	20.8	2.5	3.6	5.7	8.5	5.5	1.4	0.8
<i>Indirana duboisi</i>																	
Kerekatte	BNHS 5980 (F)[H]*	4.4	3.4	1.1	0.6	17.5	20.5	9.4	16.8	25.7	2.6	3.5	5.6	9.6	5.4	1.3	0.7
Mookambika	WILD-15-AMP-631 (F)[P]*	3.3	2.7	0.9	0.6	12.8	14.6	7.2	12.5	18.9	2.0	2.7	4.3	7.1	4.1	0.9	0.5
Mookambika	WILD-15-AMP-630 (M)[P]*	2.9	2.2	0.6	0.4	12.9	14.3	6.5	12.6	17.1	1.4	2.1	3.6	7.0	4.3	0.7	0.5
<i>Indirana gundia</i>																	
Gundia, Inde	MNHN 1985.0633 (M)[H]	3.8	3.3	1.1	0.6	13.4	15.3	6.2	13.7	18.9	2.0	2.8	4.5	7.4	4.5	1.1	0.6
Gundia, Inde	MNHN 1985.0628 (M)[P]	2.7	2.2	0.6	0.6	12.8	14.0	6.4	12.7	18.1	1.7	2.2	3.8	6.3	3.5	0.7	0.4
Gundia, Inde	MNHN 1985.0596 (M) [P]	3.0	2.1	0.9	0.5	12.7	12.9	5.7	12.2	16.9	1.6	2.6	4.0	6.9	3.5	1.3	0.6
Gundia, Inde	MNHN 1985.0608 (M) [P]	3.0	2.0	0.5	0.4	11.5	13.1	6.7	10.2	15.9	1.5	2.2	3.3	5.2	3.3	0.7	0.4
Gundia, Inde	MNHN 1985.0605 (M) [P]	2.7	2.2	0.7	0.3	12.4	13.6	5.2	11.9	15.3	1.5	2.2	3.5	6.8	4.1	0.4	0.2

Species/Locality	Voucher (gender) [type status]	F3	F4	F3D	F3W	THL	TL	ACL	FOL	TFOL	T1	T2	T3	T4	T5	T4D	T4W
Gundia, Inde	MNHN 1985.0610 (M) [P]	3.5	2.1	1.2	0.6	11.6	13.2	5.5	10.5	16.3	1.5	1.9	3.2	5.6	3.5	0.6	0.5
Gundia, Inde	MNHN 1985.0603 (M) [P]	3.1	2.0	1.0	0.7	12.5	13.6	6.0	11.8	16.2	1.4	1.8	3.6	6.5	3.5	0.7	0.4
Gundia, Inde	MNHN 1985.0599 (M) [P]	4.4	3.3	0.9	0.6	12.7	14.3	6.0	12.0	16.9	2.0	2.5	4.2	7.0	4.1	1.0	0.7
Kutta	WILD-13-AMP-211 (M)*	2.2	1.6	0.5	0.3	9.6	10.4	5.6	8.1	13.3	1.1	1.5	2.7	4.5	2.5	0.6	0.4
Gundia	WILD-14-AMP-499 (M)*	3.2	2.7	0.9	0.4	13.3	14.6	7.0	12.9	19.5	2.0	3.0	4.6	7.5	4.2	0.8	0.6
Gundia, Inde	MNHN 1985.0622 (F) [P]	3.9	2.9	1.0	0.6	13.5	16.7	7.2	14.8	21.5	1.7	3.0	5.1	8.4	4.4	0.9	0.5
Gundia, Inde	MNHN 1985.0620 (F) [P]	4.3	3.5	1.0	0.6	15.5	18.2	8.3	15.7	23.8	2.2	3.1	5.1	9.7	5.4	1.1	0.8
Gundia, Inde	MNHN 1985.0617 (F) [P]	4.1	3.3	1.0	0.7	15.6	19.2	8.7	16.2	23.7	2.2	3.1	4.8	9.3	5.2	1.2	0.4
Gundia, Inde	MNHN 1985.0611 (F) [P]	4.3	3.5	0.9	0.7	17.2	19.3	9.2	14.8	21.5	2.3	3.2	5.4	8.3	4.9	1.2	0.4
Gundia, Inde	MNHN 1985.0618 (F) [P]	4.0	3.5	0.7	0.4	14.9	19.4	8.6	16.5	24.7	2.3	3.3	5.4	8.4	4.9	0.9	0.5
Gundia, Inde	MNHN 1985.0619 (F) [P]	3.5	2.7	0.5	0.4	14.7	15.5	6.4	13.3	18.1	1.6	1.8	3.5	6.5	3.8	0.6	0.4
Gundia, Inde	MNHN 1985.0637 (F) [P]	3.4	2.5	0.8	0.5	14.7	16.8	7.1	14.1	20.8	2.1	2.8	4.7	8.1	4.3	0.9	0.6
Gundia, Inde	MNHN 1985.0638 (F) [P]	3.8	2.6	0.9	0.5	15.0	16.2	6.6	13.3	19.0	1.8	2.9	4.4	7.1	4.9	0.9	0.5
Aralam WS	WILD-13-AMP-136 (F)*	2.9	2.5	0.6	0.4	12.6	14.5	7.1	11.9	19.1	1.8	2.6	4.1	7.0	4.2	0.7	0.5
Ranipuram	WILD-15-AMP-614 (F)*	2.4	1.7	0.5	0.3	9.3	10.7	5.2	8.3	13.2	1.1	1.5	2.6	4.8	2.7	0.7	0.2
Ranipuram	WILD-15-AMP-616 (F)*	2.4	2.0	1.5	0.3	8.6	10.0	4.9	8.7	12.6	1.3	1.8	3.0	5.1	2.9	0.6	0.3
Ranipuram	WILD-15-AMP-618 (F)*	2.4	1.7	0.6	0.4	9.6	10.6	5.4	9.6	13.0	1.4	1.9	3.2	5.4	2.7	0.6	0.4
Gundia	WILD-14-AMP-500 (F)*	4.5	3.8	1.5	1.0	18.1	22.0	9.6	18.5	26.7	2.5	3.5	6.0	10.4	6.8	1.5	0.9
Coorg	WILD-13-AMP-012 (F)	7.1	6.7	2.1	1.0	29.4	34.3	15.6	30.9	45.1	4.5	6.2	10.9	17.0	11.1	1.1	1.2
Coorg	WILD-13-AMP-013 (F)	4.6	3.2	1.4	0.7	16.2	17.0	8.1	15.8	23.1	2.5	3.3	5.7	9.2	6.0	1.2	0.6
Aralam WS	WILD-13-AMP-139 (F)*	3.1	2.5	0.8	0.5	12.3	13.7	6.3	12.3	18.8	1.8	2.5	4.0	6.4	3.6	0.9	0.5
Coorg	WILD-13-AMP-210 (F)*	4.2	3.1	1.1	0.5	16.0	18.9	8.5	17.4	25.4	2.5	3.1	5.4	9.3	4.4	1.2	0.6
Subramanya-Sullya	WILD-16-AMP-649(F)*	4.4	3.3	1.0	0.6	16.8	18.3	8.1	16.5	24.0	2.5	3.6	5.1	9.2	5.9	1.1	0.6
<i>Indirana leithii</i>																	
Matheran	BNHS 5590 (F)*	4.6	4.3	1.3	0.6	18.2	19.2	8.4	16.3	25.9	2.2	2.8	5.7	9.8	5.5	1.2	0.6
Karnala	WILD-15-AMP-525 (F)*	3.4	2.9	1.0	0.5	12.9	13.4	6.2	11.7	17.7	1.4	2.2	3.9	6.6	4.0	0.9	0.5
Matheran	BNHS 5589 (M)	3.3	2.0	1.1	0.5	12.3	13.6	5.8	12.0	17.3	1.4	1.5	3.8	6.8	4.2	0.8	0.4
Javalya fort	AGCZRL- Amphibia-221 (U)*	3.5	2.5	1.1	0.7	14.8	16.6	7.7	13.7	21.2	2.0	2.2	4.7	8.1	4.7	1.1	0.5
Achala fort	AGCZRL- Amphibia-222 (U)*	3.3	3.1	1.2	0.5	13.4	15.8	8.4	13.3	20.1	2.2	2.7	5.1	7.6	4.8	1.1	0.5
Ahwa Dang	AGCZRL- Amphibia-223 (U)*	3.7	2.9	1.1	0.5	12.6	14.8	7.3	12.8	18.2	1.8	2.5	4.3	7.0	4.1	0.9	0.5
Ahwa Dang	AGCZRL- Amphibia-224 (U)*	3.8	2.9	1.2	0.5	13.7	16.2	6.7	13.9	19.6	2.3	2.8	4.4	7.7	4.8	1.1	0.5
Ratangad	AGCZRL- Amphibia-112 (U)*	4.4	4.0	1.5	0.6	15.5	18.0	6.8	15.9	23.9	2.7	3.2	5.2	8.3	5.1	1.5	0.6
Ratangad	AGCZRL- Amphibia-113 (U)*	4.5	4.0	1.9	0.9	16.7	19.2	7.6	17.9	26.0	2.8	3.6	6.4	10.6	6.5	1.3	0.8
Gaganbawda	AGCZRL- Amphibia-194 (U)*	3.2	2.7	1.0	0.6	12.7	12.8	6.5	11.5	16.8	1.8	2.1	3.6	6.3	3.7	1.1	0.5

Species/Locality	Voucher (gender) [type status]	F3	F4	F3D	F3W	THL	TL	ACL	FOL	TFOL	T1	T2	T3	T4	T5	T4D	T4W
Gaganbawda	AGCZRL- Amphibia-195 (U)	2.5	2.1	0.7	0.3	9.7	10.3	4.5	8.5	12.6	1.4	1.8	2.4	4.4	2.7	0.7	0.4
Anuskura ghat	AGCZRL- Amphibia-193 (U)*	2.6	2.0	0.8	0.3	10.0	10.0	4.8	9.0	13.4	1.3	1.7	2.8	4.9	2.7	0.7	0.3
Amba ghat	AGCZRL- Amphibia-192 (U)*	3.0	2.4	0.9	0.4	11.1	10.0	6.0	9.8	14.8	1.6	2.3	3.0	5.5	3.2	0.8	0.5
<i>Indirana salelkari</i>																	
Netravali	BNHS 5931 (M) [H]*	2.5	2.2	1.0	0.6	12.4	14.2	7.2	11.9	17.9	1.4	1.8	4.3	7.0	4.8	1.9	0.8
Netravali	WILD-15-AMP-552 (M)[P]	3.2	3.0	1.0	0.5	12.9	13.8	6.6	13.9	19.0	1.5	1.9	4.5	7.5	4.4	1.0	0.6
Netravali	BNHS 5932 (M) [P]	3.6	2.9	1.1	0.7	14.2	14.5	7.2	13.6	20.3	1.6	2.2	4.1	7.1	3.9	1.2	1.1
Netravali	AGCZRL- Amphibia-209 (M) [P]	3.9	2.8	0.8	0.4	14.4	16.7	7.1	13.2	22.0	1.7	3.0	4.5	7.8	4.5	0.9	0.7
Netravali	ZSI-WRC A/1457 (F) [P]	4.2	2.9	1.0	0.6	17.8	18.4	9.0	16.8	25.8	2.3	3.3	4.6	9.3	5.1	0.9	0.8
Netravali	WILD-15-AMP-551 (F) [P]*	4.7	3.6	0.7	0.6	16.4	20.0	8.8	17.6	25.1	3.0	3.5	6.6	9.5	5.5	1.1	0.7
Netravali	AGCZRL- Amphibia-210 (F) [P]*	4.0	3.3	1.1	0.4	15.6	17.2	8.3	15.2	22.4	2.0	3.0	5.2	9.0	5.2	1.1	0.6
Netravali	BNHS 5933 (F) [P]	4.4	3.6	1.1	0.6	17.0	17.4	9.4	16.8	25.4	2.6	3.7	5.8	9.4	5.7	1.0	0.7
<i>Indirana sarojamma</i>																	
Ponmudi	BNHS 5981 (F)[H]*	4.8	3.8	1.3	0.7	19.6	21.7	10.6	19.2	27.9	2.6	3.6	6.0	10.9	6.1	1.2	0.7
Travancore	NHM 1947.2.27.87 (F)	5.0	3.9	1.4	0.6	18.4	21.7	10.4	19.5	28.3	2.8	3.7	6.3	11.4	6.2	1.1	0.7
Travancore	NHM 1947.2.27.88 (M)	4.9	3.7	1.2	0.6	17.2	21.0	8.6	17.5	25.5	2.8	3.8	5.7	9.5	5.7	0.9	0.6
<i>Indirana semipalmata</i>																	
Malabar	NHM 1947.2.29.50 (F)[L]	3.2	2.7	0.7	0.4	17.2	18.2	8.6	16.8	23.0	2.0	3.2	4.8	8.3	4.8	0.7	0.5
Sholayar	WILD-15-AMP-610 (F)*	3.7	3.1	0.7	0.6	14.0	16.1	7.1	15.0	19.1	2.2	2.5	4.5	8.0	4.7	0.8	0.5
Sholayar	WILD-15-AMP-611 (F)*	2.7	2.4	0.7	0.4	10.9	13.0	6.0	11.6	17.0	1.7	2.2	3.7	5.9	3.2	0.7	0.5
Peruvannamuzhi	WILD-14-AMP-419 (F)*	3.5	2.9	0.8	0.5	14.2	15.5	6.5	8.1	18.7	2.3	2.7	4.6	7.9	4.5	0.8	0.6
Kizhukanam	WILD-14-AMP-438 (F)*	3.2	2.6	0.9	0.4	11.7	13.2	6.2	11.5	16.6	1.8	2.4	4.0	6.2	3.3	0.8	0.6
Shendurney	WILD-13-AMP-269 (F)*	3.7	2.6	0.8	0.5	15.7	17.0	7.2	14.8	21.0	1.9	2.5	4.3	8.1	4.3	0.9	0.6
Shendurney	WILD-13-AMP-270 (F)*	3.2	2.5	0.8	0.5	12.4	14.1	5.7	12.0	15.1	1.5	2.0	4.0	6.2	3.8	0.9	0.5
Shendurney	WILD-13-AMP-271 (F)*	3.0	2.5	0.8	0.5	13.9	15.3	7.0	12.7	18.1	2.0	2.4	4.1	6.7	4.1	0.8	0.5
Shendurney	WILD-13-AMP-273 (F)	2.7	2.4	0.7	0.5	13.0	14.5	6.9	12.0	19.0	1.8	2.2	4.0	6.5	3.4	0.8	0.5
Shendurney	WILD-13-AMP-296 (F)*	3.4	2.8	0.7	0.5	14.1	15.7	7.4	14.2	20.9	1.8	2.4	4.0	7.4	4.2	1.1	0.6
Idukki	WILD-14-AMP-351 (F)*	3.1	2.3	0.6	0.4	12.8	13.9	7.0	12.4	17.6	1.5	2.2	3.6	6.7	3.5	0.8	0.5
Painavu/Idukki	WILD-14-AMP-354 (F)*	2.7	2.4	0.6	0.5	11.9	12.3	6.1	10.9	14.4	1.5	2.2	3.3	5.8	3.3	0.8	0.4
Painavu/Idukki	WILD-14-AMP-356 (F)	2.6	2.0	0.6	0.3	10.4	11.1	5.8	9.8	14.6	1.4	1.9	3.1	5.5	2.8	0.8	0.4
Silent Valley	WILD-14-AMP-410 (F)	3.1	2.4	0.7	0.4	12.2	12.9	7.0	10.9	15.1	1.6	2.2	3.8	5.5	3.6	0.6	0.5
Silent Valley	WILD-14-AMP-416 (F)*	3.1	2.3	0.5	0.4	12.5	13.1	6.8	11.6	17.4	1.8	2.0	3.6	6.6	3.2	0.7	0.4
Idukki	WILD-14-AMP-440 (F)*	3.5	3.0	0.7	0.6	15.6	16.4	8.0	14.9	21.0	2.2	3.1	4.7	8.0	4.4	0.7	0.6

Species/Locality	Voucher (gender) [type status]	F3	F4	F3D	F3W	THL	TL	ACL	FOL	TFOL	T1	T2	T3	T4	T5	T4D	T4W
Peechi-Vazhani	WILD-14-AMP-470 (F)*	3.2	2.5	0.7	0.4	11.5	12.7	5.5	11.6	16.4	1.5	2.4	3.8	6.3	3.5	0.7	0.5
Chimmony	WILD-14-AMP-471 (F)*	2.7	2.4	0.7	0.5	12.3	13.0	6.1	10.8	15.3	1.3	1.8	3.3	6.2	3.0	0.7	0.5
Peechi-Vazhani	WILD-14-AMP-472 (F)*	3.1	2.4	0.6	0.4	11.7	12.5	6.3	10.5	16.9	1.5	2.4	3.6	6.3	3.4	0.8	0.4
Chimmony	WILD-14-AMP-473 (F)*	3.0	2.5	0.6	0.4	11.5	12.3	6.0	10.7	16.5	1.6	2.3	3.9	5.7	3.2	0.7	0.5
Chimmony	WILD-14-AMP-474 (F)*	3.0	2.1	0.6	0.5	10.8	12.7	5.8	11.6	15.7	1.7	2.1	3.5	5.9	3.0	0.7	0.5
Sholayar	WILD-15-AMP-637 (F)	3.9	2.9	0.9	0.5	14.0	15.8	7.2	13.5	18.1	2.2	3.2	5.5	8.2	4.6	1.1	0.5
Sholayar	WILD-15-AMP-638 (F)	2.3	2.1	0.8	0.3	11.8	13.7	6.5	11.4	15.5	1.5	1.9	3.5	5.7	3.6	0.7	0.4
Malabar	NHM 1947.2.29.51 (M)[PL]	2.8	2.0	0.6	0.4	12.3	12.9	6.7	10.8	17.4	1.6	2.1	3.4	5.7	3.4	0.5	0.4
Parambikulam	WILD-14-AMP-503 (M)*	2.6	1.9	0.6	0.4	10.9	11.7	5.7	9.5	11.9	1.5	1.9	3.3	5.4	2.7	0.7	0.5
Parambikulam	WILD-14-AMP-504 (M)	3.5	2.7	0.7	0.5	11.4	13.8	7.5	12.1	15.0	1.4	2.3	3.6	6.3	3.6	0.8	0.5
Chimmony	WILD-15-AMP-596 (U)	2.5	1.7	0.6	0.4	9.1	10.5	4.6	8.7	11.6	1.2	1.8	2.7	4.8	2.2	0.6	0.4
<i>Indirana tysoni</i>																	
Ranipuram	BNHS 5979 (M) [H]*	2.3	1.8	0.5	0.3	10.1	10.8	4.6	9.0	13.0	0.9	1.7	2.9	5.3	2.9	0.7	0.4
Ranipuram	WILD-15-AMP-615 (F)[P]*	2.2	1.6	0.4	0.2	8.4	9.3	3.7	8.0	12.0	0.9	1.6	2.4	4.3	2.4	0.6	0.3
Wattakole	WILD-16-AMP-650 (F)[P]*	7.0	6.4	1.7	0.8	30.8	35.7	14.6	29.9	44.5	4.7	5.4	9.9	16.4	9.6	2.1	1.0
<i>Indirana yadera</i>																	
Vagamalai	BNHS 5982 (F)[H]*	3.1	2.2	0.8	0.4	13.7	15.2	6.7	11.8	19.3	1.6	2.2	3.9	5.2	3.8	0.9	0.5
Neyyar	WILD-13-AMP-338 (F)[P]*	3.1	2.3	0.7	0.4	13.8	14.0	7.6	11.9	18.6	1.6	2.5	3.9	6.7	4.4	0.9	0.5
Chimmony	WILD-14-AMP-479 (F)[P]*	3.3	2.3	0.7	0.5	14.3	16.7	6.9	14.3	18.4	1.9	2.4	4.3	8.4	4.2	1.0	0.7

0.29 ± 0.03 vs. 0.26 ± 0.02, $t = 2.94$, $df = 36$, $p = 0.006$), longer foot (FOL/SUL 0.55 ± 0.04 vs. 0.50 ± 0.03, $t = 3.63$, $df = 36$, $P = 0.001$; TFOL/SUL 0.81 ± 0.06 vs. 0.72 ± 0.05, $t = 4.51$, $df = 36$, $P < 0.0001$), longer toe 4 (T4/SUL 0.31 ± 0.03 vs. 0.28 ± 0.02, $t = 3.94$, $df = 36$, $P < 0.0001$), tibio-tarsal articulation reaching beyond the snout ((THL+TL)/SUL 1.16 ± 0.07 vs. reaches snout or barely beyond it 1.09 ± 0.07, $t = 3.04$, $df = 36$, $P = 0.004$); from *I. duboisi* in having narrow head (HW/SUL 0.35 ± 0.02 vs. slightly broader head 0.37 ± 0.01, $t = 2.32$, $df = 25$, $P = 0.029$), distribution south of Palghat gap (vs. north of Palghat gap); from *I. gundia* in having smaller eye (EL/SUL 0.11 ± 0.01 vs. 0.14 ± 0.01, $t = 6.23$, $df = 49$, $P < 0.0001$), smaller tympanum (TyL/SUL 0.08 ± 0.01 vs. 0.10 ± 0.02, $t = 5.59$, $df = 49$, $P < 0.0001$), larger ratio between snout length and eye diameter (SL/EL 1.56 ± 0.21 vs. 1.28 ± 0.12, $t = 5.90$, $df = 49$, $P < 0.0001$), longer palm (PAL/SUL 0.25 ± 0.02 vs. 0.23 ± 0.01, $t = 4.22$, $df = 49$, $P < 0.0001$), larger palm to fore-arm ratio (PAL/FoAL 1.18 ± 0.09 vs. 1.10 ± 0.09, $t = 3.22$, $df = 49$, $P = 0.002$), longer thigh

(THL/SUL 0.55 ± 0.03 vs. 0.48 ± 0.04, $t = 6.59$, $df = 49$, $P < 0.0001$), longer tibia (TL/SUL 0.62 ± 0.05 vs. 0.55 ± 0.04, $t = 5.82$, $df = 49$, $P < 0.0001$), longer tarsus (ACL/SUL 0.29 ± 0.03 vs. 0.25 ± 0.03, $t = 4.28$, $df = 49$, $P < 0.0001$), longer foot (FOL/SUL 0.55 ± 0.04 vs. 0.47 ± 0.03, $t = 7.52$, $df = 49$, $P < 0.0001$; TFOL/SUL 0.81 ± 0.06 vs. 0.69 ± 0.06, $t = 6.66$, $df = 49$, $P < 0.0001$) and the tibio-tarsal articulation reaching beyond snout ((THL+TL)/SUL 1.16 ± 0.07 vs. barely reaches snout 1.03 ± 0.07, $t = 6.58$, $df = 49$, $P < 0.0001$); from *I. salelkari* in having slightly narrower head (HW/SUL 0.35 ± 0.02 vs. 0.37 ± 0.01, $t = 3.03$, $df = 30$, $P = 0.005$), equal length of F1 and F2 or F1 slightly longer (F1/F2 1.01 ± 0.08 vs. F1 is always longer than F2 1.16 ± 0.10, $t = 3.98$, $df = 30$, $P < 0.0001$), shallow buccal cavity (Depth of buccal cavity/HL 0.07 – 0.16 vs. deep buccal cavity 0.22 – 0.25); from *I. sarojamma* in having narrow upper eyelid (UEW/SUL 0.08 ± 0.01 vs. 0.09 ± 0.01, $t = 2.12$, $df = 25$, $P = 0.044$) and smaller disc diameter (F3D/SUL 0.03 ± 0.00 vs. 0.04 ± 0.00, $t = 2.38$, $df = 25$, $P = 0.026$); from *I. yadera* in having shorter and

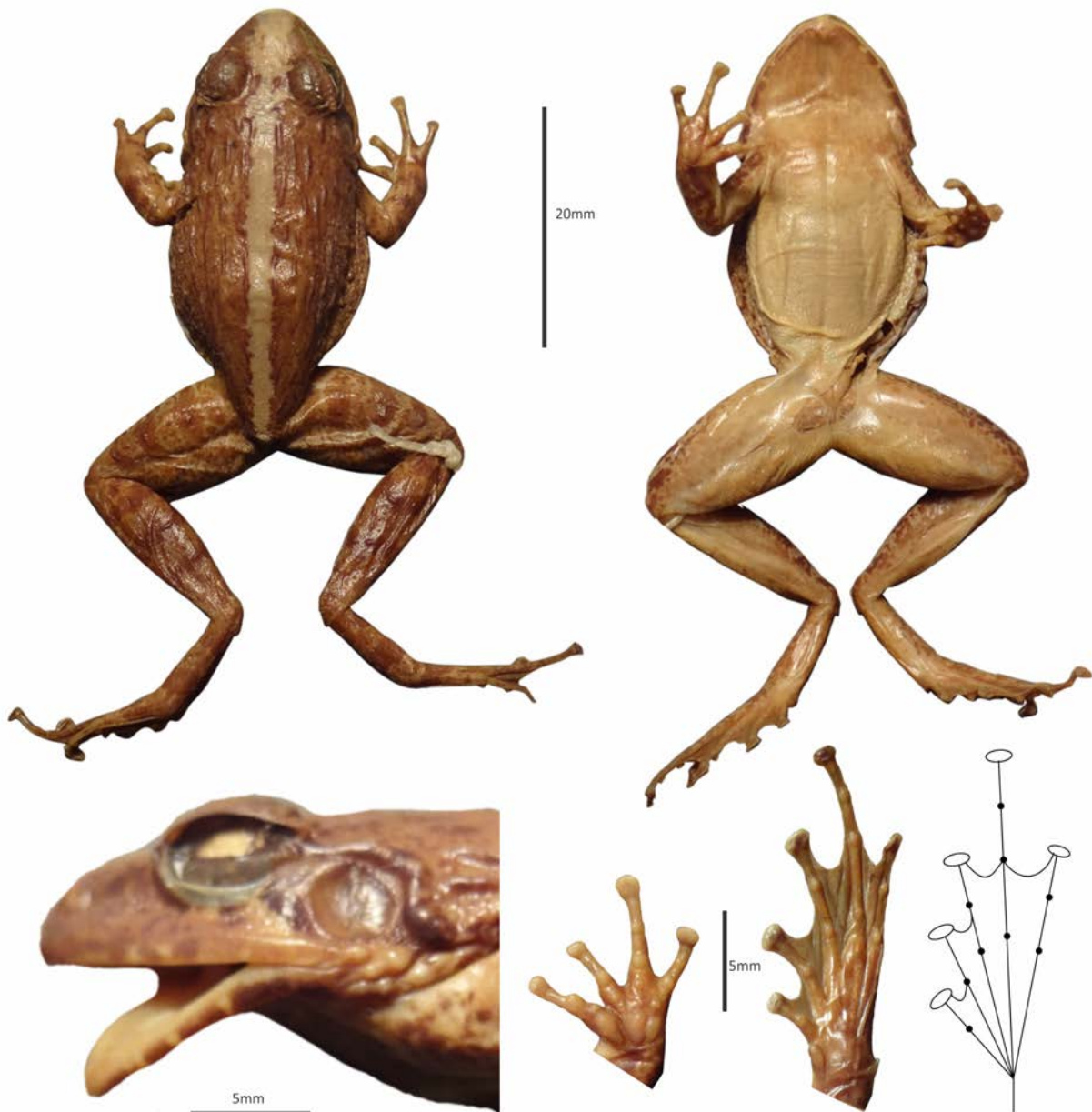


Image 17. *Indirana brachytarsus* lectotype BMNH 1947.2.27.92 (female, 36.4mm SUL) from Anamallays (=Anamalai). © Nikhil Modak

narrower head (HL/SUL 0.41 ± 0.03 vs. 0.46 ± 0.03 , $t = 2.98$, $df = 25$, $p = 0.006$; HW/SUL 0.35 ± 0.02 vs. 0.39 ± 0.02 , $t = 4.03$, $df = 25$, $p < 0.0001$).

For differences from *I. beddomii*, see comparison section for that species.

Description of Lectotype BMNH 1947.2.27.92 (Image 17), female (all measurements in mm): Medium-sized frog (SUL 36.4); head longer than wide (HL 15.4 > HW 12.6); snout longer than horizontal diameter of eye (SL 6.0 > EL 4.6); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils closer to snout

than to eye (SNL 2.1 < ENL 3.8); tympanum distinct, about $3/4^{\text{th}}$ of the diameter of eye (TYL = 3.4), separated from eye with a distance less than half of the TYL; supra-tympanic fold distinct; UEW slightly less than $3/4^{\text{th}}$ of EL (UEW = 3.2); upper eyelids densely tuberculated; IOL more than INL (IOL 4.0 > INL 3.4); canthus rostralis distinct; loreal region slightly concave and oblique; buccal cavity wide, shallow, vomerine teeth in slightly oblique rows at the posterior border of choanae; tongue thin, bifid; bear a mid ventral papilla.

Upper arm shorter than forearm (UAL 5.9 < FoAL 7.6); hand longer than forearm (PAL 8.2); fingers from



Image 18. *Indirana brachytarsus* in life. From (a) Painavu (WILD-14-AMP-358, female, 26.7mm SUL) and (b) Chimmony (WILD-14-AMP-475, female, 24.0mm SUL).

shortest to longest – F1 (2.7) \approx F2 (2.7) < F4 (2.8) < F3 (4.2); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate to large, supernumerary tubercles present, single; finger discs moderate in size, more than twice the width of finger (F3D = 1.3, F3W = 0.6), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 17.1 < TL 19.3); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 24.1); toe lengths from shortest to longest are – T1 (2.5) < T2 (3.5) < T5 (4.9) < T3 (5.6) < T4 (9.2); toe discs slightly less than finger discs, its diameter slightly less than twice the width of toe (T4D = 1.2, T4W = 0.7); bear semicircular groove; inner metatarsal tubercle elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate to large; tarsal fold and outer phalangeal fringe absent; webbing formula I1-2II1-2½III1-3IV3-1V.

Dorsal skin smooth with dense glandular longitudinal folds arranged in irregular rows; lateral side granular with dense granulation below the tympanum; ventral side smooth; postero-ventral side of femur dense granular.

Coloration: In alcohol preservation, dorsal brown

with a thick mid-dorsal stripe interrupted by dark band between upper eyelids; upper and lower mandible barred with brown stripes; distinct dark brown stripe running from tip of snout to shoulder through eye and tympanum; ventrally cream with brown throat; forelimbs and hindlimbs barred with dark brown stripes; sole and foot dark brown; ventrally cream with brown throat.

Variation: Morphometric variation is provided in Table 9 and 10. Variation in life coloration as in Image 18. Mid-dorsal broad white stripe may be absent. Dorsum coloration ranges from pale to dark brown. Darker brown spots and W-shaped mark on dorsum sometimes present. Ventrally sometimes uniform cream.

Distribution: This species is known from the Idukki Wildlife Sanctuary (locality 1: 9.844°N & 76.959°E, elevation 743m; locality 2: 9.843°N & 76.979°E, elevation 704m), Ponmudi Reserve Forest (locality 1: 8.735°N & 77.140°E, elevation 837m; locality 2: 8.735°N & 77.138°E, 794m; locality 3: 8.737°N & 77.145°E, elevation 903m), Neyyar Wildlife Sanctuary (locality 1: 8.559°N & 77.159°E, elevation 104m; locality 2: 8.534°N & 77.232°E, elevation 109m), Topslip, Anamalai Tiger Reserve (10.471°N & 76.842°E, elevation 748m), Peechi-Vazhani Wildlife Sanctuary (10.426°N & 76.466°E, elevation 61m), Chimmony Wildlife Sanctuary (10.447°N & 76.395°E, elevation 48m) (Fig. 11c). Because the species of the *beddomii* group are morphologically similar, we do not consider any previous distribution records as valid until further genetic analyses of specimens from those localities are done.

Remarks: Inger et al. (1984) mentions BMNH 1947.2.27.1307 as lectotype of *I. brachytarsus*; however, the correct voucher number should be either BMNH 1874.4.29.1307 (as per the old numbering system) or BMNH 1947.2.27.92 (as per the new numbering system). In the present study we only adopt the new numbering system for all the types studied at BMNH. Since seven other specimens from Anamalais and Sivagiri are conspecific to lectotype of *I. brachytarsus*, we have considered them as paralectotypes of *I. brachytarsus*.

***Indirana chiravasi* Padhye, Modak & Dahanukar, 2014**
(Images 19 & 20)

Common name: Amboli Leaping Frog

Type locality: Amboli (15.956°N & 73.997°E, elevation 744m), Sindhudurg District, Maharashtra, India.

Material examined: Holotype: BNHS 5888 (male), India: Maharashtra: Amboli, Sindhudurg District, coll. N. Modak, N. Dahanukar, K. Krutha & U. Katwate,

11.vi.2013.

Paratypes: BNHS 5890 (male), WILD-14-AMP-489 (male) and ZSI-WRC A/1541 (male), same data as holotype; BNHS 5889 (female), India: Maharashtra: Amboli, coll. N. Modak, 9.vi.2014; WILD-14-AMP-490 (female) India: Maharashtra: Amboli, coll. N. Modak, 9.vi.2014; WILD-14-AMP-491 (male), India: Maharashtra: Amboli, coll. N. Modak, N. Dahanukar, K. Krutha & U. Katwate, 19.vii.2013.

Comparative: WILD-15-AMP-528 (female), India: Maharashtra: Phansad (18.450°N & 72.920°E, elevation 42m), coll. K. Krutha, U. Katwate & S. Gawas, 01.xii.2014; WILD-15-AMP-529 (female), India: Maharashtra: Koyna (17.392°N & 73.678°E, elevation 862m), coll. K. Krutha, V.K. Prasad & S. Gawas, 28.xii.2014; WILD-15-AMP-530 (female), India: Maharashtra: Koyna (17.392°N &

73.678°E, elevation 862m), coll. K. Krutha, V.K. Prasad & S. Gawas, 28.xii.2014; WILD-15-AMP-535 (female), India: Maharashtra: Chandoli National Park (17.210°N & 73.811°E, elevation 920m), coll. K. Krutha, V.K. Prasad & S. Gawas, 23.xii.2014; WILD-15-AMP-544 (female), India: Maharashtra: Koyna (17.423°N & 73.725°E, elevation 848m), coll. K. Krutha, V.K. Prasad & S. Gawas, 29.xii.2014; WILD-15-AMP-612 (female), India: Maharashtra: Kitawade Plateau (16.001°N & 74.018°E, elevation 722m), coll. N. Modak, N. Dandekar & S. Bhawe, 10.vii.2015; WILD-15-AMP-613 (female), India: Maharashtra: Nawja (17.444°N & 73.721°E, elevation 717m), coll. N. Dandekar, 17.vi.2015.

Diagnosis: *Indirana chiravasi* can be diagnosed based on following combination of characters: (1) First finger equal to or longer than second, (2) double outer

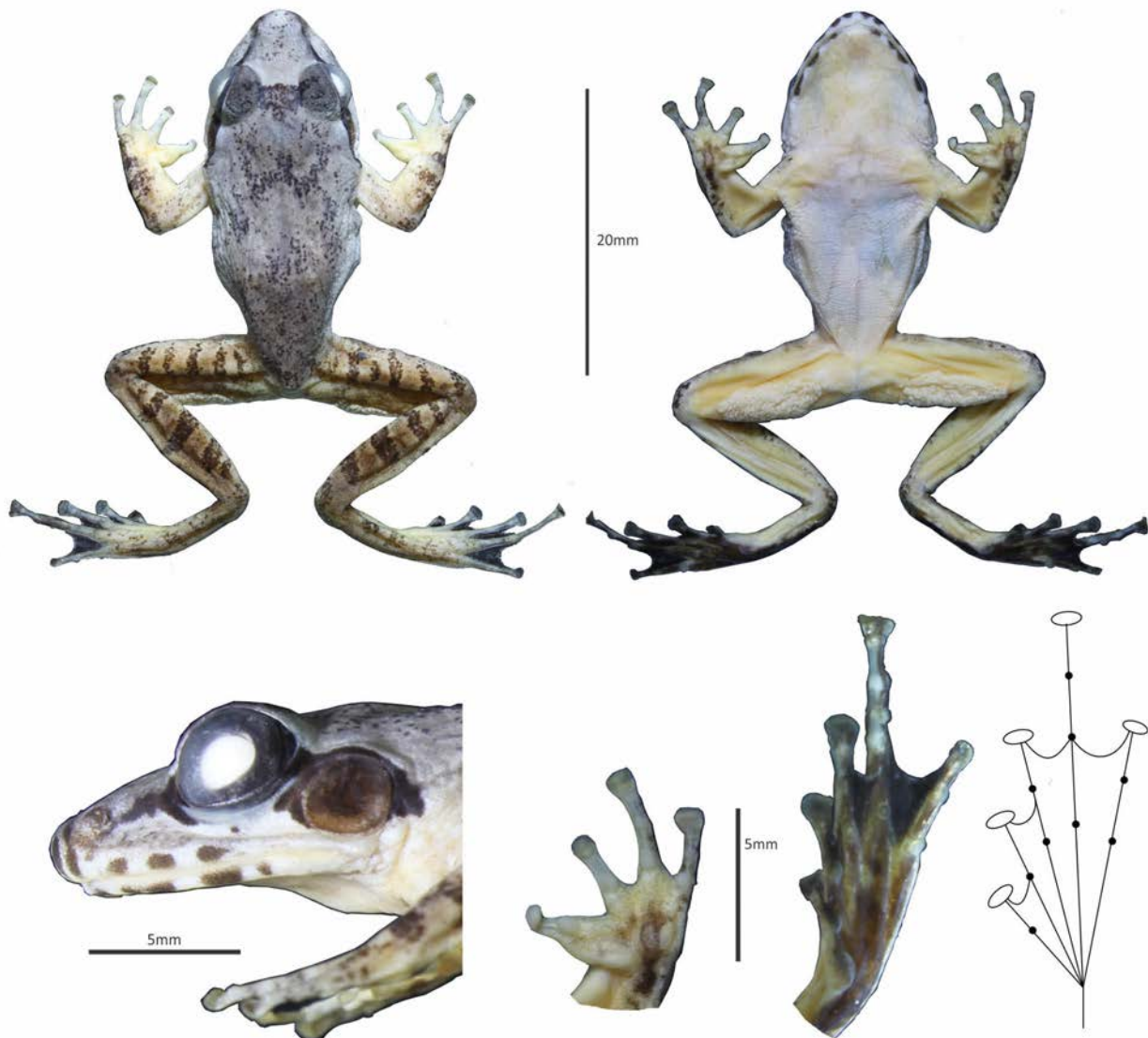


Image 19. *Indirana chiravasi* holotype BNHS 5888 (male, 27.3mm SUL) from Amboli. © Neelesh Dahanukar



Image 20. *Indirana chiravasi* in life. From (a) Amboli (paratype, BNHS 5890, male, 25.0mm SUL) and (b) Phansad (WILD-15-AMP-528, female, 24.8mm SUL).

palmar tubercle, (3) extensive webbing with a webbing formula I1-2II1-3III1¼-3IV3-1¼V in males and I1-2II1-2½III1¼-3IV3-1¼V in female, (4) tibio-tarsal articulation reaching snout or slightly beyond, (5) vomerine teeth in slightly oblique rows its length about 8.0–11.5% of HL, (6) choanae almost round its maximum to minimum ratio 1.0–1.2, (7) buccal cavity shallow 11.0–17.0% of HL and (8) presence of median single internal vocal sac. Genetically, the species can be diagnosed from other members of the *beddomii* group with 16S rRNA gene unique character position 898: C, 950: G, 1151: C (see Table 8). Geographically, this species is distributed in the Western Ghats, north of the Goa gap.

Comparison: *Indirana chiravasi* differs from *I. duboisi* in having nostrils more closer to snout (SNL/SUL 0.07 ± 0.01 vs. 0.08 , $t = 2.66$, $df = 15$, $P = 0.010$) and tibio-tarsal articulation reaching snout or slightly beyond ((THL+TL)/SUL 1.09 ± 0.08 vs. reaches beyond the snout 1.18 ± 0.09 ,

$t = 1.91$, $df = 15$, P (one tailed) = 0.038); from *I. gundia* in having longer palm (PAL/SUL 0.26 ± 0.02 vs. 0.23 ± 0.01 , $t = 5.22$, $df = 39$, $P < 0.0001$), larger palm to forearm ratio (PAL/FoAL 1.17 ± 0.10 vs. 1.10 ± 0.09 , $t = 2.42$, $df = 39$, $P < 0.020$), longer thigh (THL/SUL 0.52 ± 0.04 vs. 0.48 ± 0.04 , $t = 2.86$, $df = 39$, $P < 0.007$) and longer foot (FOL/SUL 0.50 ± 0.03 vs. 0.47 ± 0.03 , $t = 3.13$, $df = 39$, $P = 0.003$); from *I. salelkari* in having smaller upper eyelid to inter-orbital width ratio (UEW/IOL 0.72 ± 0.09 vs. 0.87 ± 0.09 , $t = 3.604$, $df = 20$, $p = 0.002$) and shallow buccal cavity (Depth of buccal cavity/HL $0.12 - 0.17$ vs. deep buccal cavity $0.22 - 0.25$); from *I. sarojamma* in having shorter toe 4 (T4/SUL 0.28 ± 0.02 vs. 0.32 ± 0.02 , $t = 3.10$, $df = 15$, $P = 0.007$), shorter foot length (0.50 ± 0.03 vs. 0.57 ± 0.02 , $t = 3.66$, $df = 15$, $P = 0.002$) and longer vomer length (vomerine series length/HL $0.09 - 0.11$ vs. 0.08); from *I. yadera* in having shorter head (HL/SUL 0.42 ± 0.02 vs. 0.46 ± 0.03 , $t = 2.76$, $df = 15$, $P = 0.015$), larger tympanum (TyL/SUL 0.09 ± 0.01 vs. 0.08 ± 0.01 , $t = 3.56$, $df = 15$, $P = 0.022$), tibio-tarsal articulation reaching snout or slightly beyond ((THL+TL)/SUL 1.09 ± 0.08 vs. reaches beyond the snout 1.19 ± 0.03 , $t = 2.35$, $df = 15$, $P = 0.033$) and larger ratio of minimum distance between vomerine teeth and head width (minimum distance between vomerine teeth/HW $0.07-0.11$ vs. $0.06-0.07$).

For differences from *I. beddomii* and *I. brachytarsus* see comparison section for the respective species.

Description: Description of holotype BNHS 5888, male (Image 19), appears in Padhye et al. (2014).

Coloration: See Padhye et al. (2014).

Variation: Morphometric variation is provided in Table 9 and 10. Color variation in life as per Image 20. Mid-dorsal white stripe may be present. Dorsum coloration ranges from grey to dark brown. Darker brown spots and W-shaped mark on dorsum sometimes present. Ventrally, sometimes uniform cream or white and mottled with brown on throat.

Distribution: The species is known from north of the Goa gap. It is reported from Amboli (15.956°N & 73.997°E, elevation 744m), Phansad (18.450°N & 72.920°E, elevation 42m), Koyna (17.392°N & 73.678°E, elevation 862m), Chandoli National Park (17.210°N & 73.811°E, elevation 920m), Kitawade Plateau (16.001°N & 74.018°E, elevation 722m) and Nawja (17.444°N & 73.721°E, elevation 717m) (Fig. 11a and figure 1 in Padhye et al. 2014).

***Indirana duboisi* sp. nov.**

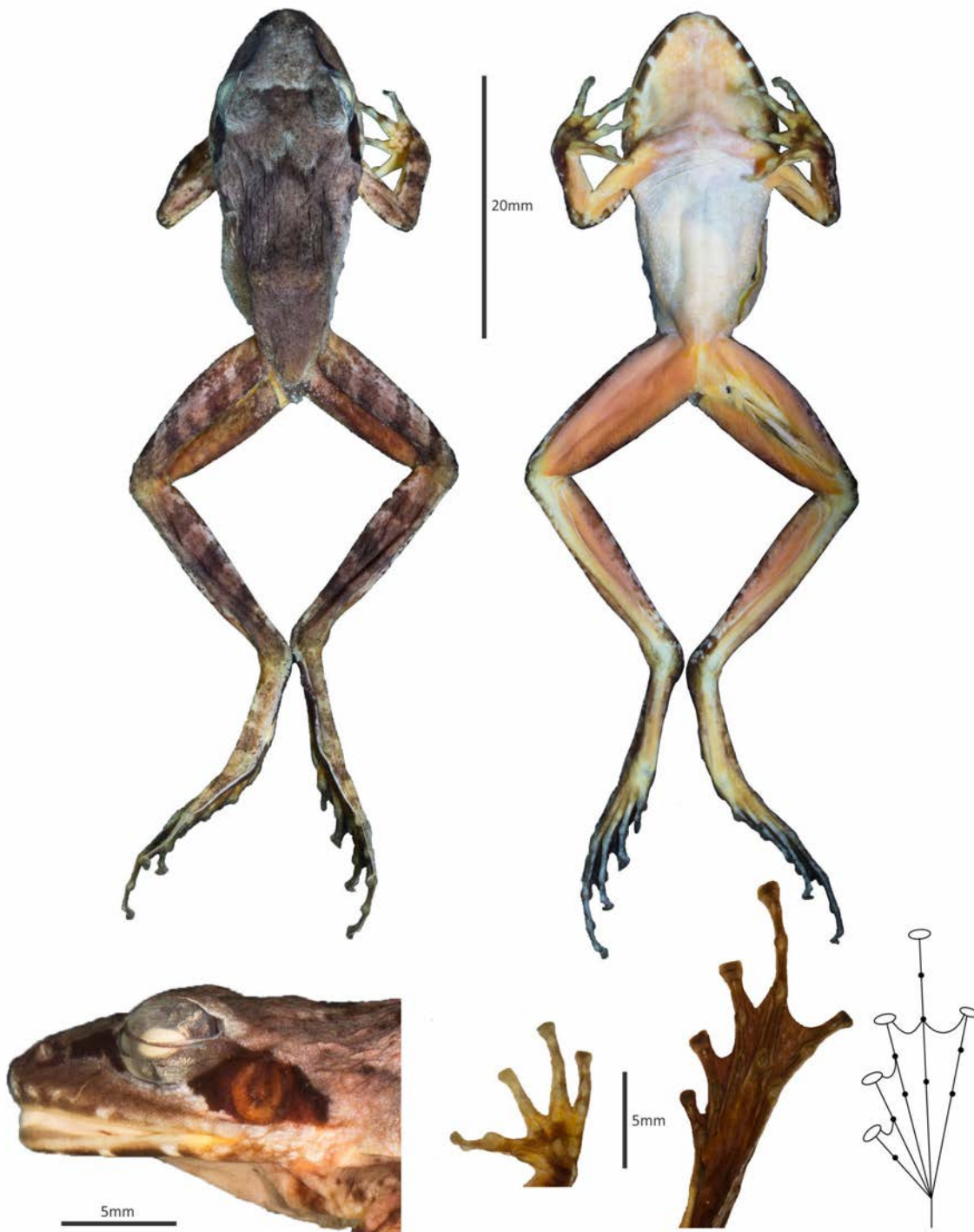
(Images 21 & 22)

urn:lsid:zoobank.org:act:09B60BA7-D562-42DB-8B15-D0BF531F0C3D

Common name: Dubois's Leaping Frog**Material examined:** Holotype: BNHS 5980 (female), India: Karnataka: Kerekatte, Kudremukh National

Park (13.322°N & 75.146°E, elevation 724m), coll. N. Dahanukar, K. Krutha & P. Iyer, 12.viii.2014.

Paratypes: WILD-15-AMP-630 (male), India: Karnataka: Mookambika Wildlife Sanctuary (13.917°N & 74.913°E, elevation 634m), coll. K. Krutha & H. Tripathi, 26.ix.2015; WILD-15-AMP-631 (female), India: Karnataka: Mookambika Wildlife Sanctuary (13.894°N &

Image 21. *Indirana duboisi* sp. nov. holotype BNHS 5980 (female, 30.3mm SUL) from Kerekatte. © Neelesh Dahanukar

74.831°E, elevation 498m), coll. K. Krutha & H. Tripathi, 25.ix.2015.

Diagnosis: *Indirana duboisi* sp. nov. can be diagnosed based on following combination of characters: (i) first finger equal to or longer than second, (ii) double outer palmar tubercle, (iii) extensive webbing with a webbing formula I1-2III1-2III1-3IV3-1V, (iv) tibio-tarsal articulation reaching beyond snout, (v) vomerine teeth in slightly oblique rows its length about 9.5–10.5% of HL, (vi) choanae round to slightly oblong its maximum to minimum ratio 1.0–1.2, (vii) buccal cavity slightly deep 10.0–17.0% of HL, (viii) FOL less than 55% of SUL, (ix) TL more than 55% of SUL, (x) PAL more than 25% of SUL, and (xi) UAL 19 – 21% of SUL. Genetically, the species can be diagnosed from other members of *beddomii* complex with 16S rRNA gene using unique characters at position 1057: T, 1161: C (see Table 8). Geographically, the species is distributed in Western Ghats between the Palghat and Goa gaps.

Comparison: *Indirana duboisi* differs from *I. gundia* in having longer thigh (0.55 ± 0.04 vs. THL/SUL 0.48 ± 0.04 , $t = 3.12$, $df = 28$, $P = 0.004$), longer foot (FOL/SUL 0.53 ± 0.03 vs. 0.47 ± 0.03 , $t = 3.11$, $df = 28$, $P = 0.004$), tibio-tarsal articulation reaches beyond snout ($(THL+TL)/SUL$ 1.18 ± 0.09 vs. barely reaches the snout 1.03 ± 0.07 , $t = 3.49$, $df = 28$, $P = 0.002$), ratio of minimum distance between vomerine teeth series and head length high (minimum distance between vomerine teeth series/HL $0.07 - 0.09$ vs. $0.04 - 0.07$); from *I. salekari* in having smaller ratio between upper eyelid width and inter-orbital width (UEW/IOL 0.72 ± 0.05 vs. 0.87 ± 0.09 , $t = 2.72$, $df = 9$, $P = 0.023$), shallower buccal cavity (depth of buccal cavity/HL $0.11-0.12$ vs. $0.13-0.14$), smaller vomerine length to head width ratio ($0.11-0.12$ vs. $0.13-0.14$); from *I. sarojamma* in having larger vomerine length to head width and head length ratio (vomer length/HL 0.10 vs. 0.08 ; vomer length/HW $0.11-0.12$ vs. 0.09), larger ratio between maximum vomerine distance to head width (max vomerine distance/HW $0.30-0.32$ vs. 0.28) and distributed north of Palghat gap (vs. south of Palghat gap); from *I. yadera* in having nostrils more closer to snout (SNL/SUL 0.08 ± 0.00 vs. 0.06 ± 0.01 , $t = 4.07$, $df = 4$, $P = 0.015$), subequal inter-narial distance to inter-orbital distance (INL/IOL 0.96 ± 0.03 vs. inter-narial distance is equal to or larger than inter-orbital distance 1.07 ± 0.07 , $t = 2.40$, $df = 4$, one tailed $P = 0.038$), larger ratio between minimum distance in vomerines and head length ($0.07 - 0.09$ vs. $0.05 - 0.06$) and larger maximum distance between vomerines by head length ratio ($0.26 - 0.28$ vs. $0.22 - 0.25$).

For differences between *I. beddomii*, *I. brachytarsus*



Image 22. *Indirana duboisi* sp. nov. from Kerekatte (holotype, BNHS 5980, female, 30.3mm SUL) in life.

and *I. chiravasi* see comparison section for the respective species.

Description of Holotype BNHS 5980 (Image 21 and 22), female (all measurements in mm): Medium-sized frog (SUL 30.3); head longer than wide (HL 12.9 > HW 11.0); snout longer than horizontal diameter of eye (SL 6.1 > EL 3.8); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils closer to snout than to eye (SNL 2.5 < ENL 4.0); tympanum distinct, more than $3/4^{\text{th}}$ of the diameter of eye (TYL = 3.0), separated from eye with a distance about $1/3^{\text{rd}}$ of the TYL; supra-tympanic fold distinct; UEW $2/3^{\text{rd}}$ of EL (UEW = 2.5); upper eyelids densely tuberculated; IOL equal to INL (IOL 3.3 = INL 3.3); canthus rostralis distinct; loreal region slightly concave and oblique; buccal cavity wide, slightly deep, vomerine teeth in slightly oblique rows between the two margins of choanae; tongue thin, bifid, bears a mid ventral papilla.

Upper arm shorter than forearm (UAL 5.7 < FoAL 6.6); hand longer than forearm length (PAL 7.9); finger lengths from shortest to longest – F2 (2.8) < F1 (3.3) < F4 (3.4) < F3 (4.4); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate to large, supernumerary tubercles present, single; finger discs moderate in size, slightly less than twice the width of finger (F3D = 1.1, F3W = 0.6), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 17.5 < TL 20.5); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 25.7); toe lengths from shortest

to longest are – T1 (2.6) < T2 (3.5) < T5 (5.4) < T3 (5.6) < T4 (9.6); toe discs slightly larger than finger discs, its diameter slightly less than twice the width of toe (T4D = 1.3, T4W = 0.7); bear semicircular groove; inner metatarsal tubercle thin, elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate to large; tarsal fold and outer phalangeal fringe absent; webbing formula I1-2II1-2III1-3IV3-1V.

Dorsal skin smooth with dense glandular longitudinal folds arranged in irregular rows; lateral side granular; ventral side smooth; posteroventral side of femur dense granular.

Coloration: In alcohol preservation (Image 21), dorsal dark brown with irregular dark brown spots; white band followed posteriorly by dark band between upper eyelids; upper and lower mandible barred with brown stripes; distinct dark brown stripe running from tip of snout to shoulder through eye and tympanum; ventrally cream; forelimbs and hindlimbs barred with dark brown stripes; sole and foot dark brown; ventrally cream; thigh and tibia orangish-yellow. In life (Image 22), color similar to preservation but slightly darker.

Variation: Morphological variation is provided in Table 9 and 10. Dorsum coloration ranges from grey to brown. Thigh and tibia could be cream.

Etymology: The species is named after Professor Alain Dubois, Muséum National d'Histoire Naturelle, Paris, for his important contributions towards understanding of higher taxonomy of amphibians.

Distribution: Currently the species is known from Kerekatte, Kudremukh National Park (13.322°N & 75.146°E, elevation 724m) and Mookambika Wildlife Sanctuary (13.917°N & 74.913°E, elevation 634m) (Fig. 11b).

***Indirana gundia* (Dubois, 1986)**

(Images 23 & 24)

Ranixalus gundia Dubois, 1986: p. 114

Common name: Gundia Leaping Frog

Type locality: Gundia, forêt de Kemphole, à l'ouest de Sakleshpur, Karnataka, Inde (= Gundia, Kemphole forest, west of Sakleshpur, Karnataka, India).

Material examined: Holotype: MNHN 1985.0633 (male), India: Karnataka: Gundia, Kemphole, west of Sakleshpur, coll. A. Dubois, 26.vii.1984.

Paratypes: MNHN 1985.0599, 0603, 0605, 0608, 0610 & 0628 (males) and MNHN 1985.0637 & 0638

(females), same data as holotype; MNHN 1985.0596 (male), locality same as holotype, 24.vii.1984; MNHN 1985.0611, 1985.0617–0620 and 1985.0622 (females), locality same as holotype, 27.vii.1984.

Comparative: WILD-14-AMP-499 (male), India: Karnataka: Gundia (12.825°N & 75.569°E, elevation 128m), coll. A. Padhye, N. Modak & S. Sulakhe, 29.vii.2014; WILD-14-AMP-500 (female), India: Karnataka: Gundia (12.829°N & 75.607°E, elevation 224m), coll. A. Padhye, N. Modak & S. Sulakhe, 29.vii.2014; WILD-13-AMP-012 & 013 (females), India: Karnataka: Shanthi Estate, Coorg (12.477°N & 75.709°E, elevation 1080m), coll. S. Molur, 2005; WILD-13-AMP-139 (female), India: Kerala: Aralam Wildlife Sanctuary (11.933°N & 75.838°E, elevation 162m), coll. K. Krutha, S. Kudalkar & A. Raj, 17.vii.2013; WILD-13-AMP-210 (female), India: Karnataka: Coorg (12.005°N & 75.890°E, elevation 817m), coll. K. Krutha & S. Kudalkar, 09.x.2013; WILD-13-AMP-211 (male), India: Karnataka: Kutta, Coorg (12.027°N & 75.932°E, elevation 812m), coll. K. Krutha & S. Kudalkar, 09.x.2013; WILD-13-AMP-136 (female), India: Kerala: Aralam (11.931°N & 75.836°E, elevation 180m), coll. K. Krutha, S. Kudalkar & A. Raj, 17.vii.2013; WILD-15-AMP-614 (female), India: Kerala: Ranipuram Vested Forest (12.414°N & 75.353°E, elevation 785m), coll. K. Krutha & H. Tripathi, 30.viii.2015; WILD-15-AMP-616 (female), India: Kerala: Ranipuram Vested Forest (12.419°N & 75.358°E, elevation 757m), coll. K. Krutha & H. Tripathi, 30.viii.2015; WILD-15-AMP-618 (female), India: Kerala: Ranipuram Vested Forest (12.416°N & 75.364°E, elevation 794m), coll. K. Krutha & H. Tripathi, 31.viii.2015; WILD-16-AMP-649 (female), India: Karnataka: Subramanya-Sullya road (12.651°N & 75.573°E, elevation 98m), A.D. Padhye, R. Patil, C. Risbud, S. Sulakhe, 30.vi.2016.

Diagnosis: *Indirana gundia* can be diagnosed based on following combination of characters: (i) first finger equal to or longer than second, (ii) double outer palmar tubercle, (iii) extensive webbing with a webbing formula I1-2II1-2½III1-3IV3-1V, (iv) tibio-tarsal articulation barely reaching snout, (v) vomerine teeth in slightly oblique rows its length about 7.5–12.0% of HL, (vi) choanae round to slightly oblong its maximum to minimum ratio 1.0–1.5, (vii) buccal cavity slightly deep 10.0–21.0% of HL, and (viii) double vocal sacs. Genetically, the species can be diagnosed from other members of *beddomii* group with 16S rRNA gene using combination of characters at position 838: T & 873: C, 890: G & 893: T, 1067: T & 1079: G (see Table 8). Geographically, the species is distributed in the Western Ghats between the Palghat and Goa gaps.

Comparison: *Indirana gundia* differs from *I. salelkari*

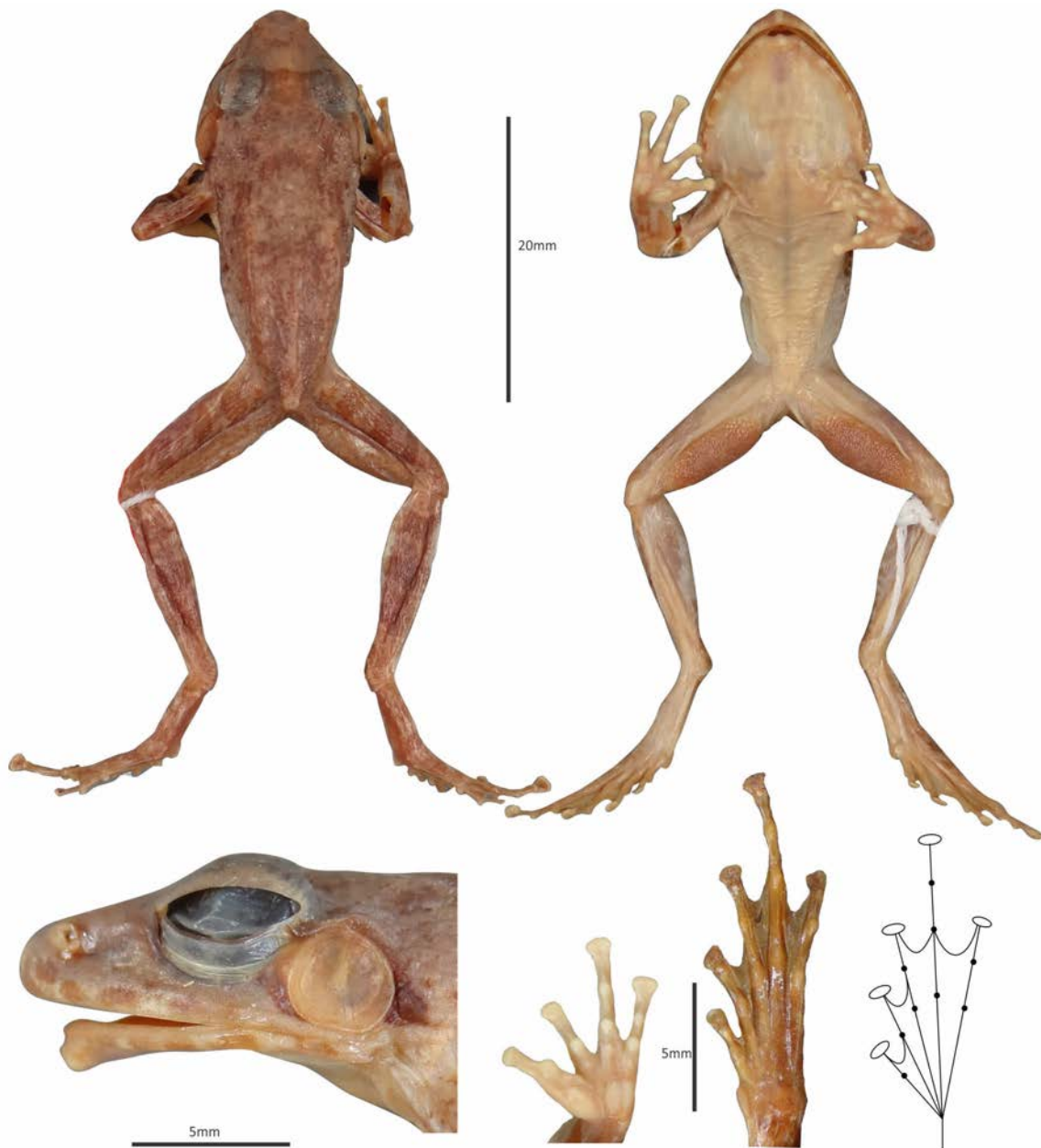


Image 23. *Indirana gundia* holotype MNHN 1985.0633 (male, 28.8mm SUL) from Gundia. © Nikhil Modak

in having shorter palm (PAL/SUL 0.23 ± 0.01 vs. 0.26 ± 0.02 , $t = 4.44$, $df = 33$, $P < 0.0001$), shorter thigh (THL/SUL 0.48 ± 0.04 vs. 0.53 ± 0.04 , $t = 3.20$, $df = 33$, $P = 0.003$) and shorter foot (FOL/SUL 0.47 ± 0.03 vs. 0.53 ± 0.05 , $t = 3.65$, $df = 33$, $P = 0.001$); from *I. sarojamma* in having shorter palm (PAL/SUL 0.23 ± 0.01 vs. 0.27 ± 0.01 , $t = 4.60$, $df = 28$, $P < 0.0001$), shorter thigh (THL/SUL 0.48 ± 0.04 vs. 0.56 ± 0.01 , $t = 3.69$, $df = 28$, $P < 0.001$), shorter foot length (FOL/SUL 0.47 ± 0.03 vs. 0.57 ± 0.02 , $t = 5.02$, $df = 28$, $P < 0.0001$) and smaller ratio between minimum distance in vomers and head length (minimum distance

between vomers/HL $0.04 - 0.07$ vs. 0.08); from *I. yadera* in having shorter thigh (THL/SUL 0.48 ± 0.04 vs. 0.57 ± 0.03 , $t = 4.01$, $df = 28$, $P < 0.0001$), shorter tibia (TL/SUL 0.55 ± 0.04 vs. 0.62 ± 0.02 , $t = 3.32$, $df = 28$, $P = 0.003$) and tibio-tarsal articulation barely reaches the snout ((THL+TL)/SUL 1.03 ± 0.07 vs. reaches beyond the snout 1.19 ± 0.03 , $t = 3.98$, $df = 28$, $P < 0.0001$).

For differences from *I. beddomii*, *I. brachytarsus*, *I. chiravasi* and *I. duboisi* see comparison section for the respective species.

Description of Holotype MNHN 1985.0633 (Image

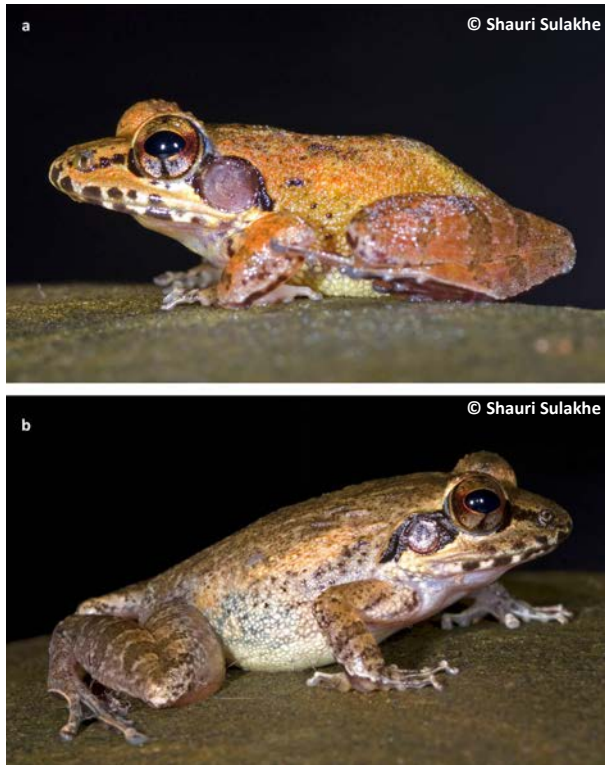


Image 24. *Indirana gundia* in life from Gundia, Karnataka. (a) Male (WILD-14-AMP-499, 26.8mm SUL) and (b) female (WILD-14-AMP-500, 36.4mm SUL).

23), male (all measurements in mm): Medium-sized frog (SUL 28.8); head longer than wide (HL 12.4 > HW 10.7); snout longer than horizontal diameter of eye (SL 5.5 > EL 4.2); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils closer to snout than to eye (SNL 2.2 < ENL 3.1); tympanum distinct, large, protruding, about 3/4th of the diameter of eye (TYL = 3.3), separated from eye with a distance about 1/6th of the TYL; supra-tympanic fold distinct; UEW slightly less than 2/3rd of EL (UEW = 2.8); upper eyelids sparsely tuberculated; IOL less than INL (IOL 2.2 < INL 3.4); canthus rostralis distinct; loreal region slightly concave and much oblique; buccal cavity wide, slightly deep, vomerine teeth in slightly oblique rows between the two margins of choanae; tongue thin, bifid; bear a mid-ventral papilla.

Upper arm longer than forearm (UAL 6.0 > FoAL 5.6); hand longer than forearm (PAL 7.1); fingers from shortest to longest – F1 (2.2) ≈ F2 (2.2) < F4 (3.3) < F3 (3.8); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate to large, supernumerary tubercles present, single; finger discs moderate in size, less than twice the width of finger (F3D = 1.1, F3W = 0.6), broad, truncate, bearing semicircular

groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 13.4 < TL 15.3); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 18.9); toe lengths from shortest to longest are – T1 (2.0) < T2 (2.8) < T3 (4.5) ≈ T5 (4.5) < T4 (7.3); toe discs equal to finger discs, its diameter slightly less than twice the width of toe (T4D = 1.1, T4W = 0.6); bear semicircular groove; inner metatarsal tubercle thin, elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate to large; tarsal fold and outer phalangeal fringe absent; webbing formula I1-2II1-2½III1-3IV3-1V.

Dorsal skin smooth with dense glandular longitudinal folds arranged in irregular rows; lateral side granular; ventral side smooth; postero-ventral side of thighs densely granular; thigh bearing large femoral glands.

Coloration: In alcohol preservation, dorsal brown with irregular dark brown spots and W shaped mark at the posterior border of head; white band followed posteriorly by dark band between upper eyelids; upper and lower mandible barred with brown stripes; distinct dark brown stripe running from tip of snout to shoulder through eye and tympanum; forelimbs and hindlimbs barred with dark brown stripes; sole and foot dark brown; ventrally cream to light brown.

Variation: Morphometric variation is provided in Table 9 and 10. Variation in coloration in life as per Image 24. Mid-dorsal broad white stripe may be present. Dorsum coloration ranges from pale to dark brown. Darker brown spots and W-shaped mark on dorsum sometimes absent. W-shaped mark sometimes has a glandular fold. Ventral surface sometimes granular.

Distribution: We recorded the species from Gundia (12.829°N & 75.607°E, elevation 224m), Coorg (12.477°N & 75.709°E, elevation 1080m), Aralam Wildlife Sanctuary (11.932°N & 75.838°E, elevation 162m), Kutta (12.027°N & 75.932°E, elevation 812m) and Ranipuram Vested Forest (12.414°N & 75.353°E, elevation 785m) (Fig. 11b). Genetically, confirmed records of the species are also available from Konnakkad (12.367°N & 75.373°E), Kanamvayal (12.295°N & 75.477°E), and Aralam (11.879°N & 75.889°E) (Jesmina & George 2015).

Indirana salelkari

Modak, Dahanukar, Gosavi & Padhye, 2015
(Images 25 & 26)

Common name: Netravali Leaping Frog

Type locality: Tanshikar Spice Farm in Neturlim (15.095°N & 74.211°E, elevation 78m), Sanguem Taluk,

South Goa District, Goa, India.

Material examined: Holotype: BNHS 5931 (male), India: Goa: Neturlim (15.095°N & 74.211°E, elevation 78m) coll. N. Modak, 11.x.2014.

Paratypes: BNHS 5933 (female), WILD-15-AMP-551 (female), ZSI-WRC A/1547 (female), BNHS 5932 (male) and WILD-15-AMP-552 (male), information same as holotype; AGCZRL-amphibia-209 (male), India: Goa: Neturlim (15.095°N & 74.211°E, elevation 78 m), coll. N. Modak & N. Gosavi, 6.ix.2014; AGCZRL-amphibia-210 (female), India: Goa: Neturlim (15.095°N & 74.211°E, elevation 78m) coll. N. Gosavi, 1.vi.2014.

Diagnosis: *Indirana salelkari* can be diagnosed based on following combination of characters: (i) first finger equal to or longer than second, (ii) double outer palmar tubercle, (iii) extensive webbing with a webbing formula I1-2II1-2½III1¼-3IV3-1¼V, (iv) tibio-tarsal articulation reaching slightly beyond the snout, (v) vomerine teeth in slightly oblique rows its length 10.0–11.5% of HL, (vi) choanae oblong its maximum to minimum ratio 1.7–2.0, and (vii) buccal cavity deep 21.0–25.0% of HL.

Genetically, the species can be diagnosed from the *beddomii* group with 16S rRNA gene unique character position 935: T, 985: A, 1023: G, 1089: C, 1092: C (see Table 8). Geographically, this species is distributed in the Western Ghats, north of the Goa gap.

Comparison: *Indirana salelkari* differs from *I. sarojamma* in having shorter toe 4 length (T4/SUL 0.29 ± 0.02 vs. 0.32 ± 0.02, $t = 2.11$, $df = 9$, one tailed $P = 0.04$), deeper buccal cavity (depth of buccal cavity/HL 0.22 to 0.25 vs. 0.17), larger ratio of vomerine length to head length (0.10–0.11 vs. 0.08) and tibio-tarsal articulation reaching just beyond the snout (THL+TL/SUL 1.12 ± 0.08 vs. reaches far beyond the snout 1.22 ± 0.02, $t = 1.97$, $df = 9$, one tailed $P = 0.04$); from *I. yadava* in having shorter head (HL/SUL 0.42 ± 0.02 vs. 0.47 ± 0.03, $t = 2.82$, $df = 9$, $P = 0.020$) and deeper buccal cavity (depth of buccal cavity/HL 0.22–0.25 vs. 0.11–0.13) and distributed in north of Palghat gap (vs. south of Palghat gap).

For differences from *I. beddomii*, *I. brachytarsus*, *I. chiravasi*, *I. doboisi* and *I. gundia* see comparison section for the respective species.

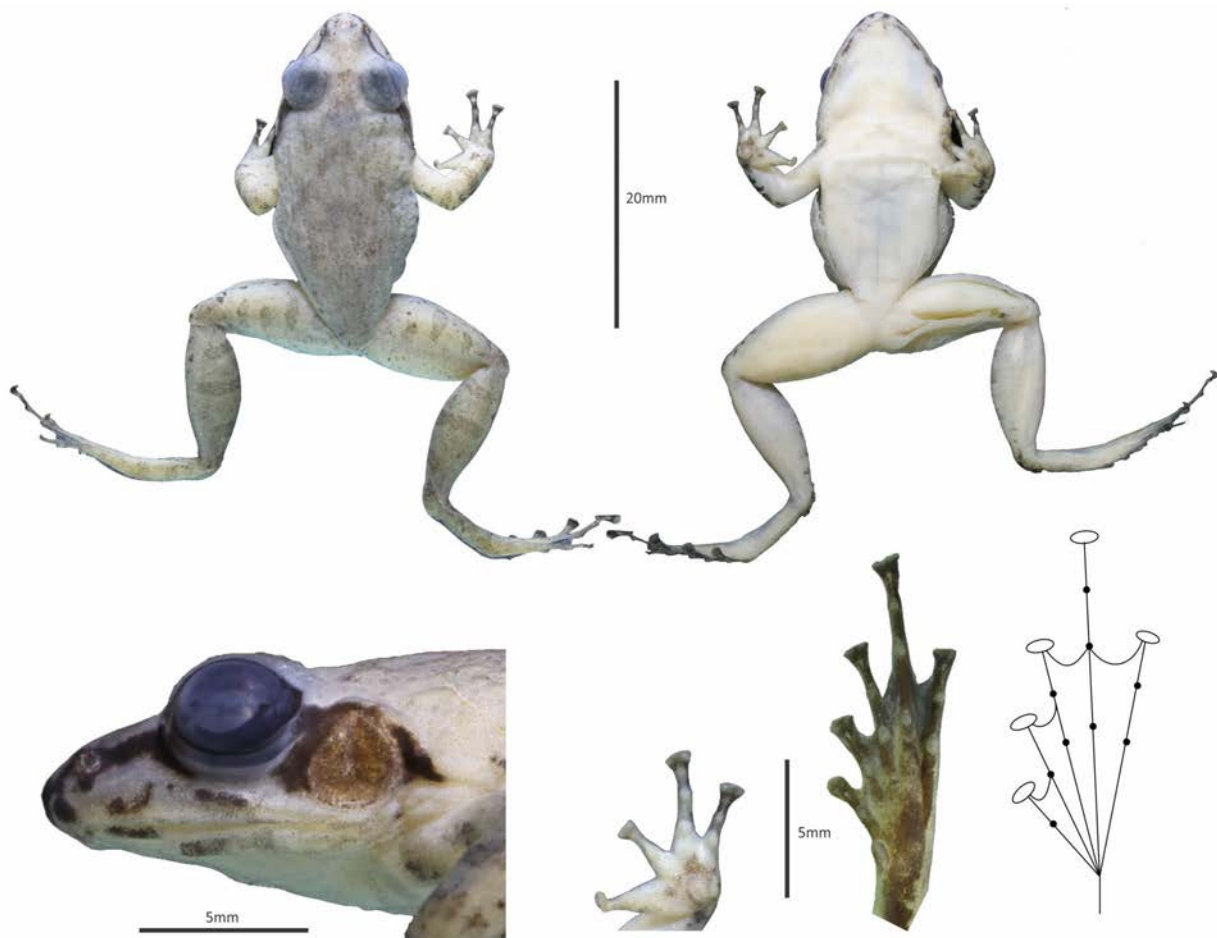


Image 25. *Indirana salelkari* holotype BNHS 5931 (male, 27.7mm SUL) from Neturlim. © Neelesh Dahanukar



Image 26. *Indirana salelkari* in life (paratype, AGCZRL-amphibia-210, female, 30.9mm SUL) from Neturlim.

Description: Detailed description of the holotype BNHS 5931, male (Image 25) appears in Modak et al. (2015).

Coloration: See Modak et al. (2015).

Variation: Morphometric variation is provided in Table 9 and 10. Variation in coloration in life as per Image 26.

Distribution: Currently the species is known only from its type locality, Tanshikar Spice Farm in Neturlim (15.095°N & 74.211°E, elevation 78m). The species is found north of the Goa gap (Fig. 11a).

Indirana sarojamma sp. nov.

(Image 27 & 28)

urn:lsid:zoobank.org:act:049266F6-6690-48FC-AA57-0A9FDE2BF8C0

Common name: Sarojamma's Leaping Frog

Material examined: Holotype: BNHS 5981 (female), India: Kerala: Ponmudi Reserve Forest (8.736°N & 77.141°E, elevation 879m), Kerala, India, coll. K. Krutha, Sivakumar & Nisha, 29.x.2013.

Comparative: BMNH 1947.2.27.87 (female) and BMNH 1947.2.27.88 (male), India: Travancore, coll. Col. Beddome (syntypes of *I. beddomii*).

Diagnosis: *Indirana sarojamma* sp. nov. can be diagnosed based on following combination of characters: (i) first finger equal to or longer than second, (ii) double outer palmar tubercle, (iii) extensive webbing with a webbing formula I1-2II1-2½III1-3IV3-1V, (iv) tibio-tarsal articulation reaching beyond snout, (v) vomerine teeth in slightly oblique rows its length about 8.0–8.5% of HL, (vi) choanae round to slightly oblong its maximum to minimum ratio 1.2–1.3, (vii) buccal cavity slightly deep 15.0–17.0% of HL, (viii) FOL more than 55% of SUL, (ix)

TL more than 60% of SUL, (x) PAL more than 25% of SUL, and (xi) UAL less than 19–23% of SUL. Genetically, the species can be diagnosed from other members of the *beddomii* group with 16S rRNA gene using unique characters at position 926: C; and character combination 960: C & 970: T & 971: G, 981: G & 982: A, 1173: G & 1230: T. 926: C; character combination 960: C & 970: T & 971: G, 981: G & 982: A, 1173: G & 1230: T (see Table 8). Geographically, the species is distributed in the Western Ghats, south of the Palghat gap.

Comparison: *Indirana sarojamma* differs from *I. yadera* in having longer palm (PAL/SUL 0.27 ± 0.01 vs. 0.25 ± 0.00 , $t = 5.34$, $df = 4$, $P = 0.006$), longer foot (FOL/SUL 0.57 ± 0.02 vs. 0.51 ± 0.02 , $t = 3.74$, $df = 4$, $P = 0.020$), deeper buccal cavity (depth of buccal cavity/HL 0.17 vs. $0.11 - 0.13$) and smaller vomerine length to head length ratio (0.08 vs. 0.10).

For differences from *I. beddomii*, *I. brachytarsus*, *I. chiravasi*, *I. duboisi*, *I. gundia* and *I. salelkari* see comparison section for the respective species.

Description of Holotype BNHS 5981 (Images 27 & 28), female (all measurements in mm): Medium-sized frog (SUL 34.5); head longer than wide (HL 14.3 > HW 12.9); snout longer than horizontal diameter of eye (SL 6.3 > EL 3.2); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils closer to snout than to eye (SNL 2.0 < ENL 3.6); tympanum distinct, about 90% of the diameter of eye (TYL = 2.9), separated from eye with a distance less than half of the TYL; supra-tympanic fold distinct; UEW slightly more than 3/4th of EL (UEW = 2.5); upper eyelids densely tuberculated; IOL more than INL (IOL 3.9 > INL 3.4); canthus rostralis distinct; loreal region slightly concave and oblique; buccal cavity wide, shallow, vomerine teeth in slightly oblique rows at the posterior border of choanae; tongue thin, bifid; bear a mid ventral papilla.

Upper arm shorter than forearm (UAL 7.9 < FoAL 8.8); hand longer than forearm length (PAL 9.3); finger lengths from shortest to longest – F2 (2.8) < F1 (3.0) < F4 (3.8) < F3 (4.8); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate to large, supernumerary tubercles present, single; finger discs moderate in size, less than twice the width of finger (F3D = 1.3, F3W = 0.7), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 19.6 < TL 21.7); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 27.9); toe lengths from shortest to longest are – T1 (2.6) < T2 (3.6) < T3 (6.0) < T5 (6.1) < T4

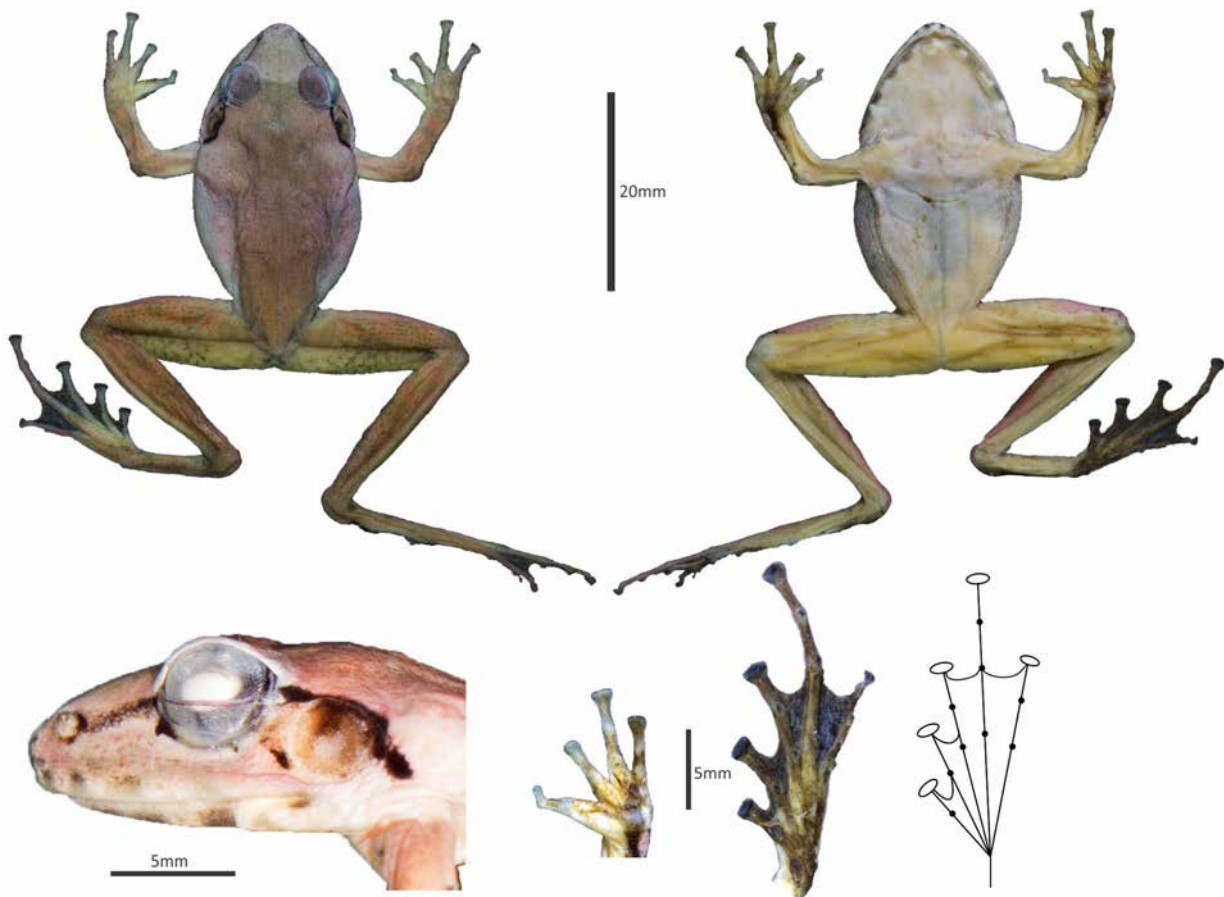


Image 27. *Indirana sarojamma* sp. nov. holotype BNHS 5981 (female, 34.5mm SUL) from Ponnudi. © Neelesh Dahanukar

(10.8); toe discs slightly less than finger discs, its diameter slightly less than twice the width of toe ($T4D = 1.2$, $T4W = 0.7$); bear semicircular groove; inner metatarsal tubercle elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate to large; tarsal fold and outer phalangeal fringe absent; webbing formula I1-2III1-2 $\frac{1}{2}$ III1-3IV3-1V.

Dorsal skin smooth with few glandular longitudinal folds arranged in irregular rows; lateral side granular with dense granulation below the tympanum; ventral side smooth.

Coloration: In alcohol preservation (Image 27), dorsal pinkish-brown; white band followed posteriorly with a dark brown band between the two upper eyelids; upper and lower mandible barred with brown stripes; distinct dark brown stripe running from tip of snout to shoulder through eye and tympanum; ventrally cream; forelimbs and hindlimbs barred with dark brown stripes; sole and foot dark brown; ventrally cream. In life (Image 28), coloration similar to that in alcohol, but slightly darker.

Etymology: The species is named after Mrs. S. Saroja, who has contributed immensely to the functioning of

the Zoo Outreach Organization for three decades and helping Sally Walker to volunteer at Mysore Zoo for five years before that. The name is in recognition of her selfless service committing all her time and forsaking her family life for the organization. Sarojamma is the name she is known by and she is the 'office mom'. It is a noun used in apposition.

Variation: Morphological variation is provided in Table 9 and 10. Mid-dorsal broad white stripe may be present, interrupted by dark band between the upper eyelids. Dorsum coloration ranges from pale to dark brown with dark brown spots and W-shaped mark on dorsum sometimes present.

Distribution: Currently the species is known only from the Ponnudi Reserve Forest (8.736°N & 77.141°E, elevation 879m), Kerala (Fig. 11c).

Remarks: Two syntypes of *I. beddomii*, BMNH 1947.2.27.87 (female) and 1947.2.27.88 (male) (Image 29), from Travancore are conspecific with *I. sarojamma* with respect to key characters such as (i) $1\frac{1}{4}$ phalange free on inner side of third to, (ii) buccal cavity deeper 18.2% HL, (iii) vomerine teeth series length less than



Image 28. *Indirana sarojamma* sp. nov. from Ponmudi (holotype, BNHS 5981, female, 34.5mm SUL) in life.

10.0% HL, (iv) vomerine teeth series separated by larger distance from each other, (v) smaller choanae, (vi) tibio-tarsal articulation reaching much beyond snout, and (vii) relatively longer snout, finger 1, tibia, foot and toe 1 as compared to the lectotype of *I. beddomii* as well as *I. brachytarsus*. We therefore consider BMNH 1947.2.27.87 (female) and 1947.2.27.88 (male) as comparative material of *Indirana sarojamma*.

***Indirana yadera* sp. nov.**

(Images 30 & 31)

urn:lsid:zoobank.org:act:0D1107AB-9999-4535-876F-D7639A5FE5A0

Common name: Yadera Leaping Frog

Material examined: Holotype: BNHS 5982 (female), India: Kerala: Vathikudy, Idukki Wildlife Sanctuary (9.874°N & 77.076°E, elevation 797m), coll. K. Krutha & B. Kumar, 17.xii.2013.

Paratype: WILD-13-AMP-338 (female), India: Kerala: Neyyar Wildlife Sanctuary (8.563°N & 77.165°E, elevation 138m), coll. K. Krutha, Sivakumar & Nisha, 4.xi.2013; WILD-14-AMP-479 (female), India: Kerala: Chimmony Wildlife Sanctuary (10.445°N & 76.460°E, elevation 55m), coll. K. Krutha & V.K. Jayanandan, 3.xii.2013.

Diagnosis: *Indirana yadera* sp. nov. can be diagnosed based on following combination of characters: (i) first finger equal to or longer than second, (ii) double outer palmar tubercle, (iii) extensive webbing with a webbing formula I1-2II1-2III1-3IV3-1V, (iv) tibio-tarsal articulation reaching beyond snout, (v) vomerine teeth



Image 29. Syntypes of *I. beddomii* conspecific with *I. sarojamma* sp. nov. (a) BMNH 1947.2.27.87 (female, 33.0 mm SUL) and (b) BMNH 1947.2.27.88 (male, 31.0 mm SUL). © Nikhil Modak

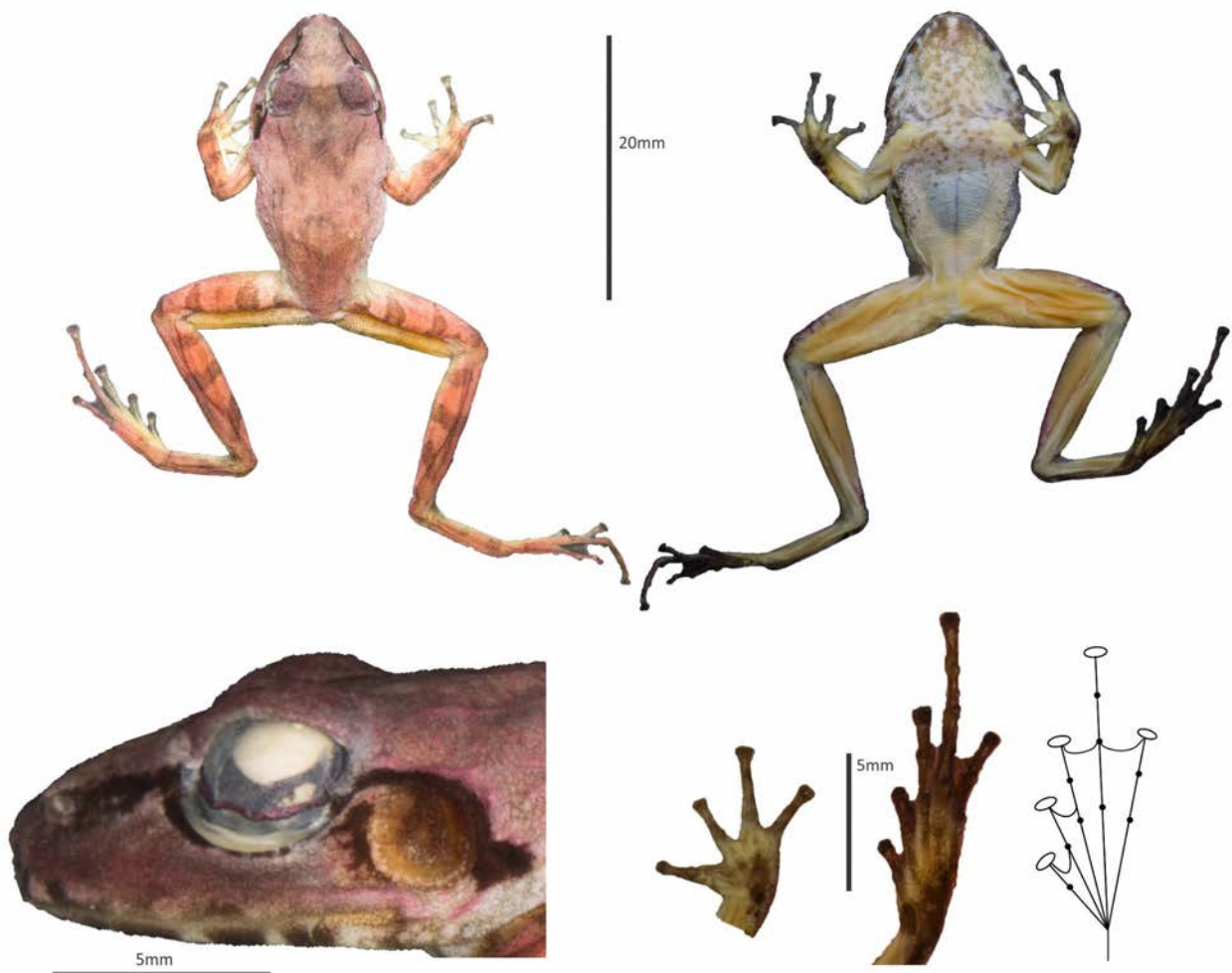


Image 30. *Indirana yadera* sp. nov. holotype BNHS 5982 (female, 23.7mm SUL) from Vagamalai. © Neelesh Dahanukar



Image 31. *Indirana yadera* sp. nov. from Chimmony (paratype, WILD-14-AMP-479, female, 26.7mm SUL) in life.

in slightly oblique rows its length about 9.5–10.0% of HL, (vi) choanae round to slightly oblong its maximum to minimum ratio 1.2–1.4, (vii) buccal cavity slightly deep 10.0–17.0% of HL, (viii) FOL less than 55% of SUL, (ix) TL more than 60% of SUL, (x) PAL less than 25% of SUL, and (xi) UAL less than 20% of SUL. Genetically, the species can be diagnosed from other members of the *beddomii* complex with 16S rRNA gene using unique characters at position 894: T, 897: A, 956: G, 982: C, 1084: T, 1112: T (see Table 8). Geographically, the species is distributed in the Western Ghats, south of the Palghat gap.

Comparison: For differences between *Indirana yadera* and *I. beddomii*, *I. brachytarsus*, *I. chiravasi*, *I. duboisi*, *I. gundia*, *I. salelkari* and *I. sarojamma* see comparison section for the respective species.

Description of Holotype BNHS5982 (Image 30). Female (all measurements in mm): Small-sized frog (SUL 23.7); head longer than wide (HL 11.3 > HW 9.5); snout longer than horizontal diameter of eye (SL 4.5

> EL 4.0); pupil horizontal; outline of snout suboval dorsally, rounded laterally; ventrally snout slightly protruding beyond the mouth; nostrils closer to snout than to eye (SNL 1.6 < ENL 2.4); tympanum distinct, half of the diameter of eye (TYL = 2.0), separated from eye with a distance about 1/3rd of the TYL; supra-tympanic fold distinct; UEW slightly more than half of EL (UEW = 2.3); upper eyelids densely tuberculated; IOL less than INL (IOL 2.3 < INL 2.6); canthus rostralis distinct; loreal region slightly concave and oblique; buccal cavity wide, slightly deep, vomerine teeth in slightly oblique rows between the two margins of choanae; tongue thin, bifid; bear a mid ventral papilla.

Upper arm shorter than forearm (UAL 4.4 < FoAL 4.9); hand longer than forearm length (PAL 5.9); finger lengths from shortest to longest – F2 (1.5) < F1 (1.7) < F4 (2.2) < F3 (3.1); palmar tubercles present, outer palmar tubercle double, subarticular tubercles moderate to large, supernumerary tubercles present, single; finger discs moderate in size, twice the width of finger (F3D = 0.8, F3W = 0.4), broad, truncate, bearing semicircular groove; fingers without web or fringe of skin.

Thigh shorter than shank (tibia) (THL 13.7 < TL 15.2); total foot length (including astragalus-calcaneum) longer than tibia (TFOL 19.3); toe lengths from shortest to longest are – T1 (1.6) < T2 (2.2) < T5 (3.8) < T3 (3.9) < T4 (5.2); toe discs slightly larger than finger discs, its diameter slightly less than twice the width of toe (T4D = 0.9, T4W = 0.5); bear semicircular groove; inner metatarsal tubercle thin, elongated; outer metatarsal tubercle absent; supernumerary tubercles absent; subarticular tubercles moderate to large; tarsal fold and outer phalangeal fringe absent; webbing formula I1-2III1-2III1-3IV3-1V.

Dorsal skin smooth with dense glandular longitudinal folds arranged in irregular rows; lateral side granular; ventral side smooth; posteroventral side of femur dense granular.

Coloration: In alcohol preservation, dorsal pinkish-brown with irregular dark brown spots and W-shaped mark at the posterior border of head; white band followed posteriorly by dark band between upper eyelids; upper and lower mandible barred with brown stripes; distinct dark brown stripe running from tip of snout to shoulder through eye and tympanum; forelimbs and hindlimbs barred with dark brown stripes; sole and foot dark brown; ventrally cream; throat mottled with brown; thigh and tibia orangish-yellow.

Etymology: The species is a combination name of Yamini, Deepa and Ravisankaran, a family of good friends who met with untimely demise. The species is named

after the three as a dedication to Ravisankaran's service to conservation, Deepa's support and Yamini's spirit. The combination name is used as a noun in apposition.

Variation: Morphological variation is provided in Table 9 and 10. Live coloration as in Image 31. Dorsum coloration ranges from grey to dark brown. Mottling on throat could be absent. Thigh and tibia could be cream. W-shaped mark sometimes absent.

Distribution: Currently the species is known from three localities south of the Palghat gap, Vagamalai in Idukki Wildlife Sanctuary (9.874°N & 77.076°E, elevation 797m), Neyyar Wildlife Sanctuary (8.563°N & 77.165°E, elevation 138m) and Chimmony Wildlife Sanctuary (10.445°N & 76.460°E, elevation 55m) in Kerala (Fig. 11c).

DISCUSSION

Molecular phylogeny of species under family Ranixalidae revealed the presence of two distinct clades distinguished from each other by the extent of webbing. It is therefore clear that the clade previously recognized as *Indirana* was polyphyletic with respect to the extent of webbing. We therefore recognize *Walkerana* gen. nov. to resolve the polyphyly and obtain two monophyletic clades. Although the taxonomic sampling in Modak et al. (2015) is not extensive, it can be inferred from their molecular clock analysis based on two mitochondrial and one nuclear gene, that *Indirana* and *Walkerana* split from each other around 58.4 mya (95% HPD interval 70.0–48.5 mya).

Molecular phylogeny and dating has revealed that Ranixalidae probably had a delayed diversification in the early cenozoic (Roelants et al. 2004; Van Boxclaer et al. 2012). Ranixalidae probably split from its sister taxon Micrixalidae around 89.7 mya (95% HPD interval 90.5–86.9 mya) and the members of Ranixalidae did not diverge much until about 58.4 mya (95% HPD interval 70.0–48.5 mya) before splitting into *Indirana* and *Walkerana* (Modak et al. 2015). Genus *Indirana* further showed a lag till 33.4 mya (95% HPD interval 41.5–26.0 mya) after which it started diverging rapidly (Modak et al. 2015). It is therefore likely that since the divergence of members of the *beddomii* group is relatively recent they are morphologically quite similar; although the species form monophyletic clades, are separated by distinct geographical areas and are morphologically distinct in multivariate morphometric space.

Morphological similarities among the members of *beddomii* group are also evident from following

discussion. While describing *Indirana brachytarsus*, Günther (1876) separated the species from *I. beddomii* based on a single character of shorter tarsus. Subsequently, Boulenger (1882) synonymized *I. brachytarsus* to *I. beddomii*. Further, while resurrecting the species from its synonymy with *I. beddomii*, Inger et al. (1984) used characters such as larger size and amount of webbing. It is interesting to note that while describing the members of the *beddomii* group, *I. gundia*, the author did not provide any comparison for separating the species from closely allied species (see Dubois 1986). Dubois (1987b) thought that *I. gundia* could be a synonym of *I. brachytarsus* based on their morphological similarity. Although Padhye et al. (2014) and Modak et al. (2015) provided some characters to separate the newly described species, *I. chiravasi* and *I. salelkari* respectively, from the *beddomii* group, their analysis was based on the study of only the type material which consisted of limited number of specimens. Our study, based on a much larger sampling clearly revealed that there are only few discrete morphological characters to separate the members of the *beddomii* group. These characters include extent of webbing on the inner side of the third toe, extent of the overlap of the heels when thighs are held at right angle to the body axis, depth of buccal cavity and length and placement of vomerine teeth series as mentioned in the key to the species of *Indirana*. A more reliable way to separate the species is by using integarted taxonomy. It is also essential to note that the keys by Boulenger (1920) and Daniel & Sekar (1989) separate *I. semipalmata*, *I. leithii* and members of *Walkerana* from *I. beddomii*; however, none provide a key to separate members of the *beddomii* group. Because members of the *beddomii* group are morphologically similar, Nair et al. (2012a) misidentified several of the known species from this group, which we could rectify (Table 11) based mainly on genetic analysis of topotypic material of the known species.

Several sequences available on NCBI for members of the genus *Indirana* and *Walkerana* are based on misidentifications. For these sequences we provide the correct species identification (Table 11) based on analysis of 16S rRNA gene. Some of the sequences identified as *I. diplosticta* (JQ596653 to JQ596657) formed a monophyletic clade separated from *I. semipalmata* and therefore are considered here as *I. cf. semipalmata*. Sequences of *I. gundia* submitted to GenBank prior to the publication of Padhye et al. (2014) have been largely misidentified as *I. beddomii*. Sequence JQ596677 deposited as *I. cf. beddomii* by Nair et al. (2012a) belongs to *I. sarojamma* sp. nov. Sequences

JQ596674, 75 and 76 submitted as *I. cf. beddomii* by Nair et al. (2012a) as well as KT282219 identified as *I. beddomii* by Jesmina & George (2015) and other sequences KJ585610-13 submitted as *Indirana* sp. are conspecific with *I. yadera* sp. nov. Sequence JQ596673 of *I. leithii* identified by Nair et al. (2012a) has already been suggested as not conspecific with topotypic *I. leithii* and was therefore considered as *I. cf. leithii* by Modak et al. (2014). Sequences AF215392 (from Ooty, approx. 11.406°N & 76.693°E), JQ596658-62, KF991280, KJ585595-99 identified as *Indirana* sp. can be assigned to *I. beddomii* based on current study. Sequences (GU136104, JQ596642-44, AF215391 and KF991281) that are currently assigned to *I. brachytarsus* have been identified previously as *I. beddomii*, *I. cf. beddomii*, and *Indirana* sp. Further, sequences KT282223, JQ596681-85 identified as *I. leptodactyla* are not conspecific with topotypic *Walkerana leptodactyla* comb. nov. and are considered as *Walkerana cf. leptodactyla* comb. nov.

We have provided the first comprehensive review of species in the family Ranixalidae and clarify the identity as well as distribution of several species. We caution the readers from relying on the review of *Indirana* provided by Nair et al. (2012b) for the following reasons: (i) they do not provide detailed taxonomic comments on the species; (ii) they are heavily dependent on the earlier literature for records of the species without critically validating the authenticity of the reports; (iii) although they mention observation of the types and other voucher specimens in the collections of several museums, they provide no details of the material examined; (iv) they acknowledge their own study (Nair et al. 2012a) for suggesting that some species, such as *I. beddomii*, are a complex, but do very little to resolve the taxonomic issue; and (v) some of the records are likely based on misidentification. For instance, Modak et al. (2014) showed that the species considered as *I. leithii* by Nair et al. (2012a), and subsequently used prominently in Nair et al. (2012b), is not conspecific with the topotypic *I. leithii*, especially in genetic analysis; hence the information provided regarding the distribution of this species is erroneous.

In the IUCN Red List of Threatened Species, *Indirana gundia* and *Walkerana phrynoderma* are listed as Critically Endangered (Biju et al. 2004c, 2004i); *I. brachytarsus*, *W. diplosticta* and *W. leptodactyla* as Endangered (Biju et al. 2004b, 2004h; Biju & Dutta 2004); *I. leithii* as Vulnerable (Biju et al. 2004g); *I. beddomii* and *I. semipalmata* as Least Concern (Biju et al. 2004a, 2004e); and *I. tenuilingua* as Data Deficient (Biju et al. 2004f). The IUCN status of most of these species need

Table 11. Sequences of *Indirana* available in GenBank and their correct identification based on current study.

GenBank number	Current identification	Correct identification
JQ596663	<i>Indirana cf. beddomii</i>	<i>Indirana duboisi</i>
JQ596666	<i>Indirana cf. beddomii</i>	<i>Indirana duboisi</i>
JQ596665	<i>Indirana cf. beddomii</i>	<i>Indirana duboisi</i>
JQ596664	<i>Indirana cf. beddomii</i>	<i>Indirana duboisi</i>
JQ596667	<i>Indirana cf. beddomii</i>	<i>Indirana duboisi</i>
AB530593	<i>Indirana cf. semipalmata</i>	<i>Indirana duboisi</i>
KJ585620	<i>Indirana sp. SG-2014d</i>	<i>Indirana duboisi</i>
KJ585619	<i>Indirana sp. SG-2014d</i>	<i>Indirana duboisi</i>
KJ585622	<i>Indirana sp. SG-2014d</i>	<i>Indirana duboisi</i>
KJ585621	<i>Indirana sp. SG-2014d</i>	<i>Indirana duboisi</i>
KJ585618	<i>Indirana sp. SG-2014d</i>	<i>Indirana duboisi</i>
JQ596653	<i>Indirana cf. diplosticta</i>	<i>Indirana cf. semipalmata</i>
JQ596654	<i>Indirana cf. diplosticta</i>	<i>Indirana cf. semipalmata</i>
KJ585583	<i>Indirana sp. SG-2014a</i>	<i>Indirana cf. semipalmata</i>
JQ596655	<i>Indirana cf. diplosticta</i>	<i>Indirana cf. semipalmata</i>
JQ596657	<i>Indirana cf. diplosticta</i>	<i>Indirana cf. semipalmata</i>
KJ585584	<i>Indirana sp. SG-2014a</i>	<i>Indirana cf. semipalmata</i>
JQ596656	<i>Indirana cf. diplosticta</i>	<i>Indirana cf. semipalmata</i>
KJ585581	<i>Indirana sp. SG-2014a</i>	<i>Indirana cf. semipalmata</i>
KJ585585	<i>Indirana sp. SG-2014a</i>	<i>Indirana cf. semipalmata</i>
KJ585601	<i>Indirana beddomii</i>	<i>Indirana gundia</i>
KJ585602	<i>Indirana beddomii</i>	<i>Indirana gundia</i>
JQ596649	<i>Indirana cf. beddomii</i>	<i>Indirana gundia</i>
JQ596648	<i>Indirana cf. beddomii</i>	<i>Indirana gundia</i>
JQ596650	<i>Indirana cf. beddomii</i>	<i>Indirana gundia</i>
JQ596651	<i>Indirana cf. beddomii</i>	<i>Indirana gundia</i>
JQ596652	<i>Indirana cf. beddomii</i>	<i>Indirana gundia</i>
KJ585600	<i>Indirana beddomii</i>	<i>Indirana gundia</i>
KJ585604	<i>Indirana beddomii</i>	<i>Indirana gundia</i>

GenBank number	Current identification	Correct identification
KJ585603	<i>Indirana beddomii</i>	<i>Indirana gundia</i>
JQ596677	<i>Indirana cf. beddomii</i>	<i>Indirana sarojamma</i>
JQ596674	<i>Indirana cf. beddomii</i>	<i>Indirana yadera</i>
KT282219	<i>Indirana beddomii</i>	<i>Indirana yadera</i>
KJ585612	<i>Indirana sp. SG-2014c</i>	<i>Indirana yadera</i>
JQ596675	<i>Indirana cf. beddomii</i>	<i>Indirana yadera</i>
KJ585617	<i>Indirana sp. SG-2014c</i>	<i>Indirana yadera</i>
KJ585611	<i>Indirana sp. SG-2014c</i>	<i>Indirana yadera</i>
KJ585610	<i>Indirana sp. SG-2014c</i>	<i>Indirana yadera</i>
JQ596676	<i>Indirana cf. beddomii</i>	<i>Indirana yadera</i>
KJ585613	<i>Indirana sp. SG-2014c</i>	<i>Indirana yadera</i>
JQ596658	<i>Indirana sp. 87</i>	<i>Indirana beddomii</i>
JQ596661	<i>Indirana sp. 95</i>	<i>Indirana beddomii</i>
KJ585596	<i>Indirana sp. SG-2014b</i>	<i>Indirana beddomii</i>
KJ585597	<i>Indirana sp. SG-2014b</i>	<i>Indirana beddomii</i>
KJ585599	<i>Indirana sp. SG-2014b</i>	<i>Indirana beddomii</i>
KJ585595	<i>Indirana sp. SG-2014b</i>	<i>Indirana beddomii</i>
JQ596659	<i>Indirana sp. 88</i>	<i>Indirana beddomii</i>
KJ585598	<i>Indirana sp. SG-2014b</i>	<i>Indirana beddomii</i>
AF215392	<i>Indirana sp. Ooty</i>	<i>Indirana beddomii</i>
KF991280	<i>Indirana sp. IN-1</i>	<i>Indirana beddomii</i>
JQ596660	<i>Indirana sp. 89</i>	<i>Indirana beddomii</i>
JQ596662	<i>Indirana sp. 99</i>	<i>Indirana beddomii</i>
GU136104	<i>Indirana beddomii</i>	<i>Indirana brachytarsus</i>
JQ596644	<i>Indirana cf. beddomii</i>	<i>Indirana brachytarsus</i>
JQ596643	<i>Indirana cf. beddomii</i>	<i>Indirana brachytarsus</i>
JQ596642	<i>Indirana cf. beddomii</i>	<i>Indirana brachytarsus</i>
AF215391	<i>Indirana sp. Kodaikanal</i>	<i>Indirana brachytarsus</i>
KF991281	<i>Indirana sp. IN-2</i>	<i>Indirana brachytarsus</i>

to re-assessed. *Indirana gundia* is listed as Critically Endangered (Biju et al. 2004c) based on restricted distribution; however, our analysis and data from Jesmina & George (2015) suggests that the species is widespread in northern Kerala and southern Karnataka. On the other hand, *I. beddomii*, listed as Least Concern based on wide distribution (Biju et al. 2004a), is likely to be more restricted in its distribution. Recent studies have also revealed the presence of infectious chytrid fungal disease caused by *Batrachochytrium dendrobatidis* in at least two species of *Indirana*, namely *I. brachytarsus* and *I. leithii* (Nair et al. 2011; Dahanukar et al. 2013; Molur et al. 2015), which needs to be considered while understanding the extinction risk of these species. It is

essential to note that since we treat *Philautus longicrus* Rao, 1937 (= *Philautus crnri* Dutta, 1985) as incertae sedis under the order Anura and *Indirana tenuilingua* as incertae sedis under the genus *Indirana* until further information is available, their current status as Data Deficient (Biju et al. 2004d, Biju et al. 2004f) is invalid.

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