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## A Novel Color Morph and Additional Population of *Raorchestes akroparallagi* (Anura: Rhacophoridae) and a Second *R. chromasynchysi* Population in Karnataka, India

Both *Raorchestes akroparallagi* and *R. chromasynchysi* are recently described members of the frog family Rhacophoridae (Biju and Bossuyt 2009), endemic to the Western Ghats region of southern India. At the time of discovery, these species were considered members of the genus *Philautus*, which has since been revised after a thorough phylogenetic review of the family Rhacophoridae and erection of the genus *Raorchestes* (Biju et al. 2010). Conservation assessments of these species are not available due to a lack of data (IUCN 2011). We present findings of additional populations of these poorly-known species, the first records from Karnataka state.

**Study Site and Methods.**—In October 2009, we documented the presence of *R. akroparallagi* and *R. chromasynchysi* during biological surveys at Mojo Plantation, a 10-ha spice farm located approximately 10 km from Madikeri, Karnataka (12.47°N, 75.70°E). Certified organic by the Institute for Marketecology (IMO), Mojo Plantation grows a variety of native and exotic spice crops (e.g., coffee, cardamom, black pepper, vanilla) without the use of inorganic fertilizers, pesticides, or herbicides. Crops are grown in low density beneath the rainforest canopy, interspersed

with patches of native vegetation. Two streams originate on the property, flowing south toward the Kaveri River. Frogs were collected on nocturnal and crepuscular surveys of this agroecosystem between 1 October and 15 November 2009. Each frog was enclosed in a terrarium, photographed, and released at the location of its capture within 48 h.

We placed each frog in a glass petri dish that was marked in ink with a 20 mm scale bar, and took digital photos at a perpendicular angle to the subject (i.e., straight above or below). We used ImageJ software (version 1.44, NIH, available from: <http://rsbweb.nih.gov/ij/>; Abramoff et al. 2004) to measure

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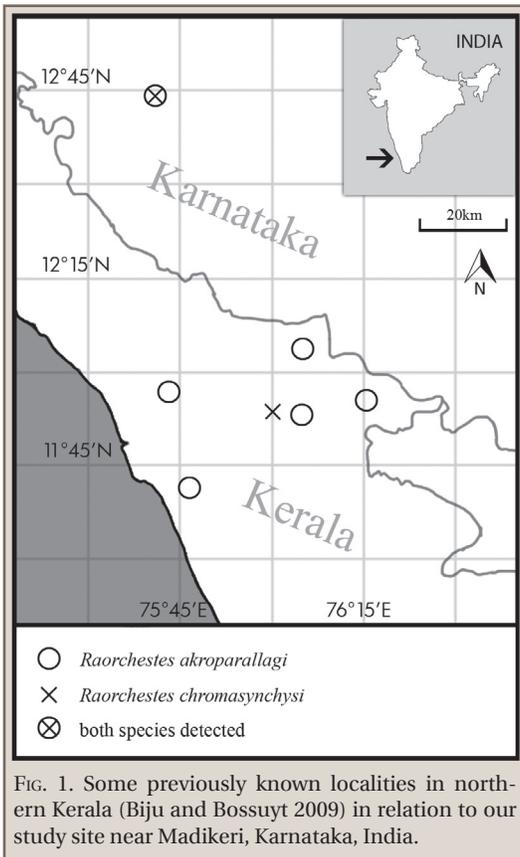


FIG. 1. Some previously known localities in northern Kerala (Biju and Bossuyt 2009) in relation to our study site near Madikeri, Karnataka, India.

morphometric traits from scaled digital photographs of live specimens ( $N = 7$ ; Table 1) using the methodology of Antwis and Browne (2008). The following morphometrics were calculated: snout-vent length (SVL); head length (HL), measured from the rear of the mandible to the tip of the snout; head width (HW), measured at the angle of the jaws. Frogs could not be assigned to sex. Due to polymorphism and metachrosis, identification of *Raorchestes* frogs is difficult based on dorsal coloration alone (Biju and Bossuyt 2009); we documented color variation due to metachrosis by photographing individual frogs, in similar light conditions, multiple times over the duration of their captivity.

*Raorchestes akroparallagi*.—Biju and Bossuyt (2009) described *R. akroparallagi* from Ponnundi ( $8.75^{\circ}\text{N}$ ,  $77.12^{\circ}\text{E}$ ), and reported populations at one site in Tamil Nadu and several sites in northern Kerala (Fig. 1). As its name implies (*akro* is Greek for “extreme,” *parallagi* for “variation”), this species exhibits substantial polychromatism. Biju and Bossuyt (2009) described four color morphs from populations in Kerala: 1) grayish white, 2) light green without markings, 3) golden yellow with contrasting brown spots on dorsum and light brown bands on limbs, 4) dark green with yellowish stripe extending laterally from snout to near the vent.

We discovered an additional population near Madikeri, Karnataka, extending the range of this poorly-known species by over 75 km northward and representing a first state record. This population features a morph with a blue dorsum (Fig. 2A) in syntopy with a light green morph (Fig. 2B; similar to paratype BNHS 4388, but with small contrasting spots on the dorsum). A blue morph of this species has been previously found in Wayanad, Kerala, (S.D. Biju, pers. comm.) but has not been described in publication.

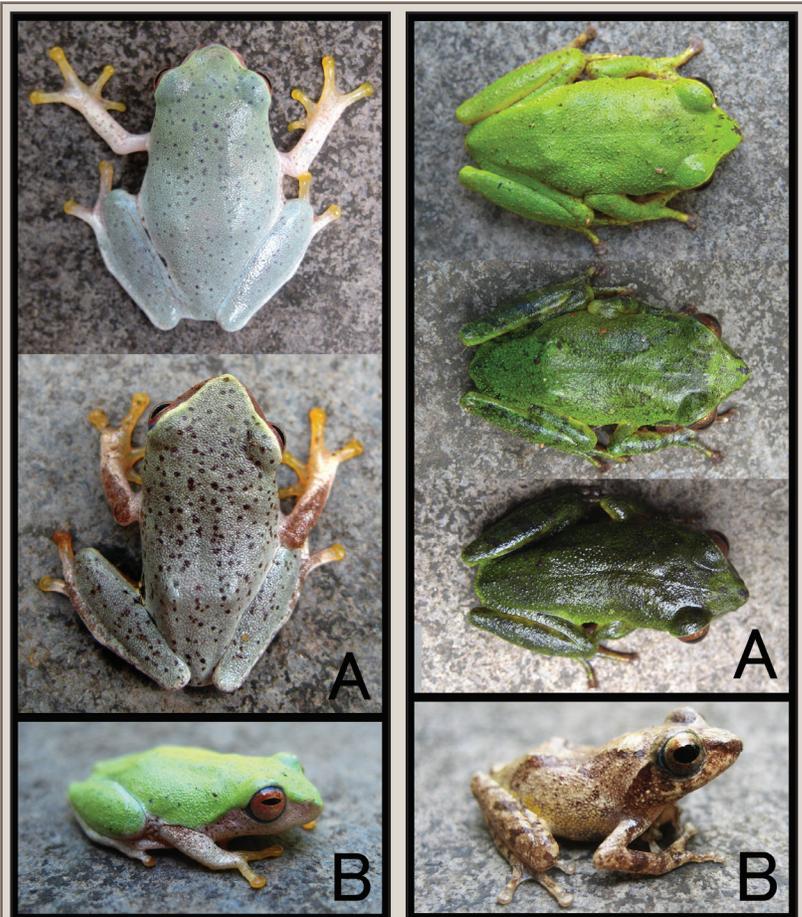


FIG. 2 (left). *Raorchestes akroparallagi* A) color variation of a single blue morph individual due to metachrosis; B) green morph found in syntopy with blue morph.

FIG. 3 (right). *Raorchestes chromasynchysi* A) color variation of a single green morph individual due to metachrosis; B) brown morph found in syntopy with green morph.

The blue morph at our study site features a white line that traces the canthal ridge and anterior edge of the upper-eyelid (similar to BNHS 4392, but terminating at the posterior edge of the eyelid). This line appears in high contrast when the dorsum turns dark blue via metachrosis (Fig. 2A). Many dark spots are apparent on the dorsum and hindlimbs of both color morphs, varying in size and irregularly spaced. We collected three individuals (2 blue, 1 green) from leafy vegetation within 2 m of the ground and within 25 m of a stream. Morphometric data are lacking for one of the blue frogs, which escaped from the terrarium before scaled photos were taken.

We identified the specimens ( $N = 2$ ; Table 1) as *R. akroparallagi* by comparing morphometric data to the identification criteria set forth by Biju and Bossuyt (2009): 1) small adult size (SVL =  $20.6 \pm 0.7$  mm) is consistent with type specimens, 2) yellowish thigh and groin, 3) metachrosis of forearm, loreal and tympanic region ranges from light brown to dark brown (Fig. 2A), a trait that is found in nearly all color morphs of *R. akroparallagi* but absent in other green congeners from the Western Ghats. Blue morphs at our study site also exhibited metachrosis to a lesser extent on their feet (Fig. 2A). No other *Raorchestes* species in the region is known to exhibit this combination of traits.

*Raorchestes chromasynchysi*.—Biju and Bossuyt (2009) described *R. chromasynchysi* from a single locality; type specimens

TABLE 1. Morphometric measurements (in mm) of five *Raorchestes chromasynchysi* and two *R. akroparallagi* frogs found near Madikeri, Karnataka, India.

Species	Individual	Dorsum Color	SVL	HW	HL
<i>R. akroparallagi</i>	1	blue	21.0	8.2	7.3
	2	green	20.1	7.8	6.8
		Mean	20.6	8.0	7.1
		SD	0.7	0.3	0.4
<i>R. chromasynchysi</i>	1	green	29.4	11.1	9.3
	2	green	26.4	10.2	8.6
	3	green	27.0	9.8	7.1
	4	green	26.7	10.0	8.6
	5	brown	26.2	9.7	–
		Mean	27.1	10.1	8.4
	SD	1.3	0.6	0.9	

were collected from a 30 km<sup>2</sup> area on an isolated mountain at Kurichiyarmala (11.57°N, 75.97°E). Our discovery of an additional population near Madikeri extends the range of this poorly known frog species northward by approximately 100 km, and represents the first record of this species from Karnataka state (Fig. 1). All five frogs were collected from leafy vegetation within 2 m of the ground and 10 m of a stream.

We identified all specimens (N = 5; Table 1) as *R. chromasynchysi* by comparing morphometric data to the criteria outlined in the species description (Biju and Bossuyt 2009): 1) medium adult size (SVL = 27.1 ± 1.3 mm) is consistent with type specimens, 2) spinular dorsum, 3) pointed snout, 4) canthus rostralis sharp, 5) posterior surface of thighs dark brown, and anterior surface of thighs and groin dark brown with yellow blotches, 6) dorsal metachrosis ranges from light green to dark green (Fig. 3A), or, in the brown morph, from light brown to dark brown. Four *R. chromasynchysi* frogs showed green dorsal coloration with few markings (similar to paratypes BNHS 4433, 4442), and the fifth frog (Fig. 3B) was light brown with contrasting dark brown markings in an hourglass shape on the limbs and dorsum (similar to BNHS 4438). These markings became less apparent when the dorsum turned dark brown via metachrosis.

*R. chromasynchysi* is also known for its polychromatism (*chroma* is Greek for “color,” *synchysi* for “confusion”; Biju and Bossuyt 2009), and may be mistaken for three similar species with which it forms a monophyletic clade: *R. marki*, *R. tinniensi*, and *R. signatus* (Biju et al. 2010). However, *R. chromasynchysi* is the only species of this group for which the groin and anterior thighs are dark brown with yellow blotches, a trait that Biju and Bossuyt (2009) found to be highly consistent in all polymorphs.

All of our specimens match this description. Additionally, our specimens have spinular dorsums (vs. slightly granular dorsums of *R. tinniensi* and *R. signatus*; Biju and Bossuyt 2009; Bossuyt and Dubois 2001) and lack a horny ridge between the eyes (as in *R. marki*; Biju and Bossuyt 2009).

There are some morphological differences between our *R. chromasynchysi* specimens and those of the Kurichiyarmala population that are worth noting (see Biju and Bossuyt 2009, figure 19): 1) both anterior and posterior thigh patterns are visible in dorsal view, as in other green *Raorchestes* of the Western Ghats (vs. patterns not visible in dorsal view), 2) toe webbing reaches the penultimate subarticular tubercle on both sides of toe IV (vs. up to the distal subarticular tubercle), 3) dorsum color does not extend onto fingers I and II. Further research may reveal these discrepancies to be artifacts of low sample size, representing variation among individuals, or unique characteristics of this population.

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