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Three new species of striped *Ichthyophis* (Amphibia: Gymnophiona: Ichthyophiidae) from the northeast Indian states of Manipur and Nagaland

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Abstract

Three new ichthyophiid species, *Ichthyophis khumhzi* **sp. nov.**, *Ichthyophis moustakius* **sp. nov.** and *Ichthyophis sendenyu* **sp. nov.**, from the northeast Indian states of Manipur and Nagaland, are described on the basis of morphological analysis of new material. The new material (16 specimens) more than doubles the number of northeast Indian caecilian specimens reported in previous literature, and increases the caecilian fauna of the region to seven species. Two of the new species have very distinctive, moustache-like stripes between their tentacles and nares, a feature not reported in other ichthyophiids. Diagnoses, type descriptions, illustrations, data on variation, distribution, and natural history are provided for the new species. Concern for the conservation of northeast Indian caecilians is raised, given the paucity of previous work, evidence of unrecognized diversity, and ongoing habitat destruction.

Key words: caecilians, conservation, ichthyophiids, new species, northeast India, systematics

Introduction

Northeast India, comprising the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Sikkim and Darjeeling district of West Bengal (Fig. 1), lies at the junction of the Indo-Burma and Himalaya global biodiversity hotspots (Mittermeier *et al*. 2004). Currently this region has 118 named amphibian species (Frost 2009) representing just over half of India's recognized amphibians. However, only four species of caecilian amphibians (Gymnophiona) are currently documented from this region, representing only 16% of the Indian caecilian fauna and very few specimens have ever been reported (e.g., Pillai & Ravichandran 1999), indicating a lack of organized basic research. One of the biggest challenges to studying terrestrial caecilians is their secretive, generally burrowing lifestyle (Gower & Wilkinson 2005). They are rarely encountered in routine herpetological surveys and excavation is generally required for their sampling (Measey *et al*. 2003; Gower & Wilkinson 2005). Although sometimes locally abundant (Oommen *et al*. 2000), even with specific effort it can sometimes prove difficult to find them, and many species are known from very small samples. However, dedicated field effort in the Western Ghats of peninsular India has resulted in a great increase in available material, and a dramatic increase in number of species new to science (Gower *et al*. 2004). Similarly extensive and dedicated surveys in northeast India might be expected to uncover taxa still unknown to science.

Based on the presence or absence of a longitudinal cream or yellow stripe on each side of the body in metamorphosed animals, the genus *Ichthyophis* can be divided for the purpose of identification into two non-monophyletic groups (Taylor 1968; Gower *et al*. 2002). Two unstriped (*I. husaini* and *I. sikkimensis*), and a single striped (*I. garoensis*) *Ichthyophis* are known from northeast India (Pillai & Ravichandran 1999). We agree with Dutta (2002) in considering a report of a specimen of *I. glutinosus* from Goalpara in Assam (Pillai

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& Ravichandran 1999; Ravichandran 2004) highly improbable because this species is endemic to Sri Lanka (Nussbaum & Gans 1980; Taylor 1968; Bossuyt *et al*. 2004).

As part of new field and collections based research into northeast Indian caecilians, specimens were collected of striped *Ichthyophis* from Manipur and Nagaland that are all distinct from described species and warrant description as three new species.

Material and methods

Field surveys were carried out in Manipur and Nagaland, northeast India between 2006 and 2008. *Ichthyophis* were mostly collected in the daytime by digging. Specimens were anaesthesized using 0.1% aqueous solution of 3-aminobenzoic acid ethyl ester methanesulfonate (MS222), fixed in 5% formalin for two days, washed and transferred to 70% ethanol. Measurements were taken to the nearest 0.1 mm using a vernier caliper, except total length and circumference, which were measured to the nearest 1 mm using a ruler and piece of thread. Sex was determined by examining the gonads through a small midventral incision in the posterior third of the specimen. Numbers of vertebrae were determined from radiographs.

For brevity we have adopted a number of abbreviations for several features of the external anatomy and ratios of measures: AG = annular groove; CM = corner of the mouth; C1 = first collar; C2 = second collar; IM = inner mandibular (= 'splenial') tooth; NG1 = first nuchal groove (between head and collars); NG2 = second nuchal groove (between first and second collars); NG3 = third nuchal groove (between collars and anteriormost annulus); ST = snout tip; TA = tentacular aperture; TG = transverse groove (on dorsal surface of collar); L/H = total length divided by head length (the latter = distance between ST and NG1 directly behind CM); L/W = total length divided by midbody width; TN/TE = ratio of the distances between the TA and the eye and naris; W/S = width at midbody divided by maximum width of stripe at midbody. Institutional abbreviations are: BNHS, Bombay Natural History Society, Mumbai, India; ZSI, Zoological Survey of India, Kolkata, India. Other abbreviations of frequently used terms are: RGK, R.G. Kamei; SDB, S.D. Biju.

The depth of scale pockets has been previously compared to the length of surrounding annuli (e.g., Wilkinson *et al*. 2007; Gower *et al*. 2008). Here we describe pockets as shallow if they are less than 1.25 annular lengths deep, and as deep if they are equal to or more than 1.25 annular lengths. Additionally we denote pockets that are less than 0.75 annular lengths or equal to or more than 1.75 annular lengths as very shallow and very deep, respectively. We describe stripes as regular or irregular if they have notably smooth or uneven edges, and as solid or patchy if they are unbroken or interrupted on the trunk, respectively. We distinguish more U- and more V-shaped heads in dorsal view; although both have rounded STs, the former are broad and taper only very slightly (if at all) behind the TAs, the latter taper substantially between the back of the head and the ST.

Caecilians are renowned as a taxonomically difficult group with a combination of paucity of external characters and lack of understanding of variation due to patchy sampling and generally small sample sizes (Nussbaum & Wilkinson 1989; Gower & Wilkinson 2005). These difficulties are perhaps most severely felt in the genus *Ichthyophis*, which is the most speciose genus but with the majority of nominate taxa known from one or only a few specimens. Most ichthyophiid species were described by E.H. Taylor, who was of the opinion that previous workers had produced descriptions that were too brief and ignored many potential characters (Taylor 1968). In contrast, the most recent description of a new species of *Ichthyophis* (Wilkinson *et al*. 2007) provided what, in retrospect, was probably too prolix a description that repeated many features that appear to be common throughout the genus. For both brevity and clarity we have endeavoured here not to repeat features included in the diagnoses and tables of data, nor features that are common to the three new species (and in some cases to all ichthyophiids), in the descriptions of the types. The latter include: body subcircular; ST rounded; lower jaws bluntly rounded; mouth weakly subterminal; edges of upper jaws straight except near CMs; eyes visible through unpigmented skin as dark circles with lighter grey central lens; TAs at tips of pale papillae; tentacles long and thin when protruded in life; anteriorly and dorsolaterally positioned subcircular nares in pale spots, visible in dorsal, lateral and anterior but not ventral views; teeth bicusped, little

variation in sizes of teeth within or between series, those of outer series larger; tongue with median furrow posteriorly; NG1 well marked (whitish) ventrally and laterally, incomplete or poorly marked dorsally, slight anteromedial curvature ventrally, posterodorsally oblique laterally; NG2 absent dorsally, otherwise well indicated, parallel to NG1; NG3 more or less complete dorsally, broadly incomplete ventrally; tail annuli shorter than those at midbody, no other obvious patterns of substantial regional variation in size of annuli; a few AGs anterior to disc curve gently anteromedially on venter; vent longitudinal; tail short, ending in a pale-tipped small terminal cap about three times longer than preceding annuli; stripe thickest at midbody.

Of the seventeen previously described and currently recognized species of striped *Ichthyophis* we have seen types of all but two (*I. humphreyi* and *I. paucisulcus*), for which we have relied exclusively upon literature reports (Taylor 1968, 1973).

***Ichthyophis khumhzi* sp. nov.**
(Figs. 1–3; Tables 1–2)

Holotype. BNHS 5210, an adult male, collected by SDB and RGK on 10 July 2007 from Khumhzi village (24°51'46''N, 93°37'23''E; 320 m asl), Tamenglong district, Manipur, India.

Paratypes (n = 2). BNHS 5211 and BNHS 5212, two adult males. BNHS 5211 was collected along with holotype, and 5212 from about 15 km away, on the same day.

Diagnosis. *Ichthyophis* with narrow (W/S > 6), irregular lateral yellow stripes extending from close to CMs to level of vent, not contacting disc, barely or not visible on collars ventrally; more than 300 AGs, darker than adjacent skin; known to attain lengths greater than 400 mm, 24 < L/W < 26; head V-shaped, short (L/H > 25); TAs more than twice as far from nares than from eyes (TN/TE > 2); C1 noticeably shorter than C2; scales as far anterior as collars, four or five rows posteriorly on dorsum; similar numbers of IMs and dentary teeth.

Description of holotype. Some morphometric and meristic data are given in Table 1. Fair condition, some stratum corneum missing, several annular scale pockets opened, some artefactual creasing on the throat, c. 50 mm midventral longitudinal incision c. 150 mm anterior to vent. 127 vertebrae. Head, nuchal region and trunk dorsoventrally compressed. Girth maximal near midbody, decreasing very gradually except over posteriormost c. 50 mm, L/W = c. 26. Tail not upturned towards tip. Head short (L/H = 25.6 mm). In lateral view, distance of CM from top approximately 1.5 times distance from bottom of head. In ventral view, lower jaws inset from upper, more so anteriorly than at level of TAs. Eye equidistant from lip and top of head in lateral view, surrounded by narrow whitish ring, eye diameter (c. 0.6 mm) about same as nares and TAs. TAs a little more than twice as distant from nares than from eyes, fairly close to lips, just above (touching) imaginary lines between nares and CMs. Nares slightly anterior of level of anterior margin of mouth; in lateral view equidistant from top and bottom of snout, closer to tip of snout; very close to (touching) sides of head in dorsal view. Teeth slender, strongly recurved, dentary tooth series extend about one third the length of the IM series (with 5 or 6 teeth on each side) behind posteriormost IM. Tongue strongly plicate posteriorly, margin overlying all except anteriormost IMs. Choanae very narrow, distance between them five or six times their greatest width. Collar region more massive than adjacent head and body, delimited by strong constrictions. C2 more than one and a half times longer than C1 measured laterally. NG3 with gentle middorsal anterior flexure, somewhat irregular, fading out on dorsum on left, on right continuous with first AG. Three gently flexed, evenly spaced TGs on C2 dorsally, first (anteriormost) short, extending right from midline, second and third increasingly longer, crossing midline, not extending as far as lateral stripes.

AGs mostly narrowly incomplete midventrally on anterior two thirds, six interrupted in disc region, two more incomplete dorsally and ventrally on tail. Dorsally, anteriormost c. 15 and posteriormost c. 10 AGs curve anteromedially, the former gently and latter strongly. Ventrally, anterior AGs strongly angulate, degree of posteromedial curvature almost length of three annuli up to midbody, decreasing posteriorly, orthoplicate by 25th annulus anterior to disc. Small scales present at second TG, a single row in very shallow pocket of first AG on dorsum; posteriorly, four to five rows of large (1.7 x 1.9 mm) scales present in deep pockets on dorsum and venter. No papillae on disc. Denticulations around vent poorly indicated.

TABLE 1. Some morphometric (in mm) and meristic data for representatives of the new species of *Ichthyophis*. H = holotype, P = paratype, ‡ = SDB 1513, - = data not recorded, * denotes approximate measure due to damage to ST, # denotes counts made on one side and doubled, / separates different counts made on left and right.

	I. khumhzi			*I. moustakius*								*I. sendenyu*				
BNHS no.	5210	5211	5212	5213	5214	5215	5216	‡	5218	5219	5220	5221	5222	5223	5224	5225
Status	H	P	P	H	P	P	P			P		H	P	P	P	P
Sex	m	m	m	f	f	f	f	f	f	m	m	f	f	f	f	m
Length	500	428	422	243	237	203	256	241	287	203	196	308	250	297	286	305
Width at midbody	19.0	17.5	16.4	11.8	11.3	10.8	10.4	11.6	13.2	9.0	9.2	14.8	11.4	11.1	11.6	12.0
Circumference at midbody	57	45	43	37	36	33	35	35	44	29	26	48	42	38	36	36
Max width of stripe at midbody	2.8	2.2	1.8	4.4	3.2	3.1	3.1	3.2	4.0	2.7	2.3	4.1	3.5	3.4	3.2	3.0
Width at anterior of vent	6.7	5.5	6.8	6.5	5.2	4.7	5.9	5.4	7.3	4.9	4.2	7.0	6.0	6.3	6.4	6.0
Head length	19.5	-	14.8	11.2	11.1	10.9	11.3	11.1	11.7	10.5	10.4	12.9	11.6	12.7	13.0	14.0
Length of C1 directly behind CM	3.5	3.2	3.7	2.7	3.0	2.3	2.4	2.6	2.5	2.5	2.3	3.7	2.6	3.7	3.3	3.8
Length of C2 directly behind CM	6.0	4.9	5.3	3.0	3.5	2.4	2.1	3.3	3.2	2.6	2.8	3.8	2.7	3.8	3.8	3.6
Head width at CM	11.0	8.9	8.3	7.4	6.6	6.4	6.7	6.9	8.3	6.6	5.9	8.8	8.1	8.9	9.0	9.0
Head depth behind CM	7.0	7.3	5.7	4.8	5.0	4.5	5.0	4.8	6.3	3.9	4.7	5.4	4.9	5.7	7.4	5.6
Head width at NG1	12.6	10.1	10.0	7.6	7.7	7.9	7.9	7.9	9.9	7.4	6.7	9.0	8.9	9.7	9.3	9.4
Distance between eyes	7.4	6.2	6.1	4.9	-	4.2	4.5	4.7	6.1	4.8	4.5	6.5	5.2	5.7	5.7	6.0
Distance between nares	2.7	-	2.2	1.8	1.5	1.8	1.9	1.6	2.1	1.7	1.3	2.5	1.8	2.2	2.0	2.4
Distance between eye and naris	6.9	6.0	5.9	4.1	3.7	3.9	3.9	4.0	4.6	4.0	3.7	4.8	4.4	4.5	4.6	4.9
Distance between TAs	8.1	7.1	6.7	5.4	5.3	5.0	5.3	5.2	3.6	5.2	4.5	7.1	5.8	6.8	6.3	6.7
Distance between TA and eye	2.4	2.0	1.7	1.5	1.5	1.4	1.3	1.5	1.5	1.3	1.2	1.9	1.6	1.8	1.8	2.0
Distance between TA and naris	5.2	4.3	4.1	2.8	2.9	2.8	2.9	2.9	3.1	2.9	2.7	3.5	2.8	3.2	3.4	3.5
Distance between TA and ST	6.8	*5.3	5.5	4.0	4.0	3.9	3.2	3.7	4.8	3.8	3.8	5.0	4.3	4.8	4.7	4.9
Distance between TA and lip	0.6	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.3	0.2	0.2	0.2	0.1	0.1	0.2	0.2
Distance between ST and eye	8.4	*7.2	6.9	5.2	5.1	4.9	5.1	4.8	6.0	5.0	4.8	6.3	5.7	6.1	5.7	6.5
Distance between ST and naris	1.5	-	1.2	0.9	0.9	1.1	0.9	0.9	1.2	0.8	0.9	1.3	1.1	1.3	1.1	1.3
Distance between ST and lip	1.2	-	0.8	1.1	0.9	0.8	0.6	1.1	0.9	1.0	0.8	1.0	1.3	0.9	1.0	1.2
Distance in front of eyes	7.3	*6.3	6.4	4.7	-	4.2	4.5	4.6	5.0	4.5	4.6	5.6	5.3	5.0	4.9	5.7
Distance between eye and lip	2.0	1.5	1.5	1.1	0.9	0.9	1.1	0.9	1.2	0.9	0.8	1.5	1.1	1.2	1.1	1.3
Distance behind anterior of vent	7.3	8.0	7.5	5.5	4.7	4.4	4.9	4.2	5.3	4.9	4.5	6.8	4.8	6.2	6.5	6.1
Distance behind posterior of vent	5.0	4.6	4.9	3.7	3.3	3.4	3.5	3.0	4.5	3.4	3.3	4.8	3.6	4.7	5.2	5.3
AGs (counted dorsally)	362	359	341	259	238	247	251	268	265	272	292	283	297	298	302	308
AGs (counted ventrally)	356	360	347	262	236	249	244	261	259	268	286	283	291	293	302	304
TGs	3	1	1	0	2	2	1	1	3	1	2	1	1	1	2	2
AGs behind disc	2	4	4	4	5/6	4	4	4	5	5	6/5	4	5	6	7	6
AGs interrupted by disc	6	4	4	4	4/5	4	4/3	5	4	3	4/5	9/8	6	6/7	5/6	5
Premaxillary-maxillary teeth	56	-	#50	40	42	44	40	45	40	43	-	39	44	44	42	#46
Vomeropalatine teeth	58	47	#48	42	-	42	42	42	-	39	-	41	44	43	44	#44
Dentary teeth	49	46	#42	40	41	42	42	45	41	43	-	39	39	44	38	#40
IMs (splenial teeth)	46	-	40	36	-	36	34	35	-	35	-	43	44	44	45	-

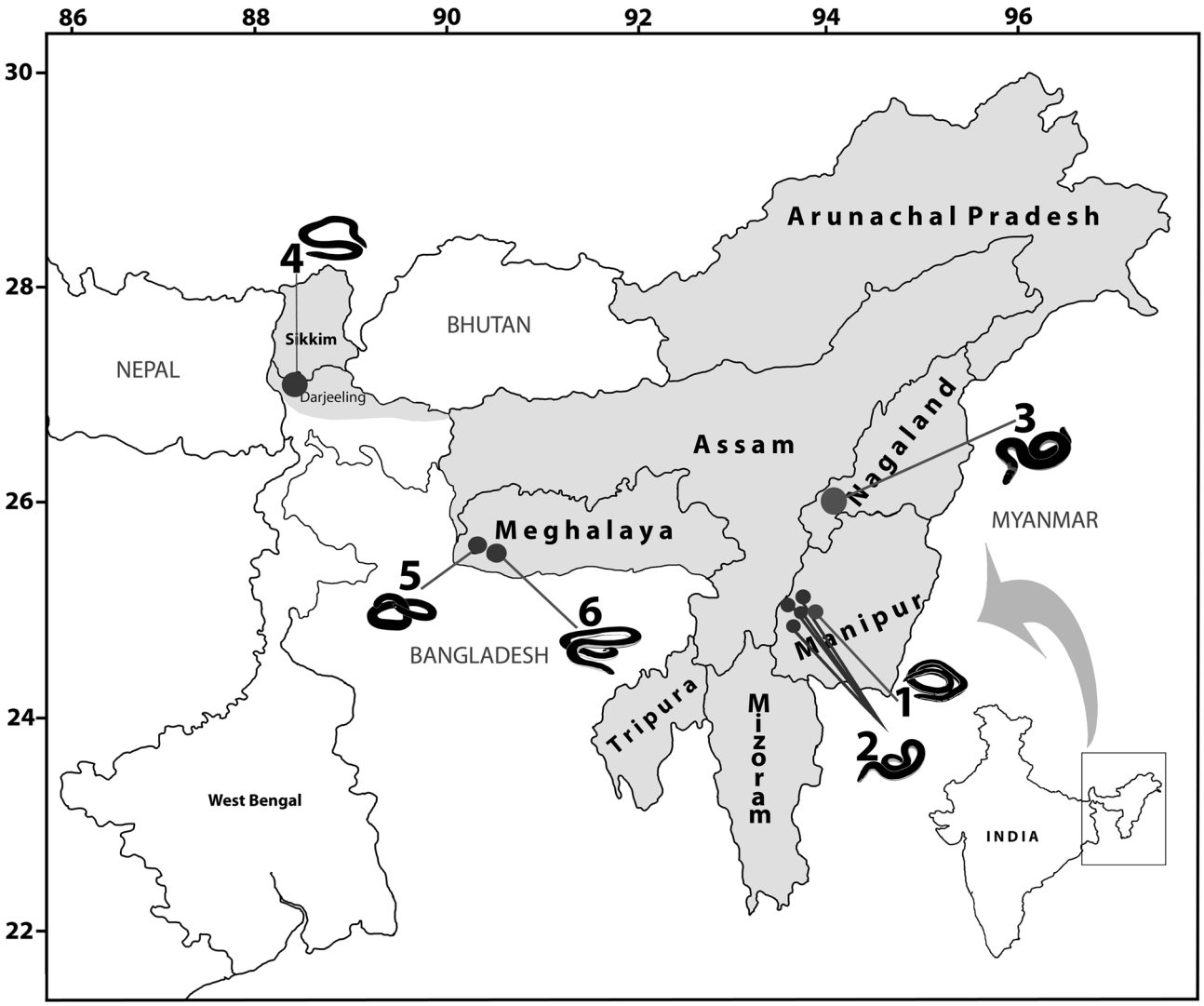

FIGURE 1. Distribution map of *Ichthyophis* species from northeast India: **1.** *I. khumhzi*, **2.** *I. moustakius*, **3.** *I. sendenyu*, **4.** *I. sikkimensis*, **5.** *I. husaini*, **6.** *I. garoensis*. Positioning of symbols is approximate.

In preservation, pale lavender grey with browner patches where stratum corneum absent. Lateral stripes extending from just behind CMs to the fifth or sixth last annuli, broadening slightly on C2 but barely visible ventrally on collars, broken on C1, not connecting with disc, fading gradually about level with vent, very patchy, incomplete or more poorly indicated in more posterior parts of many annuli, especially on last three quarters of body. Narrow, pale lines strongly marked along margins of lower jaw. AGs appear slightly pale on venter where stratum corneum missing, otherwise dark. In life, dorsum dark brownish grey, venter reddish grey, narrow lateral stripes dull-yellow.

Variation. Morphometric and meristic data for the type series are given in Table 1, and summarised in Table 2. The distance between the choanae ranges from about five to eight times the maximal choanal width. The number of anterior AGs that curve anteromedially on the dorsum ranges from 13 to 26. The tongue is not strongly plicate posteriorly in the paratypes, AGs are more complete ventrally, and a few more (up to 39) anterior to the vent are orthoplicate. BNHS 5212 has a more or less solid stripe, with few breaks on trunk and a break on C1 on right; in BNHS 5211, the stripe is continuous across the collars and patchy on trunk.

Squamation investigated in BNHS 5211. Scales widespread on body and collars; progressively larger scales, deeper scale pockets, more scale rows towards posterior; small (0.7 x 0.4 mm) oval scales present dorsally in anteriormost TG on C2; dorsally at midbody, three or four rows of large (2.0 x 1.3 mm) scales per

FIGURE 2. Holotype of *Ichthyophis khumhzi*, BNHS 5210.

FIGURE 3. *Ichthyophis khumhzi* in life (specimen not preserved).

annular groove, in deep pockets; ventrally at midbody three rows of scales (1.2 x 0.9 mm) in shallow pockets; posteriorly (approximately 25 annuli anterior to vent), scale pockets very deep on dorsum, containing large scales (2.2 x 1.7 mm) in five rows, scale pockets a little shorter than two annuli length and containing smaller scales (1.5 x 1.2 mm) in four rows on venter.

Etymology. Named after Khumhzi village, where the type series was collected. The specific epithet is considered to be a noun in apposition.

Suggested common name. Khumhzi striped Ichthyophis.

Distribution and natural history. This species is known only from the type locality. BNHS 5210 and BNHS 5211 were collected in a marshy place near agricultural fields, about one km from National Highway 53 (between Imphal and Silchar), and about 0.5 km from river Agoh (also known as Elen). BNHS 5212 was collected from secondary forest on the fringe of a banana plantation about 15 km from NH 53.

***Ichthyophis moustakius* sp. nov.**
(Figs. 1, 4–5; Tables 1–2)

Holotype. BNHS 5213, an adult female, collected by SDB and RGK on 3 June 2006 from Aziuram duikhun (duikhun = a pond) (25°01'43''N, 93°24'51''E; 990 m asl), Aziuram village, Tamenglong district, Manipur, India.

Paratypes (n = 4). BNHS 5214–5216, three adult females, and BNHS 5219, an adult male, collected along with holotype.

Referred material (n = 3). BNHS 5218, an adult female collected on 30 May 2008 from Guigailuang, Nriangluang namdaih (namdaih = a large village), (24°59'32''N, 93°29'38''E; 1107 m asl), Tamenglong district; SDB 1513, an adult female collected on 7 June 2007 from Nswanram village (25°01'04''N,

93°34'09''E; 838 m asl), Tamenglong district; BNHS 5220, an adult male collected on 29 May 2008 from Duidip Chaengluan (24°55'54''N, 93°24'53''E; 306 m asl), Bamgaizaeng village, Tamenglong district. Specimens were collected by SDB and RGK.

Diagnosis. *Ichthyophis* with broad (W/S < 4) fairly regular, mostly solid, lateral yellow stripes from anterior of tail to at least CM, broad along mandibles with narrow anterior gap, expanded and visible ventrally on collars, connected by spurs to disc; arched yellow stripes extending between nares and TAs, broader at former than latter; not known to attain lengths greater than 300 mm, 18 < L/W < 25; fewer than 300 AGs, paler than adjacent skin; head somewhat more U-than V-shaped, fairly short (25 > L/H > 19); TAs about twice as far from nares than from eyes, variable (1.9 < TN/TE < 2.3); collars of similar lengths; scales absent on collars, beginning from about fourth or fifth annulus, with five rows posteriorly on dorsum; similar numbers of IMs and dentary teeth.

Description of holotype. Some morphometric and meristic data given in Table 1. Good condition, several annular scale pockets opened, c. 15 mm midventral longitudinal incision c. 65 mm anterior to vent. 105 vertebrae. Head, nuchal region and trunk slightly dorsoventrally compressed. Girth maximal near midbody, decreasing gradually, more substantially over posteriormost c. 10 mm, L/W = 20.6. Tail upturned towards tip. Head short (L/H = 21.7). In lateral view, CM equidistant from top and bottom of head. In ventral view, lower jaws inset from upper, slightly more so anteriorly than at level of TAs. Eye closer to top of head than to lip in lateral view, surrounded by narrow whitish ring, eye diameter c. 0.6 mm, lens no larger than naris. TAs slightly smaller than eyes, larger than nares, less than twice as distant from nares than from eyes, very close to lips, just below (touching) imaginary lines between nares and CMs. Nares slightly posterior to level of anterior margin of mouth; in lateral view equidistant from tip, top and bottom of snout, inset a little less than one naris diameter from sides in dorsal view. Teeth very slender, strongly recurved, dentary series extend about one third the length of the IM series (with 5 teeth on each side) behind posteriormost IM. Tongue not strongly plicate, margin overlying all except anteriormost IMs. Choanae narrow, distance between them four or five times their greatest width. Collar region slightly more massive than adjacent head and body, delimited by weak constrictions, lacking TGs. C2 slightly longer than C1 measured laterally. Dorsally, NG3 complete with gentle anteromedial curvature.

AGs mostly ventrally incomplete on anterior one third, four interrupted in disc region, four complete ventrally on tail, last two incomplete dorsally. Dorsally, anteriormost c. 25 AGs and posteriormost nine curve slightly anteromedially. Ventrally, anterior AGs strongly angulate, degree of posteromedial curvature about length of two annuli up to midbody, decreasing posteriorly, more or less orthoplicate by 27th annulus anterior to disc. Tiny scales scattered in first AG, three rows of small (0.9 x 0.5 mm) scales in shallow pockets as far anterior as the 11th annulus. At midbody four rows of larger (up to c. 1.4 x 1.0 mm) scales in deep pockets dorsally, three or four rows of smaller scales (up to c. 1.1 x 0.5 mm) in shallow pockets ventrally. Posteriorly (c. 20 annuli anterior to vent) five rows of more rounded scales (up to c. 1.1 x 1.0 mm) in deep pockets dorsally, smaller scales (1.0 x 0.8 mm) in four rows in shallow pockets on venter. No papillae on disc. Fifteen irregular denticulations around vent.

In preservation, lilac-grey with brownish tinges, slightly paler ventrally. Lateral stripes extending from about second or third posteriormost annulus to about eye level on upper jaws and close to mandible tips, expanding ventrally on collars, especially C1, narrowly broken just behind NG1. Narrow yellow lines extending dorsally then curving anteriorly from TAs to nares, thickest near nares; AGs paler, especially posteriorly. In life, dorsum uniformly dark reddish grey, venter pale reddish grey; lateral stripe bright yellow, vent disc mauvish.

Variation. Morphometric and meristic data for the type series and referred specimens are given in Table 1, and summarised in Table 2. There are between three and six dentary teeth posterior to the last IM on each side. The distance between the choanae ranges from three to five times the maximal choanal width. Ranges of the numbers of AGs anterior to the vent that are orthoplicate, and of anterior and posterior AGs that curve anteromedially on the dorsum are quite small (21–29, 8–26, and 7–13, respectively). The number of denticulations around the vent ranges from 13 to 17. Compared to the holotype, the paratypes have mostly

FIGURE 4. Holotype of *Ichthyophis moustakius*, BNHS 5213.

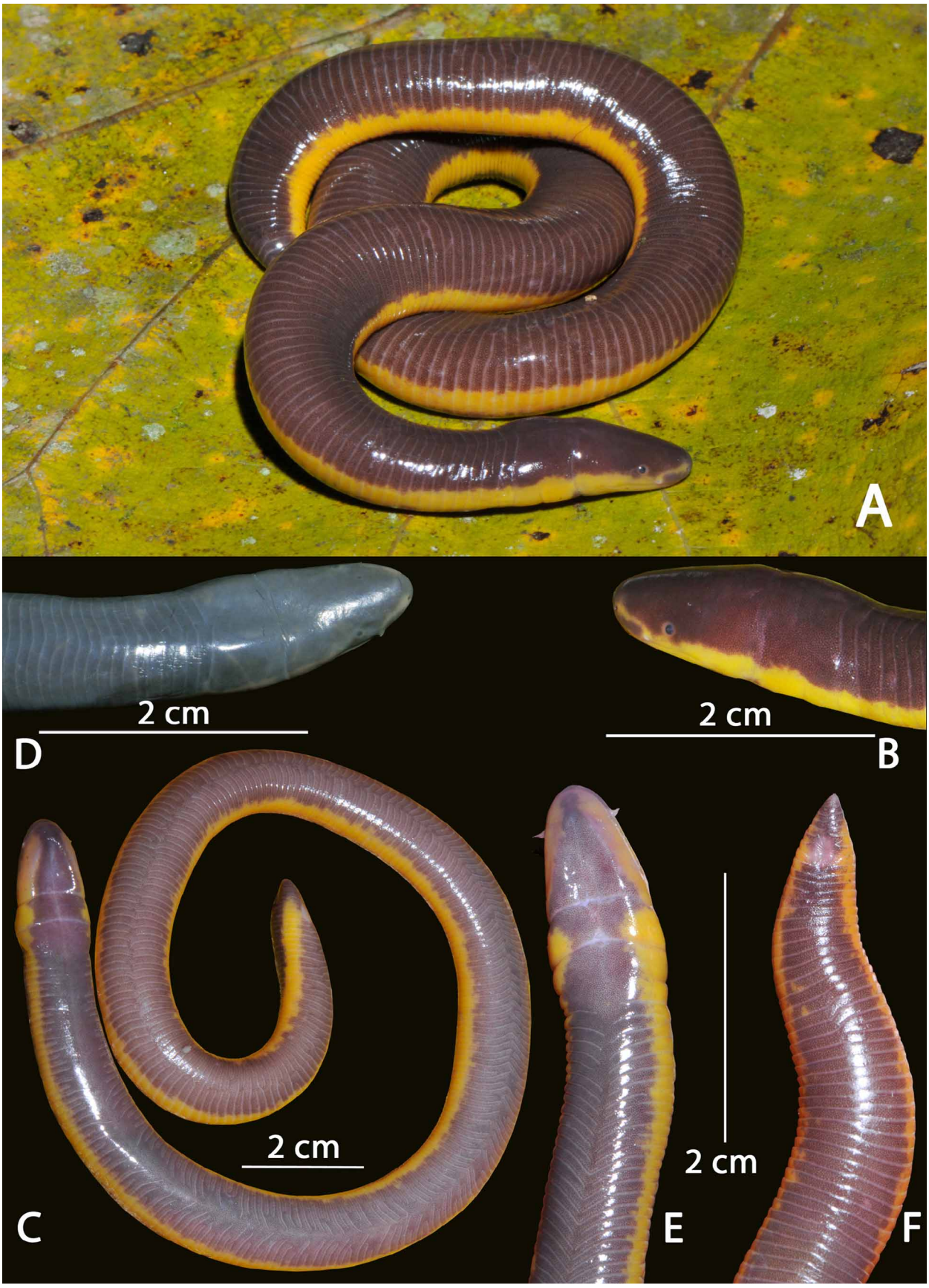

FIGURE 5. *Ichthyophis moustakius*, BNHS 5215 (paratype). **A.** Dorsolateral view in life, **B.** Dorsolateral view of head in life, **C.** Ventral view in life, **D.** Dorsal view of head in preservation, **E.** Ventral view of head in life, **F.** Ventral view of body terminus in life.

TABLE 2. Summary statistics for the data in Table 1. SD = standard deviation; * denotes use of averages of left and right side counts.

	Ichthyophis khumhzi			*Ichthyophis moustakius*			*Ichthyophis sendenyu*		
	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
Length	422–500	450	43.4	196–287	233.3	31.2	250–308	289.2	23.5
Width at midbody	16.6–19.0	17.6	1.3	9.0–11.8	10.9	1.4	11.1–14.8	12.2	1.5
Circumference at midbody	43–57	48.3	7.6	26–44	34.4	5.4	36–48	40	5.1
Max. width of stripe at midbody	1.8–2.8	2.3	0.5	2.3–4.4	3.3	0.7	3.2–4.1	3.4	0.4
Width at anterior of vent	5.5–6.8	6.3	0.7	4.2–7.3	5.5	1.0	6.0–7.0	6.3	0.4
Head length	14.8–19.5	17.2	3.3	10.4–11.7	11.0	0.4	11.6–13.0	12.8	0.9
Length of C1 directly behind CM	3.2–3.7	3.5	0.3	2.3–2.7	2.5	0.2	2.6–3.8	3.4	0.5
Length of C2 directly behind CM	4.9–6.0	5.4	0.6	2.1–3.5	2.9	0.5	2.7–3.8	3.5	0.5
Head width at CM	8.3–11.0	9.4	1.4	5.9–8.3	6.9	0.7	8.1–9.0	8.8	0.4
Head depth behind CM	5.7–7.0	6.7	0.9	3.9–6.3	4.9	0.7	4.9–7.4	5.8	0.9
Head width at NG1	10.0–12.6	10.9	1.5	6.7–9.9	7.9	0.9	8.9–9.7	9.3	0.3
Distance between eyes	6.1–7.4	6.6	0.7	4.2–6.1	4.8	0.6	5.2–6.5	5.8	0.5
Distance between nares	2.2–2.7	2.5	0.4	1.3–2.1	1.7	0.2	2.2–2.5	2.2	0.3
Distance between eye and naris	5.9–6.9	6.3	0.6	3.7–4.6	4.0	0.3	4.4–4.9	4.6	0.2
Distance between TAs	6.7–8.1	7.3	0.7	3.6–5.4	4.9	0.6	5.8–7.1	6.5	0.5
Distance between TA and eye	1.7–2.4	2.0	0.4	1.2–1.5	1.4	0.1	1.6–2.0	1.8	0.1
Distance between TA and naris	4.1–5.2	4.5	0.6	2.7–3.1	2.9	0.1	2.8–3.5	3.3	0.3
Distance between TA and ST	5.5–6.8	6.2	0.9	3.2–4.8	3.9	0.4	4.3–5.0	4.7	0.3
Distance between TA and lip	0.3–0.6	0.4	0.2	0.1–0.3	0.2	0.1	0.1–0.2	0.2	0.1
Distance between ST and eye	6.9–8.4	7.7	1.1	4.8–6	5.1	0.4	5.7–6.5	6.1	0.4
Distance between ST and naris	1.2–1.5	1.4	0.2	0.8–1.2	1.0	0.1	1.1–1.3	1.2	0.1
Distance between ST and lip	0.8–1.2	1.0	0.3	0.6–1.1	0.9	0.2	0.9–1.3	1.1	0.2
Distance in front of eyes	6.4–7.3	6.9	0.6	4.2–5	4.6	0.2	4.9–5.7	5.3	0.4
Distance between eye and lip	1.5–2.0	1.7	0.3	0.8–1.2	1.0	0.1	1.1–1.5	1.2	0.2
Distance behind anterior of vent	7.3–8.0	7.6	0.4	4.2–5.5	4.8	0.4	4.8–6.8	6.1	0.8
Distance behind posterior of vent	4.6–5.0	4.8	0.2	3–4.5	3.5	0.4	3.6–5.3	4.7	0.7
AGs (counted dorsally)	341–362	354	11.4	238–268	261.5	16.8	283–308	297.6	9.2
AGs (counted ventrally)	347–360	345.3	6.7	236–262	258.1	15.4	283–304	294.6	8.6
TGs	1–3	1.7	1.2	0–3	1.7	0.8	1–2	1.4	0.5
AGs behind disc*	2–4	3.3	1.2	4–6	4.6	0.7	4–7	5.6	1.1
AGs interrupted by disc*	4–6	4.7	1.2	3–5	4.1	0.6	5–9	6.3	1.3
Premaxillary–maxillary teeth	50–56	47	4.2	40–45	42	2.1	39–46	43	2.6
Vomeropalatine teeth	47–58	53	6.1	39–42	41.4	1.3	41–44	43.2	1.3
Dentary teeth	42–49	51	3.5	40–45	42	1.6	38–44	40	2.3

continued next page

TABLE 2. (continued)

	Ichthyophis khumhzi			*Ichthyophis moustakius*			*Ichthyophis sendenyu*		
	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
IMs (splenial teeth)	40–46	43	4.2	34–36	35.2	0.8	43–45	44	0.8
L/H	25.6–28.5	27.1	2.1	18.6–24.5	21.1	2.1	21.6–23.9	22.5	1.0
L/W	25–26	25.3	0.9	18.8–24.6	21.4	1.7	20.8–26.8	23.9	2.5
TN/TE	2.2–2.4	2.3	0.1	1.9–2.3	2.1	0.2	1.8–1.9	1.8	0.0
W/S	6.8–9.3	8.0	1.2	2.7–4.0	3.4	0.4	3.3–4.0	3.6	0.3

incomplete AGs ventrally on a larger proportion of the body. Stripes may or may not be broken across the collars, and may extend as far as the TAs. Papillae on the disc are present in one of the two male specimens (BNHS 5220). The tail is upturned in only a single paratype (BNHS 5215).

Etymology. The species name is derived from the Greek word *moustakius*, meaning moustache, referring to the distinctive yellow, arched stripes extending between the TAs and nares. The specific epithet is considered to be a noun in apposition.

Suggested common name. Manipur moustached Ichthyophis.

Distribution and natural history. Aziuram, Nswanram, Nriangluang, and Bamgaizaeng in Tamenglong district, Manipur (Fig. 1), at c. 300 to 1100 m asl. All specimens from the type series were collected by digging in perennially wet soil in the heart of the village. Four females with egg clutches containing 9–19 eggs per clutch in early developmental stages were observed in the dry period (first week of June), suggesting that this species is a relatively early breeder compared with many/most of the frogs in the same region (SDB pers. obs.). BNHS 5220 was collected from underneath a rock in a secondary forest.

***Ichthyophis sendenyu* sp. nov.**
(Figs. 1, 6–7; Tables 1–2)

Holotype. BNHS 5221, an adult female, collected by SDB and RGK on 26 June 2007 from Dhyütere (25°54'55''N, 94°06'19''E; 782 m asl), New Sendenyu village, Tseminyu sub-division, Kohima District, Nagaland, India.

Paratypes (n = 4). BNHS 5222–5224, three adult females; BNHS 5225 an adult male, all collected along with holotype.

Diagnosis. *Ichthyophis* with broad (W/S < 4) regular, mostly solid lateral yellow stripes from about level of posterior of disc to at least eye level on upper jaw and midway between TAs and nares on lower jaw, broad anterior gap expanded and visible or not ventrally on collars, connected by spurs to disc; arched yellow stripes extending halfway from TAs to nares, tapering towards latter; not known to attain lengths greater than 350 mm, 21 < L/W < 27; fewer than 315 AGs, paler than adjacent skin; head U-shaped, short (L/H > 20); TAs less than twice as far from nares than from eyes (TN/TE < 2); collars of similar lengths; scales present in anteriormost grooves, five to eight rows posteriorly on dorsum; similar numbers of IMs and dentary teeth.

Description of holotype. Some morphometric and meristic data given in Table 1. Good condition, several annular scale pockets opened, c. 30 mm midventral longitudinal incision c. 70 mm anterior to vent. 112 vertebrae. Head, nuchal region and trunk slightly dorsoventrally compressed. Girth maximal near midbody, decreasing gradually, more substantially over posteriormost c. 20 mm, L/W = 20.8. Tail upturned towards tip. Head short (L/H = 23.9). In lateral view, CM approximately equidistant from top and bottom of head. In ventral view, lower jaws inset from upper, scarcely more so anteriorly than at level of TAs. Eye marginally closer to top of head than to lip in lateral view, surrounded by asymmetric (thicker anteriorly) whitish ring,

eye diameter c. 0.8 mm, lens larger than naris. TAs much smaller than eyes, about as large as nares, a little less than twice as distant from nares than from eyes, very close to lips, below imaginary lines between nares and CMs. Nares slightly posterior to level of anterior margin of mouth; in lateral view equidistant from tip and top, further from bottom of snout, inset about one naris diameter from sides in dorsal view. Teeth very slender, recurved, dentary series extend about one sixth the length of the IM series (with 2 or 3 teeth) behind posteriormost IM. Tongue strongly plicate posteriorly, margin overlying only posteriormost IMs. Choanae relatively wide, with elevated margins, distance between them about three times their greatest width. Collar region somewhat more massive than adjacent head and body, delimited by constrictions. C1 and C2 approximately equal length measured laterally. Dorsally, NG3 complete but offset with strong anteromedial flexure. One TG on dorsum of C2, close to NG3 with strong anteromedial flexure.

Few anteriormost AGs incomplete midventrally, many offset, nine (right) or eight (left) interrupted in disc region, four more on tail, first two complete last two incomplete dorsally and ventrally. Dorsally, anteriormost c. 30 and posteriormost c. 15 AGs curve anteromedially, the former strongly and latter more gently. Ventrally, anterior AGs angulate, degree of posteromedial curvature about length of two annuli up to midbody, decreasing posteriorly, orthoplicate by c. 45th annulus anterior to disc. Very small (0.3 x 0.5 mm) scales in TG, single row of slightly larger scales in shallow pockets in anteriormost AGs. Posteriorly seven or eight rows of larger scales (up to 1.7 x 1.4 mm) in very deep pockets on dorsum, six or seven rows in deep pockets on venter. No papillae on disc. Seventeen irregular denticulations around vent.

In preservation, dorsum dark brown, venter paler grey-brown. Broad, fairly regular, solid, bright yellow lateral stripes, width varying 3.1–5.1 mm, thickest at midbody, extending unbroken from about fourth last annulus to the CMs then narrowing and ending on upper jaws at eye level, extending further along lower jaws to midway between TAs and nares in lateral view, with wide gap at mandible tip giving the darker area between stripes on throat a distinctive ('mushroom') shape, slightly expanding ventrally on C2 but barely visible ventrally on collars, with ventral spurs connecting to anterior of disc. Yellow lines extending dorsally then curving anteriorly from TAs to half way between TAs and nares, thickest near TAs. AGs paler especially on venter. In life, dorsum uniformly bright orange-brown; venter pale lilac-grey; lateral stripe bright yellow; disc whitish.

Variation. Morphometric and meristic data for the type series are given in Table 1, and summarised in Table 2. There are between two and four dentary teeth posterior to the last IM on each side. The distance between the choanae ranges from 2.5 to four times the maximal choanal width. The number of denticulations around the vent ranges from 16 to 18. Compared to the holotype, the paratypes have mostly incomplete AGs ventrally on a much larger proportion of the body, fewer (between about 19–38) AGs orthoplicate on venter anterior to the vent, and fewer anterior and posterior AGs that curve anteromedially on the dorsum (14–21 and 10–13, respectively). The stripe is mostly solid throughout but narrowly broken on one side posteriorly in a single specimen (BNHS 5225). Papillae on the disc are present in the single male paratype (BNHS 5225). The tail is upturned (only slightly) in a single paratype (BNHS 5223).

Squamation investigated in BNHS 5223. Small (1.0 x 0.4 mm) scales present dorsally in TGs on collars; dorsally at midbody five rows of large (1.7 x 1.3 mm) scales per annular groove; ventrally at midbody three rows of scales (1.0 x 0.6 mm) in shallow pockets; posteriorly slightly larger scales (1.8 x 1.7 mm) in five rows on dorsum, smaller scales (1.5 x 1.0 mm) in five rows on venter. All pockets shallow.

Etymology. Named after Sendenyu village, Nagaland state, where the type series was collected. The specific epithet is considered to be a noun in apposition.

Suggested common name. Sendenyu striped Ichthyophis.

Distribution and natural history. This species is known only from the type locality. All specimens were dug from a small banana plantation on the fringe of paddy field near a secondary forest.

FIGURE 6. Holotype of *Ichthyophis sendenyu*, BNHS 5221.

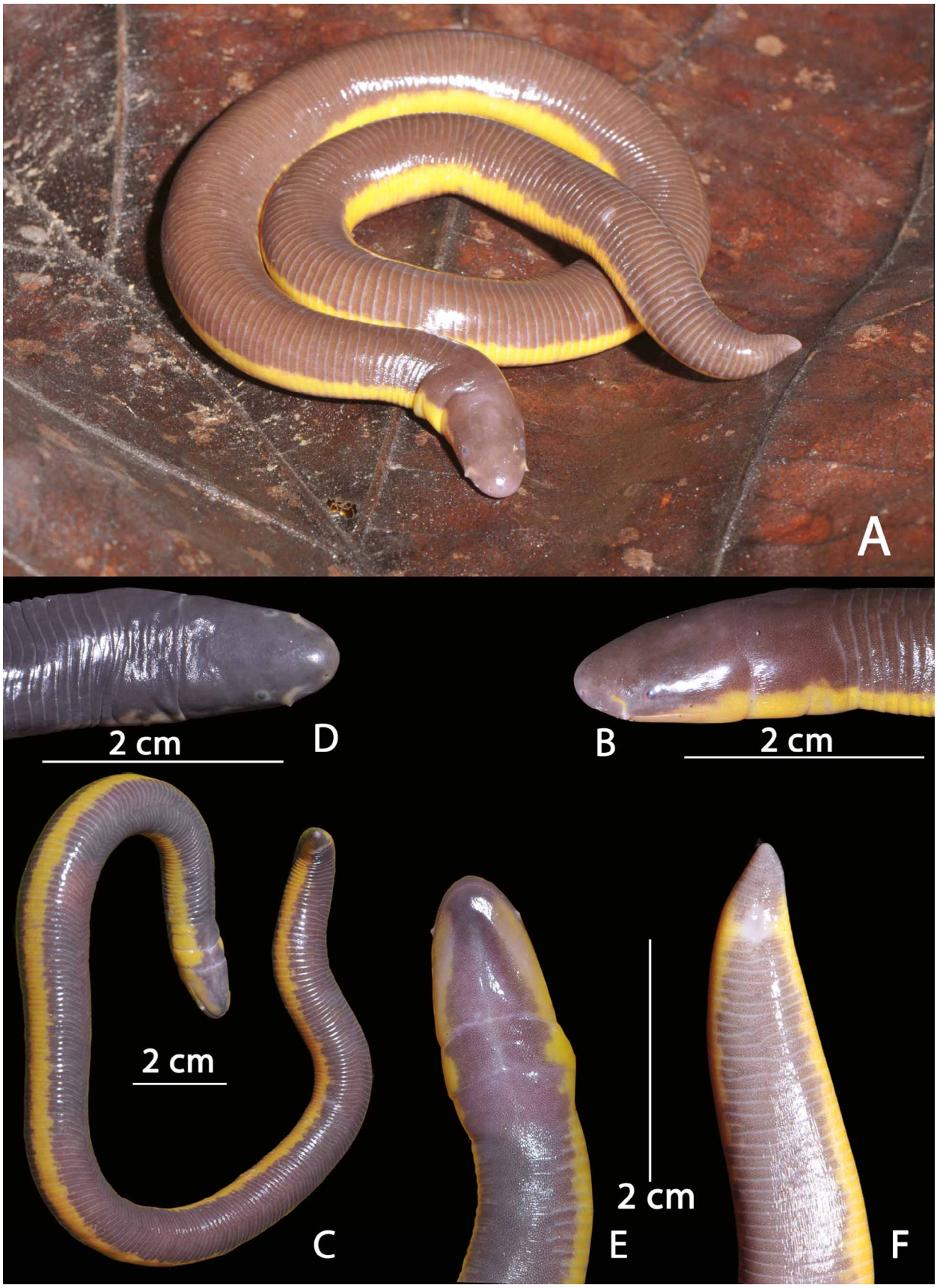

FIGURE 7. Holotype of *Ichthyophis sendenyu,* BNHS 5221. **A.** Anterodorsal view in life, **B.** Dorsolateral view of head in life, C. Ventral view in life, **D**. Dorsal view of head in preservation, **E.** Ventral view of head in life, **F.** Ventral view of body terminus in life.

Discussion

Among many other differences, *Ichthyophis moustakius* and *I. sendenyu* are distinguished from each other and from all other caecilians by their unusual and distinctive moustache-like stripes extending forward from the TAs. Although the 'moustache' is distinctive in each species, the presence of this feature suggests that they are sister species. These two species are also similar in having broad stripes with spurs connecting to the disc, relatively few annuli and vertebrae, and five or more scale rows posteriorly, with minor differences in head shape and colour. *Ichthyophis moustakius* is notable for its more highly variable tentacle position than reported for other *Ichthyophis* species.

No single character serves to distinguish *I. khumhzi* from all other *Ichthyophis* but combinations of diagnostic characters serve to distinguish it from any other species. In particular, with the exception of *I. longicephalus*, all other south Asian striped *Ichthyophis* (*I. beddomei, I. garoensis, I. glutinosus, I. kodaguensis, I. pseudangularis, I. tricolor*) differ from *I. khumhzi* in having TAs less than twice as far as from nares than eyes (TN/TE < 2). All southeast Asian striped *Ichthyophis* (*I. attricolaris, I. biangularis, I. bannanicus, I. bernisi, I. elongatus, I. humphreyi, I. hypocyaneus, I. kohtaoensis, I. paucisulcus, I. supachaii*) differ from *I. khumhzi* in having markedly fewer IMs than dentary teeth. *Ichthyophis longicephalus* differs from *I. khumhzi* in head shape and size (L/H < 18 versus > 25, respectively), and in having fewer scale rows, subequal collars, and a stripe that extends onto the tail.

The three new species are known from small samples and single or few localities. One (*I. khumhzi*) is known only from adult males, and information on various life history stages of all three species is as yet minimal or absent. Although we are confident that these are distinct species, more material is required to better characterize these taxa.

The present description of three new species of *Ichthyophis* expands the poorly known caecilian diversity of northeast India to seven species – one caeciliid, two unstriped *Ichthyophis*, and four striped *Ichthyophis*. Ichthyophiidae is endemic to south and southeast Asia (Taylor 1968), and available molecular phylogenetic data support the hypothesis that ichthyophiids dispersed into southeast Asia from south Asia (Gower *et al.* 2002). Gower *et al.*'s (2002) sampling included Sri Lankan and peninsular Indian ichthyophiid samples but none from northeast India, though their inclusion in further tests of the 'Out of India' hypothesis would be useful considering their occurrence in a region within a possible dispersal route.

All of the four previously described caecilians of northeast India are categorized as Data Deficient in the IUCN Red List (IUCN 2009). We suggest that all three of the new species described here should also be considered Data Deficient (DD) given that we know very little about their distribution. That specimens were found in areas of human disturbance gives some hope that they are not immediately threatened, but this depends foremost on a reasonable range size. In more general terms, it is of grave concern that the region's caecilian fauna is poorly known, particularly in the light of accelerating deforestation and habitat degradation in this region (FSI 1999; Lele & Joshi 2008). Dedicated fieldwork and systematic research are priorities for a more complete inventory of the caecilian fauna of northeast India and accurate and precise assessments of conservation status.

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