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A new state report of two striped *Ichthyophis* Fitzinger (Amphibia: Gymnophiona: Ichthyophiidae) from Mizoram, Northeast India

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Abstract

Aim: To survey and document the Ichthyophiids caecilians fauna in Mizoram, north-eastern India with anticipation on the occurrence of other species other than the earlier recorded *Ichthyophis*.

Methodology: During extensive surveys conducted, 22 specimens of striped *Ichthyophis* species were collected from Mizoram, India, obtained over a period of 9 years from 2010 to 2019. Standard procedures for sexing, preservation and storage of specimens were followed. All nomenclature herein follows the taxonomy as suggested in literatures and identification solely based on the morphology.

Results: Four distinct striped *Ichthyophis* species were identified on the basis of their morphological characters. Out of which, two species have already been reported from the state. In this study two additional species of striped *Ichthyophis* namely, *I. garoensis* and *I. sendenyu* have been reported.

Interpretation: This report represents a new state report of the species and also extends their geographic distribution range.

Keywords: Caecilians, Distribution, Gymnophiona, *Ichthyophis*, Mizoram

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Introduction

Mizoram is one of states in Northeast India. This region comprises the sister states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Tripura, Mizoram, Sikkim and Darjeeling district of West Bengal, lies at the junction of Indo-Burma and Himalaya global biodiversity hotspots (Mittermeier et al., 2004). Till date, the north-eastern states have more than 105 named amphibian species (Ahmed et al., 2009). Extensive surveys carried out in different localities of Mizoram within the last decade have resulted in collections of caecilians, represented by four distinct species of striped form Ichthyophiids. *Ichthyophis* Fitzinger, 1826, is a genus under the order Gymnophiona (Caecilians), in fact poorly known among the three extant orders of the amphibian subclass Lissamphibia.

They resemble large earthworm in having precise body segmentation and practically no tail and are restricted to certain tropical and subtropical environments of the world, except Madagascar and east of the Wallace Line (Himstedt, 1996; Pillai and Ravichandran, 1999). Regardless of origin and relationships, the order Gymnophiona is discrete from the members of the order Caudata (Salamanders), and Anura (Frogs) due to the presence of unique, dual, jaw-closing mechanism (Nussbaum, 1977, 1983), paired tentacular sensory organs on the edges of, or anterior to the eyes, but in some taxa, becoming apparent only at, or close to metamorphosis and absent in larvae, and also having elongated snake-like body, lacking limbs or girdles (Wilkinson and Nussbaum, 1996). Fifty ichthyophiid species have been described worldwide with 14 extant species currently recorded from India alone (Dinesh et al., 2019; Frost, 2019). Ichthyophiids species can be distinguished by the presence of angulate annuli on the anteroventral, and a short parasphenoid that does not extend as far anteriorly as the posterior margin of the choanae (Nussbaum, 1977; Wilkinson and Nussbaum, 2006).

Indian ichthyophiid caecilians are represented by 2 constituent genera — *Uraeotyphlus* Peters, 1880 whose distributional range is restricted to the South Western Ghats, and a more widespread *Ichthyophis* Fitzinger, 1826, inhabiting the mesic regions of peninsular India and north-eastern states (Gower et al., 2002; Wilkinson et al., 2007; Kamei and Biju, 2016). The provisional division of the genus *Ichthyophis* into 2 non-monophyletic groups are based on the presence or absence of a yellow lateral stripe, which serves as a useful diagnostic character (Gower et al., 2002; Wilkinson et al., 2007).

Out of 14 Ichthyophiid species reported in India, only *I. sikkimensis* Taylor, 1960 and *I. bombayensis* Taylor, 1960 are without stripes. In north-eastern India, seven striped form *Ichthyophis* are found namely: *I. alfredi* Mathew and Sen, 2009; *I. garoensis* Pillai and Ravichandran, 1999; *I. khumhzi* Kamei et al., 2009; *I. moustakius* Kamei et al., 2009; *I. nokrekensis* Mathew and Sen, 2009; *I. daribokensis* Mathew and Sen, 2009 and *I.*

sendenyu Kamei et al., 2009, while *I. sikkimensis* Taylor, 1960 is the only unstriped form (Kamei and Biju, 2016).

However, *I. husaini* Pillai and Ravichandran, 1999 formerly considered as an unstriped form was relegated into the synonymy of *I. garoensis* based on morphological examination by Kamei and Biju (2016). Moreover, we agree with Dutta (2002) to the improbability of *I. glutinosus* being reported from Goalpara in Assam (Pillai and Ravichandran, 1999; Ravichandran, 2004) since the species being endemic to Sri Lanka (Nussbaum and Gans, 1980; Taylor, 1968; Bossuyt et al., 2004). Noteworthy, *Ichthyophis* species recently described from the north-eastern states of India are known hitherto only from their respective type localities (Mathew and Sen, 2009; Kamei et al., 2009). Thus, recent efforts to understand the caecilian fauna of north-eastern India undoubtedly yielded interesting results in terms of taxa new to science (Kamei et al., 2009, 2012, 2013; Mathew and Sen, 2009). The present study deals with the collection and identification of *Ichthyophis* species in Mizoram. Herein, we present a new state report of two Ichthyophiid species in addition to the two Ichthyophiid species previously reported from Mizoram.

Materials and Methods

Catalogued specimens of caecilians deposited in the Departmental Museum of Zoology, Mizoram University were examined. Species identification was done by following identification keys provided in the literatures (Pillai and Ravichandran, 1999; Kamei et al., 2009; Kamei and Biju, 2016; Chaitanya et al., 2017), and sex was determined on the basis of Gower and Wilkinson (2002). Twenty two specimens of striped form *Ichthyophis* spp. from Mizoram, India, collected over a period of 9 years from 2010 to 2019 were studied. Specimen collection is in accordance with the permission issued by the Chief Wildlife Warden, Environment, Forest and Climate Change Department, Government of Mizoram, India (Permit No. A.33011/2/99-CWLW/225). The specimens were fixed in 4% formaldehyde solution for 2 days, washed and preserved in 70% ethanol. Fresh tissue samples were preserved in 70% ethanol for further DNA analysis. All specimens were deposited in the Departmental Museum of Zoology, Mizoram University (MZMU).

All of the morphometric and meristic measurements were taken to the nearest 0.1 mm using a Mitutoyo™ dial vernier calliper except total length, which was measured with the help of a thread and a scale. The following abbreviations for external morphological characters were adopted for the sake of brevity (Table 1): Number of annular grooves counted dorsally (AG); transverse grooves (TGs); total length (TL); corner of mouth (CM); distance between tentacle and nare (TN); distance between tentacle and eye (TE); length of the first collar (C1); length of the second collar (C2); circumference at mid-body (CM); tentacle (TA); snout to tentacle (ST); nuchal groove (NG); length/width (L/W); length/height (L/H); width/stripe (W/S).

Results and Discussion

Our dedicated and strenuous surveys at different localities in Mizoram have resulted to the collection of 22 specimens of striped Ichthyophiids species, which were morphologically analyzed and thereby revealed the occurrence of four distinct species in the state. All nomenclature herein follows the taxonomy suggested by Kamei *et al.* (2009). However, the nominate species of *Ichthyophis* from north-eastern India have solely been described and identified on the basis of morphological characters (Taylor, 1960a; Pillai and Ravichandran, 1999; Mathew and Sen, 2009; Kamei *et al.*, 2009; Kamei and Biju, 2016). The previously reported two species i.e. *I. khumzhi* and *I. moustakius* distinct from the congeners species of Northeast India in terms of the number of annular grooves counted dorsally (AG), and the possessing of unique moustache-

like arched yellow stripe that extends beyond its tentacles coupled with the number of annular grooves on its body respectively (Kamei *et al.*, 2009). Both *I. khumzhi* and *I. moustakius* are distinguished from *I. sikkimensis* by the presence of a yellow lateral stripe. Moreover, *I. khumzhi* is diagnosed from all other striped form congeners from northeastern India based on the number of annular grooves counted dorsally: 341–362 vs. 269–299 (*I. alfredi*), 264–310 (*I. daribokensis*), 269–300 (*I. nokrekensis*), 264–309 (*I. garoensis*), 238–268 (*I. moustakius*) and 283–308 (*I. sendenyu*); a distinct V-shaped head tapering substantially after the TAs; C1 visibly shorter than C2; TN/TE ratio 2.2–2.4; narrow, irregular lateral stripes with uneven edges extending from close to CM to level of vent. *I. moustakius* is diagnosed using the following combination of characters: 238–268 AGs vs. 282–287 (*I. garoensis*) and 283–308 (*I. sendenyu*); arched yellow stripes extending between nares and

Table 1 : Measurements (in mm) and meristic data of *I. garoensis* and *I. sendenyu* from Mizoram

	<i>I. garoensis</i>			<i>I. sendenyu</i>	
Museum Number (MZMU)	1506	899	918	925	1504
Length	235	287	243	248	240
Width at midbody	9.9	11.2	9.6	9.08	10.1
Circumference at midbody	30	33	33	28	31
Max width of stripe at midbody	3.4	3.1	2.45	2.8	2.9
Width at anterior of vent	4.5	5.8	4.5	4.3	4.2
Head length	10.2	11.2	11	10.1	10.3
Length of C1 directly behind CM	3.2	3.3	2.8	2.3	2.6
Length of C2 directly behind CM	5.9	6.5	4.6	4.7	4.7
Head width at CM	6.6	6.5	5.9	5.8	7.2
Head depth behind CM	4.5	3.9	4.04	4.2	4.2
Head width at NG1	6.5	6.5	7.6	6.3	7.1
Distance between eyes	5.2	5.2	4.9	4.4	5.1
Distance between nares	1.8	1.9	2	1.7	1.9
Distance between eye and nares	4.1	4.4	4.3	3.8	4.4
Distance between TAs	5.2	4.8	5.2	4.6	4.9
Distance between TA and eye	1.44	1.6	1.9	1.6	1.5
Distance between TA and naris	3.2	3.1	3.1	3	3
Distance between TA and ST	3.7	4	3.8	3.8	3.8
Distance between TA and lip	0.4	0.4	0.5	0.34	0.4
Distance between ST and eye	5.1	5.2	5.2	4.7	5
Distance between ST and naris	0.9	0.9	1.1	0.9	1.1
Distance between ST and lip	1	1	1.2	1.1	1
Distance in front of eyes	5.2	5.3	5.3	4.6	5.2
Distance between eye and lip	1.2	1.3	1.2	0.8	1.4
distance behind anterior of vent	5.2	6.5	5.8	6	5.3
Distance behind posterior of vent	3.4	4	3.1	3.1	2.8
AGs (counted dorsally)	283	293	292	296	298
AGs (counted ventrally)	279	287	287	289	291
TGs	2	1	2	1	2
AGs behind disc	6	5	5	6	5
AGs interrupted by disc	4	3	5	4	4
L/W	23.7	25.6	25.3	25.3	23.7
L/H	23.03	25.6	22.09	24.5	23.3
TN/TE	2.22	1.9	1.6	1.87	2
W/S	2.9	3.6	3.9	3.24	3.48

Fig. 1 : *Ichthyophis garoensis* from Mizoram: (A) Ventral view of mid-body in life, (B) Dorsolateral view of head in life, (C) Ventral view of body terminus in preservation, and (D) Dorsal view in life.

TAs, broader at the TAs vs. no arched yellow stripes on head (*I. alfredi*, *I. daribokensis* and *I. nokrekensis*); U-shaped head tapering only slightly after the TAs; C1 and C2 of similar lengths; TN/TE 1.9–2.3; fairly regular, solid lateral stripes extending until CM. Kamei et al., (2009) described *I. khumhzi* based on 3 specimens collected from a single locality. V-shaped head characteristic coupled with a few other descriptive morphological characters of *I. khumhzi* were observed in numerous specimens of our collection. However, the AGs of these specimens do not conform to the range published for *I. khumhzi* (364–396 vs. 341–362). Similarly, Kamei et al. (2009) described *I. moustakius* with 238–268 AGs in their summary table, but their morphology datasheet includes 2 specimens (out of eight) with 272 and 292 AGs respectively. For excluding possible conspecific, this report took a conservative approach, thereby employed the narrower AG range to diagnose *I. moustakius*.

The specimen of *I. garoensis*, MZMU 1506 (Fig. 1) was confirmed by having dorsal annular grooves (AGs): 264–308; ventral annular grooves (AGs): 263–307; transverse groove: 1–3; AGs behind disc: 5–8; AGs interrupted by disc: 3–6; L/W: 19.6–29.7; W/S: 2.8–5; L/H: 20.7–25.3; TN/TE: 1.8–2.3; Total length: 220–323. The specimens of *I. sendenyu*, MZMU 899, MZMU 918, MZMU 925 and MZMU 1504 (Fig. 2) were also confirmed by having dorsal annular groove: 283–308; ventral annular groove: 283–304; transverse groove: 1–2; Total length: <300; L/W: 21–27;

Fig. 2 : *Ichthyophis sendenyu* from Mizoram: (A) Dorsolateral view of head in life, (B) Ventral view of body terminus in life, and (C) Dorsal view of preserved specimen.

L/H: >20; TN/TE: <2; W/S: <4; AGs behind disc: 4–7. These distinguishing features agreed with the identifications mentioned in the existing literatures. The occurrence of *I. garoensis* and *I. sendenyu* in Mizoram represents a new state report and extending their geographic distribution range. Astoundingly, *I. garoensis* is currently categorized as Data Deficient (DD) in the IUCN Red List because “it has only recently been discovered, and there is still very little information on its extent of occurrence, status and ethological requirements” (Dutta et al., 2004). Moreover, three striped species, *I. alfredi* Mathew and Sen, 2009, *I. nokrekensis* Mathew and Sen, 2009, and *I. daribokensis* Mathew and Sen, 2009 need further verification as their descriptions are not clear enough to be elevated at the species level. There is no clear distinctive feature between *I. garoensis* and *I. sendenyu* on the basis of existing literatures except in the TN/TE and AGs interrupted by disc. If we are following the number of AGs interrupted by disc, all the present specimens might come under either *I. garoensis* or *I. moustakius*. Moreover, the range of AGs in *I. garoensis*, *I. moustakius* and *I. sendenyu* are overlapping, which is not dependable for discriminating these species. Thus, a comprehensive study employing molecular and morphological analyses for the phylogenetical data of these cryptic amphibians would go a long way in helping assess their diversity, distribution, conservation statuses, and also to improve the knowledge on their taxonomy, ecology, and life history with better accuracy.

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