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A new species of *Indotyphlus* Taylor (Amphibia: Gymnophiona: Caeciliidae) from the Western Ghats, India

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Abstract

A new species of Indian caeciliid caecilian, *Indotyphlus maharashtraensis* (Amphibia: Gymnophiona), is described based on a series of 12 specimens from the northern Western Ghats of the State of Maharashtra. This species differs from the only other species in the genus, *I. battersbyi*, in having fewer primary annuli, many more primary annuli bearing secondary annular grooves, and in the presence of a modified subterminal region that has a depressed preanal strip extending anteriorly from around the vent. A key to the species of *Indotyphlus* is provided.

Key words: caecilians, *Gegeneophis*, herpetology, *Indotyphlus battersbyi*, South Asia, systematics

Introduction

The Western Ghats are a recognised global biodiversity hotspot (Myers et al. 2000) and a centre of caecilian diversity and endemism (e.g. Bhatta 1997; Gower et al. 2004; Ravichandran 2004). Recent description of two new species of the caeciliid genus *Gegeneophis* from localities in the State of Maharashtra have drawn attention to this herpetologically relatively poorly known northern region of the Western Ghats (Giri et al. 2003; Ravichandran et al. 2003). Earlier, Taylor (1960) established the caeciliid genus *Indotyphlus* to receive a new species, *I. battersbyi*. This was based on a single specimen from Khandala, a Western Ghats locality between Mumbai and Pune in Maharashtra, with additional specimens subsequently reported from nearby Lonavla (Taylor 1968) and 'near Mumbai' (Taylor 1970). Caecilians recently collected from another Maharashtran locality approximately 150 km south of the known provenance of *I. battersbyi* represent a second species of this endemic genus that we describe here.

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***Indotyphlus maharashtraensis* sp. nov.**
(Figs. 1–3, Table 1)

Holotype: Bombay Natural History Society, Mumbai, India (BNHS) 4217. A female, collected near Dhanagarwada, Humbarli village, near Koyna, Satara District, Maharashtra, India, by Varad Giri, Sameer Kehimkar, Ishan Agarwal and Vithoba Hegade, 19th June 2003. The specimen was found on a plateau (Fig. 4), under a rock in an open patch of grass surrounded by semievergreen forest. The locality is situated in the Western Ghats at approximately 1042 m above sea level.

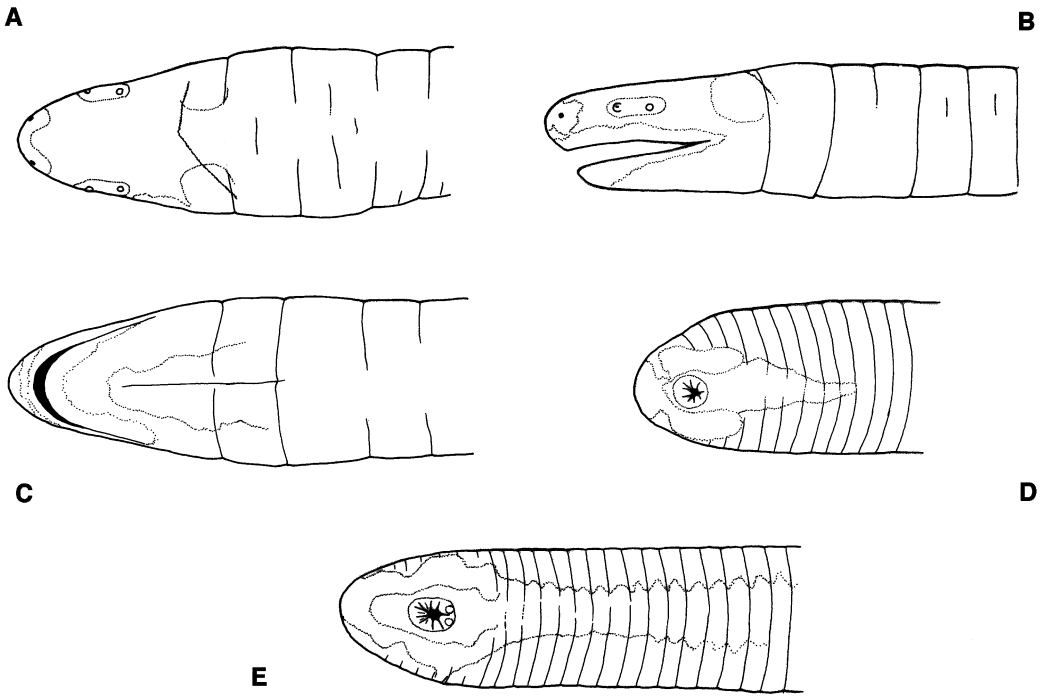

FIGURE 1. Figures (from camera lucida drawings) of the head and posterior terminus of *Indotyphlus maharashtraensis*. For the holotype (BNHS 4217, an adult female), the head and nuchal region are shown in A) dorsal, B) lateral, and C) ventral views, with paler regions at the snout tip, eye-tentacle stripe, margins of the lips, superficial to the depressor mandibulae muscles, and gular patch indicated by dotted lines. Ventral views of the posterior terminus are shown for D) the holotype, and E) a paratopotype (BNHS 4223, an adult male). In both specimens, the disc surrounding the vent and the tip of the terminus are whitish. The preanal strip extending anteriorly from immediately around the disc is an even lavender-grey colour, while the background colour of the rest of the underside of the posterior of the body is lavender-grey, flecked with large white glands. For dimensions of these two specimens, see Table 1.

TABLE 1. Some morphometric (in mm) and meristic data for the type series of *Indotyphlus maharashtraensis*. Measurements were made to the nearest 0.1 mm with dial callipers, except for length and circumference, which were measured with a ruler and piece of thread. * indicates holotype; all other specimens are paratopotypes. † indicates doubling of tooth count recorded from one side of the mouth.

Specimen number (BNHS prefix)	4217*	4200	4218	4219	4220	4221
Sex	f	f	m	f	m?	f
Total length	181	197	78	138	72	100
Number of primary annuli	127	133	129	131	126	129
Anteriormost primary annulus with indication of secondary groove	70	77	70	88	68	69
Anteriormost primary bearing dorsally complete secondary groove	87	96	79	101	74	78
Anteriormost primary bearing ventrally complete secondary groove	111	114	c.114	118	113	112
Head length (snout tip to first nuchal groove, laterally)	5.3	5.5	3.3	4.7	3.6	4.0
Distance between snout tip and angle of jaws	4.1	4.5	3.0	3.4	2.8	3.4
Distance between tip of lower jaw and first nuchal groove (laterally)	4.7	4.9	3.0	4.0	3.4	3.4
Distance between tip of lower jaw and angle of jaws	3.7	3.3	2.7	3.1	2.7	2.7
Length of first nuchal collar (measured laterally)	1.5	1.7	0.9	1.5	0.9	1.0
Length of second nuchal collar (measured laterally)	2.1	2.1	1.3	1.8	1.2	1.5
Head width at first nuchal groove	3.6	3.7	2.2	2.7	2.1	2.3
Head width at angle of jaws	3.3	3.5	2.0	2.5	2.0	2.2
Distance between external nares	1.2	1.2	0.8	1.3	0.9	0.9
Distance between tentacles	2.3	2.1	1.3	2.0	1.5	1.6
Distance between eyes (where visible)	2.2	na	1.3	1.8	1.4	1.5
Distance between external naris and tentacle	1.4	1.3	0.9	1.2	0.9	0.9
Distance between external naris and eye	1.9	na	1.1	1.6	1.3	1.3
Distance between tentacle and eye	0.5	na	0.3	0.5	0.3	0.4
Distance between tentacle and margin of upper lip	0.6	0.8	0.5	0.6	0.4	0.5
Distance between external naris and first nuchal collar groove	4.7	5.0	3.0	4.0	3.2	3.4
Distance between external naris and angle of jaws	3.4	3.3	2.1	2.8	2.4	2.7
Distance between tentacle and tip of snout	2.0	1.8	1.3	1.9	1.3	1.5
Distance between tentacle and angle of jaws	2.1	2.2	1.3	1.8	1.7	1.6
Distance between eye and angle of jaws	1.5	na	1.0	1.2	1.0	1.2
Distance between snout tip and anterior margin of mouth	0.8	1.1	0.7	0.7	0.5	0.7
Width at midbody	3.8	3.6	1.7	2.8	1.5	2.5
Body width at level of vent	2.7	2.4	1.4	2.0	1.1	1.7
Distance from vent to body terminus	1.7	1.5	1.0	1.4	0.8	1.0
Circumference at midbody	14	14	6	10	8	8
Premaxillary-maxillary teeth	25	24	19	22	22	20
Vomeropalatine teeth	24	26	20	23	22	22
Dentary teeth	20	21	19	22	19	21
Splenial teeth	4	3	4	4	3	3

.....continued on the next page

TABLE 1 continued.

Specimen number (BNHS prefix)	4222	4223	4224	4225	4333	4334
Sex	f?	m	m	f	f	f
Total length	70	179	205	123	145	193
Number of primary annuli	129	124	125	131	128	133
Anteriormost primary annulus with indication of secondary groove	68	58	72	81	66	64
Anteriormost primary bearing dorsally complete secondary groove	76	71	85	100	83	91
Anteriormost primary bearing ventrally complete secondary groove	108	100	107	113	107	118
Head length (snout tip to first nuchal groove, laterally)	3.6	6.0	7.0	4.4	4.4	5.5
Distance between snout tip and angle of jaws	2.9	4.4	5.4	3.6	3.4	4.4
Distance between tip of lower jaw and first nuchal groove (laterally)	3.3	5.2	6.0	3.9	4.0	4.8
Distance between tip of lower jaw and angle of jaws	2.3	3.5	4.6	3.2	2.8	3.9
Length of first nuchal collar (measured laterally)	1.0	1.5	1.9	1.4	1.4	1.5
Length of second nuchal collar (measured laterally)	1.3	2.0	2.3	1.7	1.7	2.0
Head width at first nuchal groove	2.0	3.1	3.8	2.7	3.1	3.6
Head width at angle of jaws	2.0	3.0	3.7	2.5	2.5	3.1
Distance between external nares	0.9	1.2	1.4	1.1	1.0	1.4
Distance between tentacles	1.4	2.3	2.6	1.9	1.9	2.4
Distance between eyes (where visible)	1.3	2.2	2.5	1.8	1.6	2.4
Distance between external naris and tentacle	0.9	1.5	1.9	1.0	1.0	1.6
Distance between external naris and eye	1.2	2.1	2.4	1.5	1.6	2.5
Distance between tentacle and eye	0.3	0.5	0.6	0.5	0.5	0.7
Distance between tentacle and margin of upper lip	0.4	0.6	0.8	0.6	0.5	0.8
Distance between external naris and first nuchal collar groove	3.9	5.2	6.5	3.9	4.0	4.9
Distance between external naris and angle of jaws	2.4	3.9	4.5	3.1	2.9	3.9
Distance between tentacle and tip of snout	1.4	2.2	2.4	1.7	1.5	2.1
Distance between tentacle and angle of jaws	1.4	2.5	2.4	2.0	1.9	2.4
Distance between eye and angle of jaws	1.2	1.7	1.9	1.7	1.2	2.0
Distance between snout tip and anterior margin of mouth	0.6	0.8	1.1	0.8	0.5	0.9
Width at midbody	2.2	3.6	4.6	2.7	4.0	5.0
Body width at level of vent	1.1	3.2	3.9	2.0	2.6	3.2
Distance from vent to body terminus	0.8	2.0	2.3	1.3	1.5	2.0
Circumference at midbody	6	13	15	9	13	16
Premaxillary-maxillary teeth	20	22	25	22	22	26
Vomeropalatine teeth	23	24	28†	24	23	24†
Dentary teeth	20	19	21	21	19	20
Splenial teeth	4	4	2	4	4	4

FIGURE 2. Photographs of *Indotyphlus maharashtraensis*, showing whole adult (upper) and lateral view of head of same specimen (lower left) in life, and ventral view of terminus of paratopotype male BNHS 4223 in preservation (lower right).

Paratopotypes: Eleven further specimens collected either on the same day (or within two days) as the holotype (BNHS 4200, 4218 to 4225) or on 20th August 2004 (BNHS 4333, 4334), all from the same locality and habitat as the holotype.

Diagnosis: An *Indotyphlus* differing from *I. battersbyi* in having secondary annular grooves present anterior to the 100th primary annulus behind the nuchal collars, and in having a depressed preanal strip (longer in adult males) anterior to the disc surrounding the vent.

Description of the holotype: Some morphometric and meristic data are given in Table 1. The holotype is in good condition generally. It is a little dehydrated so that the skin throughout much of the body is roughened by raised glands, especially on the dorsum. Dehydration has also caused a darkening in colour, and is probably responsible for an intermittent midventral groove that is not present in life. There is a small (7 mm) midventral longitudinal incision into the body cavity 65 mm in front of the vent. There is a small V-shaped scar on the posterior part of the dorsal surface of the head.

The natural body shape is subcylindrical, slightly dorsoventrally compressed throughout most of the body (a little more so in preservative), distinctly flattened on the ventral surface for approximately the terminal 20 mm. It is fairly uniform in width, but gently nar-

rowing in the anterior fifth (where it is less dorsoventrally compressed). The body also narrows gradually for its posterior third, narrowing strongly in lateral view from just anterior to the level of the vent.

In dorsal view, the head tapers strongly from the level of the occiput to the external nares, with a slight bulging in the region of the tentacles. Anterior to the nares, it terminates in a rounded, narrow snout tip. In lateral view, the top of the head is straight, with no strong bulges. The margin of the upper lip is not markedly concave in lateral view. The snout tip is bluntly rounded, and its apex lies just below the horizontal level of the naris. The distance between the jaw angle (the corner of the mouth) and the top of the head is marginally (less than one and a half times) greater than the distance between the jaw angle and the lower surface of the lower jaw.

The eyes are visible (more clearly visible in life) through the skin as small dark spots (no lens visible) at the posterior end of a whitish (pale pink in life) stripe extending from immediately posterior to the eye to immediately anterior to the tentacle. In lateral view, the eye lies approximately halfway between the margin of the upper lip and the top of the head. In dorsal view, the eyes are inset from the lateral margins of the head. The eye region is not elevated or depressed.

In life, the tentacles are short and globular (i.e. non-filamentous) but with a pointed tip. The tentacular apertures are horseshoe shaped (posteriorly concave) when occluded by a distinct flap that is continuous posteriorly with the skin. They are raised and dorsolaterally positioned, clearly visible in dorsal view, visible only as a bulge in ventral view. In lateral view, each tentacle appears approximately twice as close to the top of the head as to the margin of the upper lip (0.6 mm), and just above an imaginary straight line between eye and naris. In lateral view, an imaginary straight line extending backwards from the naris through the position of the tentacular aperture crosses the upper margin of the head at about the second nuchal groove. The tentacular apertures are far posterior to the anteriormost margin of the mouth, 2 mm from the tip of the snout. The distance between tentacle and eye (0.5 mm) is substantially smaller than between tentacle and naris (1.4 mm).

The very small (0.2 mm) subcircular nares are set back slightly from the tip of the snout. They are not notably closer to the anteriormost margin of the mouth than to the level of the snout tip or *vice versa*. They are 1.2 mm apart, visible dorsally, anteriorly and laterally, but not ventrally. Each naris lies in the anteromedial part of a 0.7 mm wide whitish spot. The tip of the snout lies 0.8 mm in front of the anteriormost margin of the upper lip. The underside of the rostrum is essentially flat. In ventral view, the tip of the lower jaw is broadly rounded, more so than the tip of the snout.

The jaw angles are not cut and tooth counts are approximate. We counted 25 premaxillary-maxillary, 24 vomeropalatine, 20 dentary, and 4 splenial teeth (including empty ‘sockets’). The tooth crowns of all series are gently recurved and, as far as can be ascertained, all are bicusped with smaller labial cusps. The dentary teeth are the largest, followed by those of the premaxillary-maxillary (PMM) series. The teeth of the splenial, and

vomeropalatine (VP) series are the smallest. The PMM, VP and splenial teeth show little variation in size within each series. The largest teeth in the dentary series are in the third position behind the anterior tip (symphysis) of the mandible, where they are twice the size of the largest in the PMM series. Behind this, the dentary teeth gradually decrease in size, being very small posteriorly. The VP series lacks diastemata, and is masked in lateral view by the outer, PMM series. The splenial teeth are less than one third the size of the largest dentaries.

The subcircular choanae are large and separated by a distance that is approximately equal to the width of each choana. Choanal valves are not clearly visible. The fleshy tip of the tongue is unattached anteriorly and does not overlie the splenial teeth. Laterally it is separated from the gingivae by a deep groove. There is a pair of large, prominent narial plugs. Their anterior and medial margins are clearly demarcated by a groove, but posteriorly they are smoothly continuous with the surface of the rest of the tongue. The tongue lacks a midline longitudinal groove. Posterior to the narial plugs, and separated from the plugs by a gap, are a pair of grooves close, and parallel, to the lateral edges of the tongue. There are some longitudinal plicae between these grooves and the posteromedial edge of the plugs. The tongue tip is pink, the narial plugs are dark, and the region between them whitish.

The nuchal region is slightly broader than the adjacent areas. The two nuchal collars are marked clearly by three nuchal grooves that have the same whitish colour (laterally and ventrally) as the following annular grooves. The second collar (2.1 mm, measured laterally) is longer than the first (1.5 mm). The first (anteriormost) nuchal groove is narrowly incomplete ventrally and more broadly incomplete middorsally. It curves forwards slightly midventrally. The second nuchal groove (between the first and second collars) is incomplete only middorsally. It is marked ventrally by a slight fold and is notably paler than the adjacent area. The third nuchal groove, marking the end of the nuchal collar region, is broadly incomplete midventrally and narrowly incomplete middorsally. The first collar bears a faint, short middorsal transverse groove. The second collar bears a faintly indicated, broad, middorsal transverse groove, more pronounced on the left and seemingly incomplete across the midline. A fainter, more superficial crease lies between this transverse groove and the back of the second collar. Neither collar bears transverse grooves ventrally or laterally. A midventral longitudinal groove extends from about halfway between the tip of the lower jaw and the first nuchal groove to the second nuchal groove.

The nuchal and annular grooves are mostly perpendicular to the long axis of the body. The annuli are marked by whitish coloured (more pronounced laterally) grooves that are increasingly conspicuous posteriorly. There are 127 primary annuli. The annular grooves are mostly incomplete dorsally for the first two thirds or so of the body, and this incompleteness decreases posteriorly. Ventrally, they are mostly complete but faintly indicated. The first, second and third primary annuli bear short, faint, dorsolateral transverse grooves, clear only on the left side. These are in a position that might be expected of sec-

ondary annular grooves, but the first clear indication of a secondary annular groove behind this (which we consider the first secondary), is dorsolaterally on the left of the 70th primary annulus. The next five primaries (71–75) also bear dorsolateral secondary grooves on the left side only, but secondary grooves are on both sides of the body behind this. The anteriormost secondary annular groove that extends across the dorsal midline is on the 87th primary annulus, and all primary and secondary grooves posterior to this also cross the dorsum. Secondary annular grooves extend across the midline of the ventral surface from the 111th primary annulus backwards. However, the annular groove is interrupted midventrally by the vent and surrounding disc. There are no annular grooves posterior to the vent, and there is a short terminal cap.

Searches for annular scales were made at three points along the body. At the posterior groove of the 10th primary annulus anterior to the posterior terminus, there are four scale rows dorsally. Two rounded but subquadrangular scales removed from here measured 0.6 x 0.9 mm and 0.5 x 0.6 mm. The fold or pocket holding these scales is about as deep as the length of each primary annulus in this region. Ventrally at this point, one or two scale rows lie in a fold that is less than one secondary annulus deep. At about the 75th primary annulus (just behind where secondary grooves begin), the fold in the dorsal part of the annular groove is not well developed. It contains a single row of subcircular scales, one of which measured 0.3 x 0.2 mm. There are no scales ventrally at this position. At the 50th primary annulus, there are no pockets or scales.

The body terminus is bluntly rounded in dorsal view. In lateral view, the ventral surface appears flat, the short terminal cap tapers more steeply from the dorsum, and is upturned only slightly on its ventral surface. There is no indication of a terminal keel. The subcircular vent lies just 1.7 mm from the body terminus within a small subcircular disc. The vent is slightly irregular, but the disc has a pattern of five posterior and four anterior denticles, the posteromedial of which is the largest. No papillae are evident on any of the denticulations. The subterminal area around the disc and onto the terminal cap is flattened. There is a long (c. 6 mm), progressively narrowing and slightly depressed, mid-ventral preanal strip (Fig. 1D) in which granular glands are conspicuously absent so that superficially annular grooves appear (but are not) incomplete.

In preservative and in life the ground colour of the dorsal surface of the body is mostly brownish, but more grey/lavender posteriorly, and paler laterally and ventrally. Granular glands are visible as white flecks scattered over much of the body. Alignment of granular glands along annular grooves makes the grooves conspicuous laterally throughout. The extent to which annuli are marked by glands, both dorsally and ventrally, increases gradually towards the posterior of the body as the annular grooves become more complete. Granular glands are much less abundant or absent on the head and the preanal strip.

There is a paler, triangular gular patch on the underside of the first collar and onto the lower surface of the head between the mandibular rami. Here the longitudinal groove is enveloped by this patch. The paler patch (not visible laterally) is separated from the whit-

ish lower lips by a darker ground colour. In dorsal view, the head is darker and more lavender than the nuchal region (and body), except for pale, broad eye-tentacle stripes, halos surrounding the nares, and patches in the position of the slightly bulging depressor mandibulae muscles. The snout tip is also pale, but less so than the halos around the nares, from which it is incompletely separated. The lips are edged in a whitish colour, more broadly on the lower jaw, particularly anteriorly. In dorsal and lateral views, the eye-tentacle stripes are subparallel to the longitudinal axis of the head. In dorsal view, these stripes reach the margins of the head. In life, the paler regions of the head are infused with blood and pinkish. Dorsally, the terminal cap is a darker lavender than the preceding annuli. It has a whitish tip that is continuous with pale patches extending lateral and anterior to the disc. The preanal strip is lavender grey and this extends back as a narrow area surrounding the white disc (Fig. 1D). Areas either side of this and back onto the underside of the terminal cap are white.

Etymology: The species is named for Maharashtra, the Indian State within which the type locality lies.

Additional information from paratopotypes

Size and sexual dimorphism: Morphometric and meristic data for the type series are given in Table 1. The sample provides a restricted understanding of variation and offers some insights into the biology of the species. Specimens range in size from 70 mm to 205 mm. Sex was confidently determined by examining gonads in specimens as small as 78 mm. The larger males had mature testes. The female BNHS 4334 is the only specimen with large yolky ova, containing a total of nine such eggs (smallest 2.9 by 1.6 mm) and many much smaller ova (smallest 0.6 by 0.3 mm). Overall, the sample suggests that *I. maharashtraensis* may be a relatively small species that reaches sexual maturity at a relatively small size and age compared to other studied caecilians (e.g. *Ichthyophis* sp., Kupfer et al. 2004; *Typhlonectes compressicauda*, Exbrayat 2000; *Dermophis mexicanus*, Wake 1980). Another indication of maturity is clear sexual dimorphism. Adult males have a much more conspicuous and longer preanal strip. There are no obvious indications of other external sexual dimorphism. Papillae on the vent denticulations, which Taylor (1968: 21–22) thought were present only in male caecilians, are present in all males and most females in this sample.

Mouth and skull: One specimen, BNHS 4200, was selected for a more detailed examination of the inside of the mouth by cutting the jaws, and for a preliminary examination of dermal bones of the skull roof by reflecting the skin of the left side of the head. In this specimen, the oval choanae are separated by 0.5 mm, which is slightly greater than the maximum transverse width of each choana (c.0.4 mm). The medial rims of the choanae are raised. The long axis of the oval outline of each choana is 0.6 mm. Each valve is clearly visible as a slit along the longitudinal axis of the choana. The medial edge of the valve is

continuous with the skin on the medial wall of the choana. The lateral side is a more distinct flap.

Anteriorly, the PMM tooth series traces a broad arc across the midline, whereas the anterior convergence of the VP series is more abrupt and acute, paralleling the shape of the tongue. There are four vomerine teeth anterior to the choanae on each side (and one further tooth anteromedially). There are five palatine teeth posterior to each choana. Soft tissue along the ridge of the anterior part of the VP series forms two sides of a subequilateral triangle in front of the choanae. The distance between the PMM and VP series increases anteriorly.

On each side, two teeth of the VP series lie posterior to the end of the PMM series. The PMM teeth increase slightly in size from the anterior to the 3rd or 4th position. They then decrease gradually posteriorly. The VP teeth are largest anteriorly, they decrease gradually in size behind this. The largest VP teeth are larger than the smallest PMM teeth, and the smallest VP teeth are smaller. The tooth crowns of the VP series appear more slender than the PMM series. The dentary teeth increase rapidly in size up to the 3rd or 4th position, where they reach a maximum (being the largest teeth in the mouth) before steadily decreasing posteriorly. The small splenial teeth are about the same size as the medium VP teeth. All teeth are very gently recurved. The anterior of the tongue is free, with a whitish fleshy tip. Elsewhere the tongue is a little darker, especially on the narial plugs. There are faint longitudinal plicae medially, between the posterior parts of the narial plugs. The splenial teeth are not covered by the tongue. The eye is not covered by bone, and is embedded in the base of the thick tentacle. The tentacular groove is open.

Nuchal collars, throat and anterior annuli: The longitudinal submental groove is present in all specimens, but is sometimes faint (e.g. BNHS 4225). There is variation in the number and extent of dorsal transverse grooves on the nuchal collars. The first collar has one (e.g. holotype, BNHS 4221) or two (BNHS 4200, 4218, 4219, 4222, 4225) grooves, and the second collar no (BNHS 4200) or one or two (holotype, BNHS 4221) grooves. The completeness of dorsal transverse grooves across the midline of the collars varies. Short dorsolateral, secondary-like grooves on the anteriormost few primary annuli are present in all but one small specimen (BNHS 4218). They are variable in their appearance and extent, and there is usually bilateral asymmetry. For example, they are present on the first three primaries in BNHS 4200, more clearly on the right, and perhaps on the first eight primaries of BNHS 4222, where they are much clearer on the left.

Region of the vent: The denticulations bordering the vent never extend to the edge of the disc. Often there are five posterior denticulations and four anteriorly (as in the holotype), but they are sometimes irregular and vary by one or two both anteriorly and posteriorly, so that the total number ranges from seven (BNHS 4225) to more typically ten (BNHS 4220, 4221, 4222). All but two paratopotypes (BNHS 4222, 4334) differ from the holotype in having a pair of unpigmented papillae on the anteromedial denticulations. When present these may be weakly indicated (e.g. BNHS 4219) and in BNHS 4224 they

are pinkish. The disc surrounding the vent is often depressed, sometimes with a thickened rim. It is mostly creamy white, but is sometimes dark grey, either entirely except for the denticulations (BNHS 4221) or only posteriorly (e.g. BNHS 4222, 4223, 4224). The smooth preanal strip that extends anteriorly from around the disc of the holotype is present in all specimens. In the majority of these, it extends forward for no more than six (BNHS 4219) primary annuli. However, in the two large males (BNHS 4223, 4224) it extends far anteriorly (Figs. 1E, 2) across up to 15 primary annuli (c. 15 mm), and it is more strongly depressed (concave transversely). The number of annular grooves posterior to the vent varies in the paratopotypes from two (e.g. BNHS 4200, 4218) to five (only BNHS 4223), being zero only in the holotype. The number of grooves posterior to the vent is perhaps approximately inversely correlated with the size of the terminal cap, which is small, for example, in BNHS 4223. The underside of the terminal cap does (e.g. holotype) or does not (BNHS 4218, 4222) have a pale tip.

Scales: No scales could be found in the smallest specimen, BNHS 4222, even dorsally and within 10 mm of the posterior terminus.

Colour: The larger paratopotypes are more dark and brown, and the smaller specimens more pale and grey, with the holotype being toward the middle of this spectrum. Body colour also varies strongly with state of preservation, so that more dehydrated specimens are more dark and brown. There is a little variation in head colour, mostly in the tone of the paler patches. For example, the snout tip varies from very pale (e.g. BNHS 4225) to rather dark (BNHS 4218 and 4223). The gular patch varies from smaller and weak (e.g. BNHS 4218) to larger and better defined (e.g. BNHS 4200).

Gut contents: Small pieces of earthworm were found in the gut of the two smallest specimens, BNHS 4220 and 4222. These were removed through small incisions in the gut that made accidentally while gaining access to the coelom. No systematic inspection of other gut contents was conducted.

Relationships and comparison with *I. battersbyi*

A diagnosis of *Indotyphlus* was provided by Nussbaum & Wilkinson (1989) who employed a core set of characters to distinguish all caeciliid genera. They diagnosed *Indotyphlus* as caeciliids with the eye not under bone; no temporal fossae; mesethmoid not exposed dorsally; splenial teeth present; secondary grooves present; scales present; tentacular opening closer to eye than to external naris; no unsegmented terminal shield; small narial plugs on tongue; no diastema between vomerine and palatine teeth; no terminal keel. Based on our observations, the narial plugs of the type species, *I. battersbyi*, are not especially small. Allowing for this, the new species matches precisely the generic diagnosis and is an *Indotyphlus* as currently conceived.

Data for some meristic and morphometric characters for a sample of *I. battersbyi* (including the holotype), all from the vicinity of the type locality, are presented in Table 2.

TABLE 2. Some morphometric (in mm) and meristic data for a sample of *Indotyphlus battersbyi*. Measurements as for Table 1. * indicates holotype (American Museum of Natural History, New York).

Specimen number	AMNH A 49974*	BNHS 1	BNHS 2	BNHS 3	BNHS 4
Sex	m	m	f	m	na
Total length	158	211	187	195	86
Number of primary annuli	139	139	137	137	133
Anteriormost primary annulus bearing indication of secondary groove	106	110	113	109	111
Anteriormost primary bearing dorsally complete secondary groove	119	117	117	116	120
Anteriormost primary bearing ventrally complete secondary groove	130	125	129	122	-
Head length (snout tip to first nuchal groove, laterally)	4.8	5.9	5.6	5.5	3.1
Distance between snout tip and angle of jaws	na	4.5	4.3	3.8	2.4
Distance between tip of lower jaw and first nuchal groove (laterally)	4.1	4.9	5.1	4.4	2.7
Distance between tip of lower jaw and angle of jaws	na	3.7	3.6	3.3	2.0
Length of first nuchal collar (measured laterally)	1.1	1.1	1.1	1.2	0.8
Length of second nuchal collar (measured laterally)	1.7	2.2	1.9	1.9	1.1
Head width at first nuchal groove	2.8	3.4	3.4	3.2	1.7
Head width at angle of jaws	na	3.3	3.1	3.0	1.7
Distance between external nares	1.0	1.4	1.3	1.3	0.7
Distance between tentacles	1.8	2.7	2.1	2.3	1.3
Distance between eyes (where visible)	na	na	na	2.2	1.1
Distance between external naris and tentacle	1.1	1.8	1.5	1.6	0.6
Distance between external naris and eye	na	na	na	2.0	0.9
Distance between tentacle and eye	na	na	na	0.5	0.3
Distance between tentacle and margin of upper lip	0.5	0.8	0.6	0.5	0.5
Distance between external naris and first nuchal collar groove	4.2	5.6	4.9	5.0	2.7
Distance between external naris and angle of jaws	na	3.9	3.7	3.9	2.0
Distance between tentacle and tip of snout	1.6	2.3	2.2	2.1	1.1
Distance between tentacle and angle of jaws	na	2.7	2.5	2.3	1.1
Distance between eye and angle of jaws	na	na	na	1.7	0.8
Distance between snout tip and anterior margin of mouth	0.6	1.0	0.8	0.8	0.6
Width at midbody	3.6	3.9	3.7	3.2	2.1
Body width at level of vent	2.3	2.5	1.9	2.3	1.5
Distance between vent and body terminus)	1.0	1	1.2	0.9	0.6
Circumference at midbody	7	15	14	13	6
Premaxillary-maxillary teeth	21	22	21	22	18
Vomeropalatine teeth	22	26	25	26	22
Dentary teeth	18	20	22	21	22
Splenial teeth	4	2	4	4	4

.....continued on the next page

TABLE 2 continued.

Specimen number	BNHS 5	BNHS 6	BNHS 4206	BNHS 4232
Sex	m	f	f	f
Total length	192	205	228	240
Number of primary annuli	133	139	134	132
Anteriormost primary annulus bearing indication of secondary groove	109	117	115	109
Anteriormost primary bearing dorsally complete secondary groove	115	120	118	118
Anteriormost primary bearing ventrally complete secondary groove	121	127	118	124
Head length (snout tip to first nuchal groove, laterally)	5.7	6.0	6.3	6.4
Distance between snout tip and angle of jaws	c. 4	4.3	5.0	5.1
Distance between tip of lower jaw and first nuchal groove (laterally)	4.6	4.5	5.3	5.3
Distance between tip of lower jaw and angle of jaws	3.4	3.7	4.0	4.3
Length of first nuchal collar (measured laterally)	1.5	1.4	1.5	1.7
Length of second nuchal collar (measured laterally)	2.2	2.0	2.5	2.3
Head width at first nuchal groove	3.0	3.3	3.9	3.2
Head width at angle of jaws	3.0	3.2	3.6	3.1
Distance between external nares	1.2	1.3	1.4	1.5
Distance between tentacles	2.4	2.4	2.6	2.5
Distance between eyes (where visible)	na	na	na	2.4
Distance between external naris and tentacle	1.7	1.5	1.7	1.5
Distance between external naris and eye	na	na	na	2.5
Distance between tentacle and eye	na	na	na	0.8
Distance between tentacle and margin of upper lip	0.8	0.7	0.6	0.7
Distance between external naris and first nuchal collar groove	5.4	5.0	5.7	6.0
Distance between external naris and angle of jaws	3.7	3.7	4.2	4.4
Distance between tentacle and tip of snout	2.2	2.1	2.2	2.4
Distance between tentacle and angle of jaws	1.9	2.5	2.9	2.8
Distance between eye and angle of jaws	na	na	na	1.9
Distance between snout tip and anterior margin of mouth	0.8	0.9	0.9	0.9
Width at midbody	4.2	4.3	4.5	3.1
Body width at level of vent	2.2	2.6	2.4	2.2
Distance between vent and body terminus)	0.9	1.0	1.5	1.3
Circumference at midbody	14	12	15	11
Premaxillary-maxillary teeth	21	22	25	25
Vomeropalatine teeth	25	28	27	24
Dentary teeth	19	22	22	19
Splenial teeth	3	2	4	4

Differences in external morphology that we can discern between the two *Indotyphlus* species occur primarily in annulation. Numbers of primary annuli in the samples examined by us range from 132 to 139 in *I. battersbyi* (mean = 135.9, n = 9) and from 125 to 133 in *I. maharashtraensis* (mean = 128.8, n = 12). Towards the posterior of the body, the first occurrence of secondary annular grooves ranges from the 106th to the 117th (mean = 110.7) primary annulus in *I. battersbyi*, and from the 58th to the 88th (mean = 70.9) primary in *I. maharashtraensis*. Thus, *I. maharashtraensis* has fewer primary annuli, many more of which bear secondary annular grooves, both proportionately and absolutely. The difference in number of primary annuli is not absolute but differences in the numbers of secondary annuli and of secondary annuli that are complete dorsally are substantial, and serve to discriminate the species. The secondary-like grooves on the anteriormost primary annuli that are rather variable in extent but present in all but one small individual in the sample of *I. maharashtraensis*, are not present in any of the *I. battersbyi* sample and also appear to distinguish the species. The number of denticulations around the vent is closely similar to that of *I. maharashtraensis.*

Comparing the holotype of *I. maharashtraensis* with the BNHS series of *I. battersbyi*, the former has a more concave upper lip in lateral view, more laterally positioned external nares, and a more pointed snout tip in dorsal view. In the mouth, *I. battersbyi* has a less pointed tongue tip and VP tooth series, and choanae that are perhaps a little more widely separated relative to their transverse width. Examination of an annular groove approximately 10 mm anterior to the posterior terminus of BNHS 6 revealed three scale rows dorsally, with oval to subcircular scales, the largest measuring 0.75 x 0.5 mm. Ventrally at this point, we detected a single, incompletely overlapping row of very small scales. Variation in squamation and its taxonomic significance are poorly understood generally (Wake & Nygren 1987), and more detailed study is needed to determine if the differences between the examined specimens reflects differences in the species.

The most striking difference between *I. battersbyi* and *I. maharashtraensis* is in the area around and anterior to the disc. *Indotyphlus battersbyi* lacks the depressed preanal strip that extends forward midventrally from around the vent in *I. maharashtraensis*. The subterminal region also appears more flattened and the distance between the vent and the posterior terminus of the body proportionately larger in *I. maharashtraensis*. A bivariate plot of the latter against head length (Fig. 3) separates the species fairly well with the exception of the smallest specimens. However, most of the *I. battersbyi* specimens are older and we cannot be certain that preservation has not contributed to at least some of the observed difference.

None of the diagnostic features of *Indotyphlus* is thought to be uniquely derived. For example, those that distinguish *Indotyphlus* from *Gegeneophis*, the eye not under bone and the tentacle closer to the eye, might both be considered plesiomorphic (e.g. Dunn 1942; Nussbaum 1977), although the relatively dorsal position of the tentacular apertures might constitute a synapomorphy. Clear evidence of the monophyly of *Indotyphlus* is currently

lacking. Nevertheless, *I. battersbyi* and *I. maharashtraensis* are very similar in most respects and are most likely each other's closest known relatives.

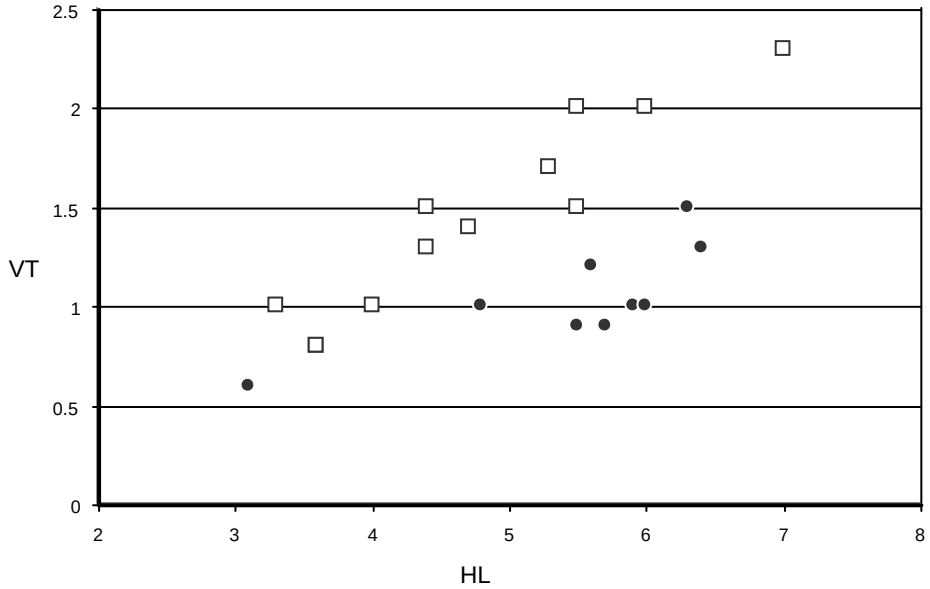

FIGURE 3. Scatter plot of measurements in mm of length of the body posterior to the vent (VT) against head length (HL) for samples of the two species of *Indotyphlus*. Open squares *I. maharashtraensis*, solid circles *I. battersbyi*.

The phylogenetic relationships *of Indotyphlus* have yet to be investigated. A sister-group relationship with *Gegeneophis*, the only other Indian (and Asian) caeciliid genus, might be hypothesised on the basis of geography and is not ruled out by the morphological differences. Testing this phylogenetic hypothesis will help determine whether there is a single or multiple radiations of caeciliid caecilians in Asia.

Key to the species of *Indotyphlus*

The following key is based on readily observable annulation characters. At least adults of the two species should also be distinguishable on examination of the region surrounding the vent, which in *I. maharashtraensis* has a smoother, depressed preanal strip (longer in males).

1 More than 130 primary annuli, with secondary grooves restricted to the posteriormost part of the body, not on the anteriormost 100 primaries ..... *battersbyi*

- May have fewer than 130 primary annuli, with secondary grooves on more than the posteriormost part of the body, beginning anterior to the 100th primary annulus .... *maharashtraensis*

Discussion

Knowledge of the poorly understood caeciliid caecilian fauna of India has recently progressed, with the recognition and description of several new species. A recent revision of all Indian caecilians (Pillai & Ravichandran 1999; see also Ravichandran 2004) recognised five species of caeciliid, one of them new, in two genera — *Indotyphlus* and *Gegeneophis*. Since 1999, four additional species of *Gegeneophis* have been described (Giri et al. 2003; Ravichandran et al. 2003; Bhatta & Prasanth 2004; Bhatta & Srinivasa 2004) which, along with the new species of *Indotyphlus* described here, are from the more northern part of the Western Ghats of Karnataka, Goa and Maharashtra States. These recent discoveries support the belief that the northern Western Ghats are relatively underexplored herpetologically, and that the caecilian fauna of India is far from completely documented (e.g. Giri et al. 2003; Gower et al. 2004).

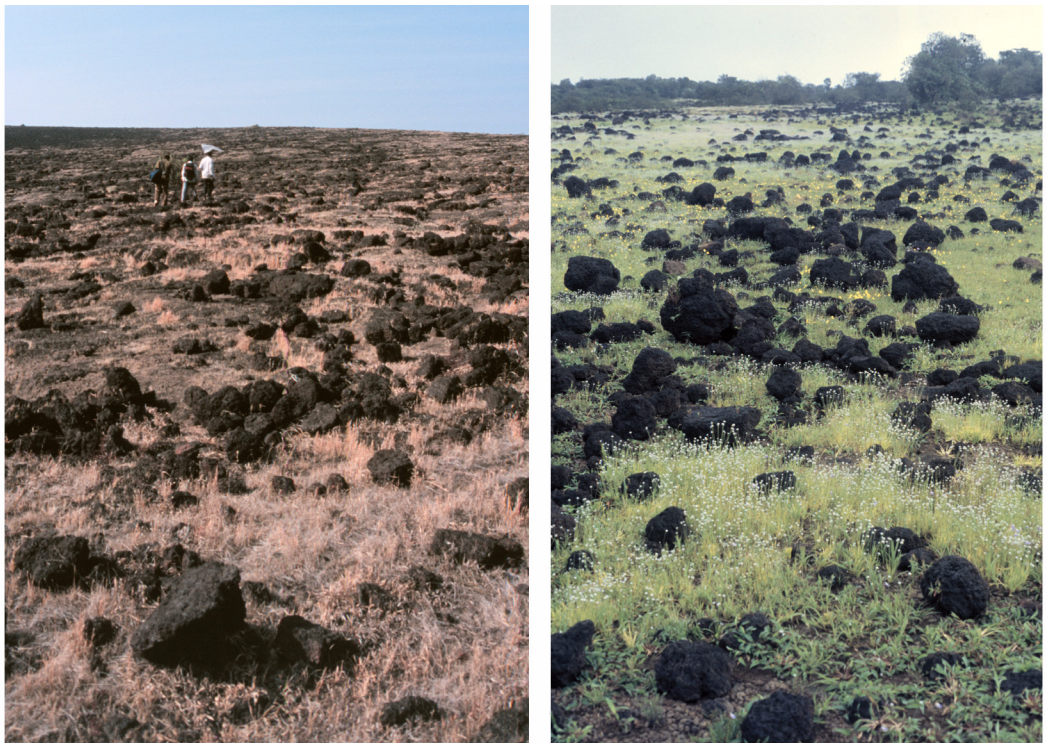

FIGURE 4. Photographs of the habitat at the type locality for *Indotyphlus maharashtraensis.* This locality has strongly demarcated dry (left, seen in January 2003) and monsoon (right, September 2003) seasons.

The type locality of *Indotyphlus maharashtraensis* is approximately 150 km south of the known provenance of *I. battersbyi*, and at a similar altitude. These are the most northerly confirmed localities for any Western Ghats caeciliids and they receive less rain for less of the year than more southern Western Ghats localities, particularly in Kerala and Tamil Nadu (Daniels 1992), where caecilian diversity has previously seemed particularly high (Bhatta 1997). Both species have been collected during the monsoon season in similar habitats — often under rocks in open, grassy, shallow-soiled areas within strongly seasonal, semievergreen or deciduous vegetation without perennial surface water (Fig. 4; personal observations; McCann 1927; Taylor 1960, 1968). Such habitats might be considered atypical for terrestrial caecilians, which are generally known more from moist soils and litter, and they would appear to be inhospitable environments for caecilians during the long dry season. Thus, it is worth noting the ability of some caecilians to exploit atypical environments at the margins of their range. We predict that *Indotyphlus* species will have derived behavioural and physiological traits, perhaps including aestivation, that enable them to survive the dry season.

Taylor (1970: 339) remarked that the presence of narial plugs on the tongue of *I. battersbyi* "suggests that the species has a free swimming period at sometime in the life cycle". This is a curious remark because there is no general correlation between narial plugs and aquatic habitus in caecilians. The smallest *Indotyphlus* examined by us (70 mm) betray no trace of an aquatic larval stage and we suspect that the two species have direct development (as in the presumably closely related *Gegeneophis*, where known), but we stress that reproductive mode is not known for either species. Taylor (1970: 339) also reported that one male specimen of *I. battersbyi* “had the anterior part of the snout from the region of the tentacle to the tip thickly covered with minute hair-like processes” that broke off during examination, and that “this growth may be a temporary phenomenon, occurring during the breeding season”. We found no evidence for similar features in any of the specimens of *I. battersbyi* or *I. maharashtraensis* examined during the present study.

The flattening of the subterminal region is an unusual feature of *I. maharashtraensis* and the associated preanal strip is unique among caecilians. Similar but probably convergent morphologies are seen elsewhere only in the Neotropical Typhlonectidae. In *Potomotyphlus* the disc is expanded anteriorly, and the anterior region is usually depressed (Taylor 1968; Wilkinson 1989) in the region corresponding to the preanal strip of *I. maharashtraensis*. The two taxa differ in that the area is devoid of annuli and is clearly a part of the disc in *Potomotyphlus* whereas annuli are present and the area is clearly not part of the disc in *I. maharashtraensis*. Taylor (1968) suggested that *Potomotyphlus* use the expanded disc as a clasper or sucker but relevant observations of their use in live animals are lacking. The function of the preanal strip of *I. maharashtraensis* is unknown but the strong sexual dimorphism suggests a role in reproduction, and the structure of this unique feature merits histological study.

Although known from a series of specimens, the documented material of *I. maharashtraensis* is from a single locality with almost nothing known of its ecology and reproduction. We recommend that its conservation status currently should be considered as data deficient.

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