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A new species of the Indian caecilian genus *Gegeneophis* Peters (Amphibia: Gymnophiona: Caeciliidae) from the surroundings of Mahadayi Wildlife Sanctuary, Western Ghats

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A new species of Indian caecilian, *Gegeneophis mhadeiensis* (Amphibia: Gymnophiona: Caeciliidae) is described based on three specimens collected from the Western Ghats, northern Karnataka, India. The species is distinguished from all other *Gegeneophis* by a combination of the number of primary and secondary annuli. One of the paratypes is an albino.

Keywords: Caecilians, *Gegeneophis mhadeiensis*, Mahadayi Wildlife Sanctuary.

THE Indian caecilian (Gymnophiona) genus *Gegeneophis* contains nine nominate species[1], with six of these having been described since 1999 in a wave of new systematic work[2]. We recently collected three specimens resembling each other which fit the generic diagnosis given by Ravichandran *et al.*[3] for *Gegeneophis*, but which differ from all known species. Here we describe this form as a new species.

Gegeneophis mhadeiensis sp. nov. Figures 1–3. Holotype: Bombay Natural History Society, Mumbai, India (BNHS/4643). A mature male, collected from the surroundings of Rameshwar temple, 15°39′ N lat., 74°08′E long. (Chorla Village, Khanapur Taluk, Belgaum District, Karnataka), July 2006. The locality is situated at 728 msl, adjacent to the Mahadayi Wildlife Sanctuary in the Western Ghats region.

Paratypes: Zoological Survey of India, Calicut (ZSI/WGFRS/V/A/640), an immature female, collected from Chavatyaar, Chavato vaddo, Chorla village at 732 msl. This locality is about 2 km from the type locality and the other collection details are as for the holotype. BNHS/4643, an albino, mature male collected from Chavatyaar; other collection details are as for the holotype.

Diagnosis: A species of *Gegeneophis* that fits the generic diagnosis of Ravichandran *et al.*[3] differing from all other species in the genus except *G. carnosus*, *G. krishni* and *G. nadkarnii* in having more than 100 primary annuli (117–122), but differing from *G. carnosus* (secondary grooves 7) and *G. krishni* (secondary grooves 13–15) in having far more (29–31) primary annuli with secondary annular grooves, and from *G. nadkarnii* (secondary grooves 86) in having lower number of secondary annular grooves (29–31).

Description of holotype: Some morphometric and meristic data are given in Table 1. The specimen is in good condition generally, except for minor artifacts associated with preservation; notably mid-ventral longitudinal groove of 134 mm length extends between the third nuchal groove and the vent. There is a 20 mm long mid-ventral incision into the body cavity beginning 41 mm in front of the vent. There are several small scratches on the skin on both the dorsal and ventral surfaces made during the search for scales.

The body in life is sub-cylindrical and slightly dorsoventrally compressed (Figure 1), though almost uniform in its width throughout (Table 1). In dorsal view, the head tapers strongly from the level of the occiput to the tentacular apertures. Anteriorly, the head tapers and terminates in a bluntly rounded but narrow snout tip. The posterior part of the head is slightly narrower than the nuchal region. In lateral view, the top of the head is straight and without any strong bulges. The margin of the upper lip is slightly arched. The distance between the jaw angle and the top of the head is less than the distance between the jaw angle and the ventral surface of the lower jaw. In ventral view, the anterior margin of the lower jaw is more broadly rounded than the anterior margin of the snout.

The small sub-circular nostrils are close to the front of the snout tip, and are visible dorsally and laterally but not

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Table 1. Morphometric and meristic data (in mm) for the holotype and paratypes of *Gegeneophis mhadeiensis*. Measurements were made to the nearest 0.1 mm using vernier calipers. For measuring the length and circumference, a ruler and piece of thread were used

	Holotype BNHS/4643	Paratype BNHS/4644	Paratype ZSI/WGFRS/ V/A/640
Total length	185	202	180
Head length	4.0	4.2	3.8
Head width at jaw angle	3.5	3.5	3.0
Circumference at mid-body	16	15	13
Width of the body at 1st annular groove	4.0	3.6	3.2
Width of the body at broadest region	4.6	4.4	3.8
Width of the body at the level of vent	3.0	2.4	2.2
Length divided by width	40.2	45.9	47.3
Length of the snout projecting beyond mouth	1.0	1.0	0.8
Distance between jaw angle and top of head	1.2	1.2	1.0
Distance between jaw angle and ventral surface of lower jaw	1.4	1.4	1.2
Distance between jaw angle and tip of lower jaw	3.5	3.2	3.0
Distance between nostrils	1.0	1.0	0.8
Distance between nostril and snout tip	0.6	0.7	0.5
Distance between tentacles	2.8	2.5	2.2
Distance between tentacle and snout tip	2.0	2.0	1.6
Distance between tentacle and jaw angle	2.2	2.2	2.0
Distance between tentacle and nostril	1.0	1.2	1.0
Distance between tentacle and margin of upper lip	0.4	0.4	0.4
Distance between tentacle and top of head	0.6	0.5	0.5
Width at 1st nuchal groove	4.0	3.8	3.4
Width at 2nd nuchal groove	4.2	4.0	3.6
Length of 1st nuchal collar (laterally)	1.5	1.8	1.2
Length of 2nd nuchal collar (laterally)	2.0	2.2	2.0
Distance between snout tip and 1st nuchal groove	5.1	5.6	4.8
Distance between snout tip and 2nd nuchal groove	6.4	7.0	6.0
Distance between snout tip and 3rd nuchal groove	8.5	8.6	7.2
Total number of primary annuli	122	119	117
Total number of secondary annuli	29	31	29
Anterior most primary annulus with secondary groove	94	89	89
Number of complete secondary annuli in front of the vent	6	7	6
Width of disc surrounding vent	1.0	1.0	1.0
Length of disc surrounding vent	0.5	0.6	0.5
Width of vent	0.4	0.4	0.4
Number of denticles surrounding the vent	10	10	11
Number of premaxillary–maxillary teeth	10 + 1 + 10 (21)	9 + 9 (18)	8 + 8 (16)
Number of vomeropalatine teeth	10 + 10 (20)	9 + 10 (19)	10 + 1 + 8 (19)
Number of dentary teeth	7 + 7 (14)	7 + 7 (14)	7 + 7 (14)
Number of splenial teeth	2 + 2 (4)	1 + 1 (2)	1 + 1 (2)

Figure 1. The holotype (BNHS/4643) of *Gegeneophis mhadeiensis* in life.

ventrally, surrounded by a narrow whitish rim. In life, the tentacles are globular. The tentacular apertures are circular, lateral in position, visible in both dorsal and ventral views, and much closer to the margin of the upper lip than to the top of the head. Each tentacle lies a little below an imaginary line between the nostril and eye. The eyes lie beneath the bone and are visible in life (Figure 2 *a*), but are not readily visible in preservation. In life, the eyes lie at the posterior end of a light cream stripe that extends from behind the eye to immediately anterior to the tentacle. In lateral view, the eyes lie approximately halfway between the margin of the upper lip and the top of the head. In dorsal view, the eyes are close to the lateral margins of the head.

We counted 21 premaxillary–maxillary, 20 vomeropalatine, 14 dentary and four splenial teeth. The teeth in all four series are generally recurved and are monocusped. They are smaller posteriorly than anteriorly. The posteriormost teeth of the premaxillary–maxillary and vomeropalatine series are parallel and lie closer together. The vomeropalatine series lacks diastemata. Both in the upper and lower jaw the teeth of the outer rows are markedly

larger than those of the inner rows. The premaxillary–maxillary and vomeropalatine tooth rows clearly extend posterior to the choanae. When viewed anteriorly, the dentary teeth appear largest, followed by the premaxillary–maxillary, vomeropalatine, and splenial teeth.

The choanae are small, oval and are separated by a distance of approximately two times the width of each choana. The tongue is broad, spearhead shape in dorsal view. The unattached tip of the tongue does not overlap the splenial teeth. The tongue is separated by a groove from the gingivae. The raised narial plugs are situated far antero-laterally, close to the edge of the tongue and are with encircling grooves. The tongue is uniformly dark, and its posterior part behind the narial plugs is marked by three tiny longitudinal grooves.

The nuchal region is broader and higher than the adjacent parts of the body. The two collars are marked clearly by three nuchal grooves. The nuchal grooves are complete with the exception of the third, which is incomplete mid-ventrally. The first collar bears one short transverse groove mid-dorsally and mid-ventrally. The second collar also bears a mid-dorsal transverse groove that is longer than the transverse groove of the first collar. Although the nuchal and annular grooves are mostly perpendicular to the long axis of the body, the transverse groove on the second collar and the third nuchal groove are slightly angulate antero-dorsally. On the ventro-lateral surface, the free ends of the third nuchal groove bend slightly posteriorly.

The annuli are marked by whitish coloured grooves that are more conspicuous posteriorly. Most of the annular grooves fade mid-dorsally (particularly anteriorly) where they appear to be incomplete, at least up to the point where the secondary grooves appear. The first (anteriormost) secondary annular groove appears laterally on the left side of the 94th primary annulus. On the 95th primary annulus also the secondary groove is on the lateral left side. The secondary grooves become dorsolateral from the 96th primary annulus onwards. The secondary grooves extend across the midline on the ventral surface and become complete from the 115th primary annulus along to the sub-circular disc surrounding the vent. Six secondary grooves in front of the vent are complete. The rounded terminus ends in a small cap that is completely demarcated by the last secondary annular groove. The transverse vent is surrounded by ten denticles.

Scales were sought at four different points along the body, both dorsally and ventrally. No scales were found at the 50th primary annulus. At both the 75th and 90th primary annuli, oval scales are found in a single row on the dorsal side only. At the 110th primary annulus, where the secondary annular grooves become almost complete mid-dorsally, oval scales occur in four rows both dorsally and ventrally.

In life, the colour of the holotype was dark brown throughout with the exception of the whitish annular grooves and the head, which was pinkish-brown with a cream eye-tentacle stripe. The skin contains whitish glands throughout the body. In preservation, the body is grey throughout. The annular grooves are whitish and more prominent laterally and posteriorly. The under surface of the lower jaw is off-white in colour up to the second nuchal groove. The disc surrounding the vent is a similar tone to the body colour both in life and preservation.

Additional information from paratypes: Morphometric and meristic data are given in Table 1. The paratypes are in good condition generally, except for minor preservational artifacts. The two specimens are similar to the holotype, and only notable differences are summarized here. ZSI/WGFRS/V/A/640 is an immature female, with an artifactual 125 mm long mid-ventral groove, beginning c. 11 mm from tip of the chin. There is a 15 mm long mid-ventral incision into the body cavity beginning c. 23 mm in front of the vent. Secondary annular grooves first occur

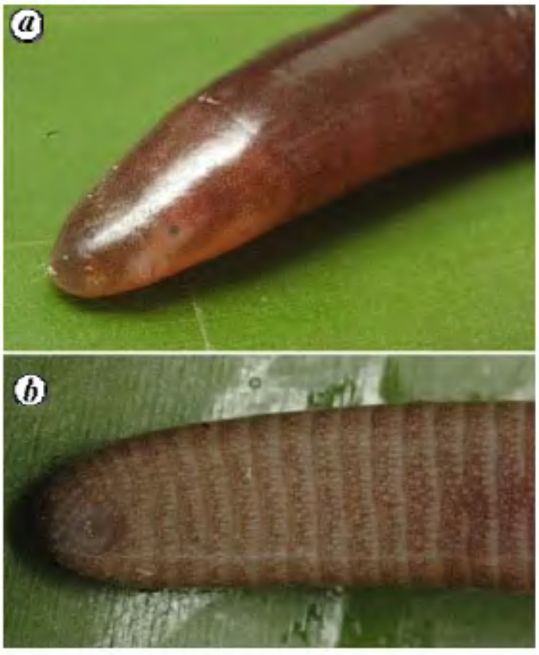

Figure 2. (***a***) Dorsolateral view of the head, (***b***) Ventral view of the body terminus of the holotype of *G. mhadeiensis* in life.

Figure 3. Albino paratype (BNHS/4644) of *G. mhadeiensis* in life.

mid-dorsally from the 89th (out of a total of 117) primary annulus. The secondary grooves extend across the midline on the ventral surface and become complete from the 111th primary annulus onwards. No scales were found at the 40th and 80th primary annuli. At the 90th primary annulus, oval scales are found in three rows on the dorsal side, but no scales were found on the ventral side. At the 110th primary annulus, where the secondary annular grooves become almost complete except ventrally, scales occur in four rows both dorsally and ventrally.

BNHS/4644 (Figure 3) is a mature, albino male, with an artifactual mid-ventral groove of 30 mm, beginning c. 10 mm from tip of the chin, and another 35 mm long beginning c. 15 mm in front of the vent. There are two mid-ventral incisions of 10 mm each into the body cavity beginning c. 55 mm and c. 70 mm in front of the vent. Secondary grooves first occur laterally on left the side of the 89th (total 119) primary annulus. The secondary grooves extend across the midline and became complete on the ventral surface from the 112th primary annulus backwards. Seven secondary annular grooves in front of the vent are complete. No scales were found at the 50th and 75th primary annuli. At the 90th primary annulus, oval scales are found in three rows on the dorsal side and two rows of scales on the ventral side. On the 110th primary annulus where the secondary annular grooves become almost complete except ventrally, scales occur in four rows both dorsally and ventrally. Tooth counts are similar in all specimens, except that we counted two splenial teeth in the paratypes in contrast to four in the holotype.

Ecology, habitat and conservation: The holotype was collected from underneath piled rotting grass in a field with open sky, at a distance of c. 50 m from Haltar nallah (nallah = canal). The soil was lateritic, temperature 28°C (at 30 cm depth) and humidity 80%. Both paratypes were dug from soil in a small plantation of young banana plants and mature jackfruit trees (canopy cover c. 40%). At the site where the paratype (BNHS/4644) was collected, a strong monsoonal stream flows along the edge of the site, and subsequently joins the Haltar nallah, a tributary of the River Mahadayi. The soil was mixed with cow dung, silt, plastic waste and garbage, temperature 28°C (at 30 cm depth), humidity 85%. Although *G. mhadeiensis* can clearly tolerate disturbed habitats, its distribution and biology remain largely unknown and its conservation status should probably be considered data-deficient until more data are obtained.

Discussion: The numbers of primary and secondary annuli are important external characters differentiating the species of *Gegeneophis*[4]. *G. mhadeiensis* differs from all other species, except *G. danieli*, *G. goaensis*, *G. madhavaorum* and *G. nadkarnii* in having more than 20 primary annuli subdivided by secondary annular grooves, and is further easily distinguished from *G. danieli*, *G. goaensis* and *G. nadkarnii* because these three species have more than 60 primaries bearing secondary grooves. The remaining species, *G. madhavaorum*, is also readily distinguished from the new species in that the former has 96–97 (n = 2) vs >116 (n = 3) primary annuli.

The species is named after the River Mhadei on the bank of one of the tributaries of which the type locality is situated (in Government records Mahadayi is spelled as Mhadei).

The description of *G. mhadeiensis* provides further evidence for the incompleteness of our knowledge of the Indian caecilian fauna[2,5] for the Western Ghats as a biodiversity hotspot[6] and centre of caecilian diversity[2,5,7], and the ability of some caecilian species to tolerate habitat disturbance in the form of non-intensive agriculture[5,8–10]. With ten named species, *Gegeneophis* is now one of the most diverse caecilian genera. All the new species of *Gegeneophis* described since 1999 have been documented from a handful of specimens from small distributions. Larger and more widespread samples are urgently needed to fully characterize these species, especially if the numbers of primary and secondary annuli are to remain useful for relatively easy external identification.

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