

A new species of *Gegeneophis* Peters (Amphibia: Gymnophiona: Caeciliidae) from southern Maharashtra, India, with a key to the species of the genus

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Abstract

A new species of Indian caeciliid caecilian, *Gegeneophis danieli* (Amphibia: Gymnophiona), is described from a single specimen from the Western Ghats of southern Maharashtra. This distinctive species differs from all other Indian caeciliids in having more numerous secondary annuli that are not restricted to the posterior half of the body. A new key to the species of *Gegeneophis* is presented, and the diversity of the genus is briefly discussed.

Key words: caecilians, eyes, herpetology, *Indotyphlus*, South Asia, systematics

Introduction

In their recent monograph on the caecilians of India, Pillai & Ravichandran (1999) recognised four species in the endemic Indian caeciliid genus *Gegeneophis* Peters, including one (*G. krishni*) that they described as new. A further new species of *Gegeneophis* (*G. seshachari*) from Ratnagiri District in central western Maharashtra was recently described by Ravichandran et al. (2003), who also provided a revised diagnosis of the genus. A caecilian collected in 2002 from southern Maharashtra fits the generic diagnosis provided by Ravichandran et al. but differs significantly from all previously described species of *Gegeneophis*. Here we describe this new form, provide a key to the known species of *Gegeneophis*, and briefly discuss aspects of the diversity of the genus.

***Gegeneophis danieli* sp. nov.**

(Figs. 1, 2, Table 1)

Holotype: Bombay Natural History Society, Mumbai, India (BNHS) 4157. Collected approximately 3 km East of Amboli, Sindhudurg District, Maharashtra, India, by Varad Giri, Sameer Kehimkar, Ishan Agarwal and Vithoba Hegade, June 2002. The specimen was found under a rock in an open patch of grassland within semievergreen forest. The locality is situated in the Western Ghats at approximately 850 m above sea level.

Diagnosis: A *Gegeneophis* differing from all other species of the genus in having many more secondary annuli (> 50) that are strongly edged in white and present on both the anterior and posterior halves of the body. All other *Gegeneophis* have annuli that are less clearly marked without strong whitish edges, and they have fewer than 50 secondary annuli, restricted to the posterior part of the body.

TABLE 1. Some morphometric data (in mm) for the holotype of *Gegeneophis danieli*, BNHS 4157. 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.

Total length	193
Distance between tentacles	3.4
Distance between eyes	3.1
Distance between eye and naris	2.8
Distance between snout tip and eye	3.4
Distance between snout tip and tentacle	2.3
Distance between snout tip and jaw angle	5.9
Distance between snout tip and midpoint between front of eyes	3.1
Distance between jaw angle and tip of lower jaw	5.3
Distance between jaw angle and eye	2.6
Distance between jaw angle and tentacle	3.8
Depth (height) of head immediately posterior to jaw angle	3.4
Distance between snout tip and lateral part of first nuchal collar groove	7.7
Head width at level of jaw angles	4.7
Head width at level of first nuchal collar groove	4.9
Circumference at midbody	16

Description of the holotype: Some morphometric and meristic data are given in Table 1. The specimen is a mature female. It is in good condition, with a few minor exceptions. There is an artefactual, approximately 40 mm long, middorsal ridge and associated groove on the left side beginning c. 30 mm behind the snout tip. There is a further, weak, 55 mm

long midventral groove in the midbody region. There is a small (5 mm) midventral incision into the body cavity about 40 mm in front of the vent. The skin overlying the left side of the cranium and mandible has been reflected. The body is generally dorsoventrally compressed (at least partly artefactually), being more cylindrical anteriorly. Some teeth are missing and some remaining tooth crowns are broken.

The natural body shape is probably subcylindrical and slightly dorsoventrally compressed. It is largely uniform in width (5.1 mm at midbody), though slightly narrower anteriorly. Posteriorly, the body tapers strongly (in lateral view) towards the terminus for only the ultimate 5 mm.

In dorsal view, the head tapers gently from the level of the occiput to the tentacular apertures. Anterior to this, it tapers more strongly and terminates in a rounded, but narrow snout tip. In lateral view, the top of the head is straight, with no strong bulges. The margin of the upper lip is weakly arched 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, but distinctly (approximately one and a half times), greater than the distance between the jaw angle and the lower surface of the lower jaw.

The eyes are faintly indicated (more clearly visible in life) as a darker grey region 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 eyes lie approximately halfway between the margin of the upper lip and the top of the head. In dorsal view, they are very close to the lateral margins of the head. The surface of the eye region is level with the surrounding surface of the head.

In life, the tentacles are globular rather than elongate. The tentacular apertures are horseshoe shaped (posteriorly concave), slightly raised, and laterally positioned, being visible in both dorsal and ventral views. They are approximately twice as close to the margin of the upper lip (0.7 mm) as to the top of the head, and about halfway between the margin of the lip and 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 passes anterior to the jaw angle. The tentacular apertures are posterior to the anteriormost margin of the mouth, 2.5 mm from the tip of the snout. The distance between tentacle and eye (1.4 mm) is slightly smaller than between tentacle and naris (1.7 mm).

The small subcircular nares are slightly closer to the level of the snout tip than the anteriormost margin of the mouth in lateral view, are 1.7 mm apart, and visible dorsally and laterally, but not ventrally. They are surrounded by a narrow whitish rim (pinkish in life). The tip of the snout lies 1.2 mm in front of the anteriormost margin of the mouth. In ventral view, the tip of the lower jaw is broadly rounded, more so than the tip of the snout.

We counted 30 premaxillary-maxillary, 33 vomeropalatine, 24 dentary, and 6 splenial teeth (including empty 'sockets'). Where clearly visible, the tooth crowns of the premaxillary-maxillary and dentary series are undoubtedly bicusped. Although less easily

observed, the teeth of the vomeropalatine and splenial series also appear to be bicusped. The vomeropalatine series lacks diastemata, and is masked in lateral view by the outer, premaxillary-maxillary series. The posteriormost teeth of the two upper jaw series are not parallel, but instead lie closer together posteriorly. The teeth in all four series are generally recurved and smaller posteriorly than anteriorly. The dentary teeth are the largest, followed by (in decreasing order of size) those of the premaxillary-maxillary, splenial, and vomeropalatine series.

The ovate choanae are small, slightly wider than long, and separated by a distance that is approximately 2.5 times the width of each choana. Choanal valves are not clearly visible.

The tongue is smoothly rounded and unattached anteriorly. It is separated from the gingivae by a deep groove. It has a pair of far-laterally positioned, raised narial plugs. Their posterior and lateral margins are indistinct, but the anterior and medial margins are clearly demarcated by a groove. In preservative, the tongue is generally off-white, although its anterior part and the dorsal surface of the plugs are slightly darker. The tongue has no longitudinal groove. Posterior to the narial plugs, its surface is uniformly pitted, possibly artefactually.

The nuchal region is not markedly expanded relative to either the back of the head or the body immediately posterior to it. The two nuchal collars are marked clearly by three nuchal grooves that have the same whitish colour as the following annular grooves. The second collar (3 mm, measured laterally) is longer than the first (2.6 mm). The first (anteriormost) nuchal groove passes around the circumference of the nuchal region, but a short discontinuous middorsal section (not distinctly marked from the surrounding area in the whitish colouration seen elsewhere) lies immediately anterior to, and overlaps with, the continuous, major part of the groove. The first collar bears two short transverse grooves, one middorsally (not marked in the whitish colour) and one midventrally (weakly marked in the whitish colour). The second nuchal groove (between the first and second collars) is complete. The third nuchal groove, marking the end of the nuchal collar region, is continuous except for a midventral gap. The second collar bears three transverse middorsal grooves that are also whitish in colour. The middle of these is the clearest and is slightly longer than the posteriormost groove. The anteriormost groove is the most weakly expressed and is about two thirds as long as the middle groove. It extends further on the right side of the midline than the left. On the ventral surface, a longitudinal, whitish groove extends from about halfway between the tip of the lower jaw and the first nuchal groove to about halfway along the length of the second collar.

The nuchal and annular grooves are mostly perpendicular to the long axis of the body, but the transverse grooves on the second collar, the third nuchal collar groove and the posterior grooves of the first three primary annuli are weakly angulate anterodorsally. Ventrolaterally, the free ends of the third nuchal groove bend slightly posteriorly.

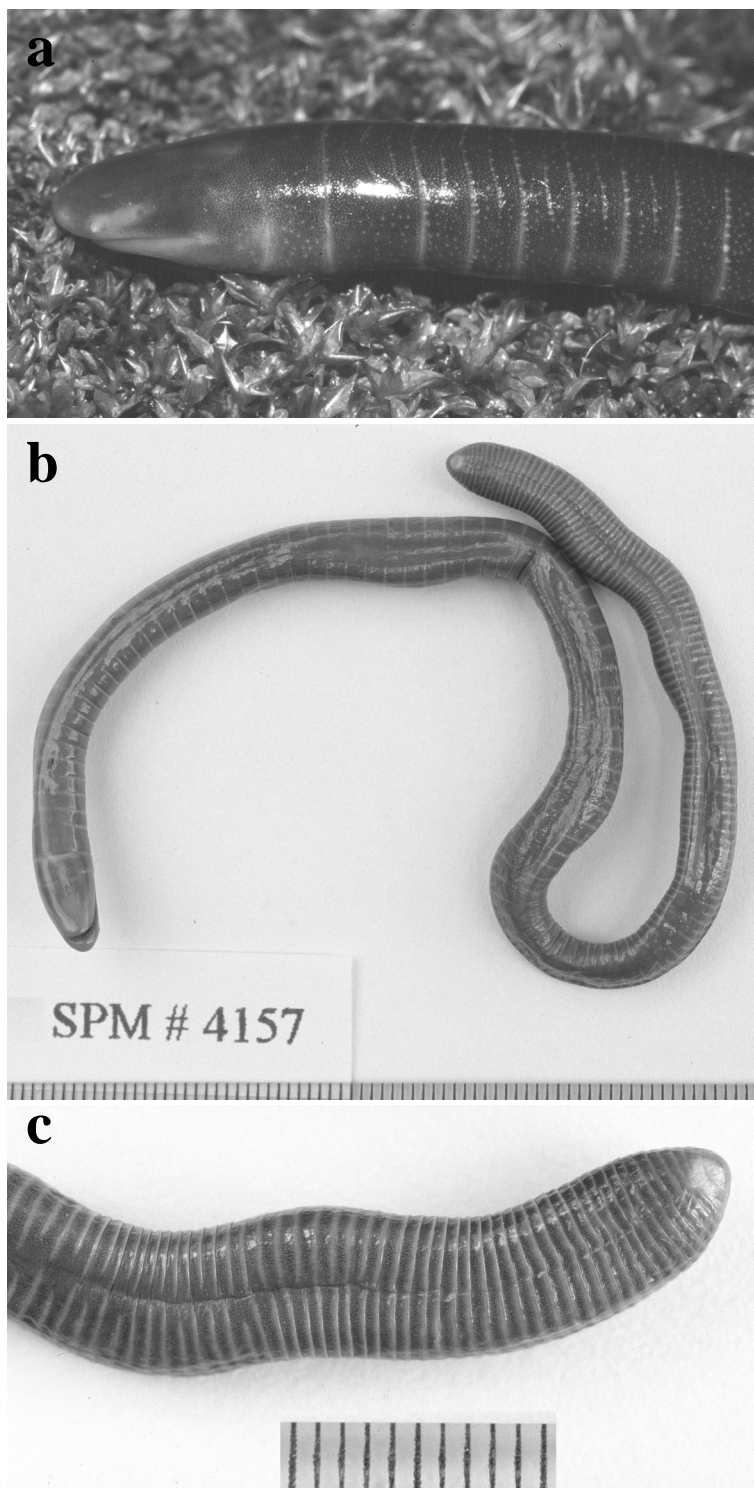


FIGURE 1. Photographs of the holotype of *Gegeneophis danieli* (BNHS 4157). a) lateral view in life, b) ventral view of preserved specimen, c) ventral view of body terminus in preserved specimen. Scales in mm.

The annuli are marked by whitish coloured grooves that are increasingly conspicuous posteriorly. There are 112 primary annuli, the grooves of which appear to be complete or very nearly so. Anteriorly, the whitish colouration of the grooves is absent middorsally as far posterior as the anterior groove of the 35th primary annulus and up to the 99th primary annulus midventrally. On the first four primary annuli, weakly marked secondary annular grooves are present middorsally. The fifth and sixth primary annuli bear short dorsolateral secondary annular grooves, either side of the midline. Secondary annular grooves are absent or not clear on the seventh and eighth primary annuli. The ninth primary annulus bears a short dorsolateral secondary annular groove on the left side. The tenth and eleventh primary annuli lack secondary annular grooves, but the twelfth again bears a short dorso-lateral groove on the left side. The first indication of a secondary annular groove on the right side posterior to this is on the sixteenth primary annulus. The first secondary annular groove that extends across the dorsal midline behind this is on the 35th primary annulus, though there are a few primary annuli posterior to this on which the secondary annular grooves are incomplete middorsally. Secondary annular grooves extend across the midline of the ventral surface from the 99th primary annulus up to the disc surrounding the vent, which interrupts the grooves of the 111th and 112th primary annuli.

Searches for annular scales were made at three points along the body. At the posterior groove of the 22nd primary annulus, scales are absent and there is no development of a pocket. At the 36th primary annulus, scale pockets are about half as deep as the length of the secondary annuli. Here, the dorsal part of both the primary and secondary annular grooves contains a single row of very small (c. 0.5 mm wide) oval scales that overlap each other transversely, at least in part. No scales are visible ventrally at this point. At the 104th primary annulus the scale pockets are deeper (approximately 2.5 mm), extending for more than three times the length of each secondary annulus in this region. Here, the scales also occur ventrally and encircle the body in a transversely overlapping arrangement. The scales are ovate, being generally much wider than long, and large (up to approximately 2.5 mm wide). Dorsally, they occur in about three rows, although the scales in some rows may contain multiple layers.

The rounded terminus is mildly conical and ends in a very small terminal cap that is incompletely demarcated by the final annular groove. There is no indication of a terminal keel. Dorsally, the posteriormost annular groove lies just posterior to the level of the vent. The posteroventrally directed vent and surrounding disc interrupts the posteriormost annular groove. The subcircular disc surrounding the vent is 1.6 mm wide and 1.5 mm long. The transverse vent lies just 1.1 mm from the body terminus. It is delineated by five posterior and six anterior denticles. This can be perceived of as a basic and fairly regular five-five, (anterior-posterior) pattern, but with the right anteromedial denticle subdivided into two smaller denticles.

The colour of the specimen is generally steel grey. The dorsal surface is darker in colour and also somewhat lavender. This lavender colouration is more pronounced in life.

The darker dorsal surface merges gradually with the lighter ventral surface. The annular and nuchal collar grooves are mostly marked in a whitish colour, being particularly clear laterally. The whitish colouration is interrupted along much of the ventral midline and part of the dorsal midline (approximately the anterior 55 mm).

The dorsal surface of the head anterior to a level just behind the eyes is darker than the dorsal surface of the back of the head and body. There is an irregular, diffuse, approximately middorsal lighter coloured patch on the dorsal surface of the back of the head, extending from behind the eyes to the first nuchal collar. In dorsal view, the tip of the snout bears a thin arc of paler colouration. The stripes extending from just behind the eyes to just in front of the tentacular apertures are also much paler in colour. These stripes are subparallel to the long axis of the head in lateral view. In dorsal view they are slightly divergent anteriorly. The ventral surface of the rostrum is also pale, but slightly darker than the eye-tentacle stripe. There is only a short (0.5 mm) gap between the eye-tentacle stripe and the pale region of the anteroventral surface of the snout.

The underside of the lower jaw is indistinguishable in colour from the underside of the body behind it. On the lower jaw, the flesh immediately overlying the mandible is thin and here the colour is similar to that on the tip of snout and ventral surface of rostrum, i.e. pale but darker than the eye-tentacle stripe. This pale region is all that can be seen of the lower jaw in lateral view.

In preservative, the paler regions of the head are varying degrees of whitish. In life, these regions are infused with pink. The posterior terminus of the body is not differentiated from the rest of the body in colour. The disc surrounding the vent is whitish.

The reflection of the skin overlying the left side of the cranium allows a few details of osteology to be documented. In general, the skull is similar to that of *G. ramaswamii*, as figured by Taylor (1968: fig. 405; see also Ramaswami, 1942: figs. 1-3). The eye lies mostly under the anterior limit of the squamosal, its anterior margin is covered by the maxillopalatine, with the frontal excluded from the 'orbital' region. The tentacular groove and tentacular aperture lie entirely within the maxillopalatine with the groove covered by bone for most of its length. Posteriorly, the maxillopalatine is extensive and reaches almost to the jaw angle. The frontal-nasal suture is oriented at approximately 45° to the long axis of the cranium, meeting the dorsal margin of the maxillopalatine approximately halfway along its length.

Remarks: Based on variation in other species, we would expect there to be some variation in the rather high number of secondary annuli in *G. danieli*. However, the differences between the holotype of *G. danieli* and all other Indian caeciliids in the number, marking and distribution of secondary annuli are substantial, and we would not expect any overlap in these features.

Etymology: The species is named in honour of J. C. Daniel, former director of the BNHS, in recognition of his many contributions to Indian herpetology.

Key to the species of *Gegeneophis*

The following dichotomous key should serve to differentiate the six described species of *Gegeneophis*. The species that are most likely to be confused are the two southernmost species *G. ramaswamii* and *G. carnosus*. These species may overlap in their numbers of primary and secondary annuli, and *G. carnosus* particularly resemble small *G. ramaswamii*. Determining the visibility of the eye may be difficult without a microscope and good lighting, especially with small specimens.

- 1 Secondary annuli and annular grooves absent *seslachari*
- Secondary annuli and annular grooves present 2
- 2 Secondary annular grooves present anteriorly, even within first 20 primary annuli
..... *danieli*
- Secondary annular grooves restricted to posterior half or less of body 3
- 3 More than 120 primary annuli *krishni*
- Less than 120 primary annuli 4
- 4 Eyes not visible externally *ramaswamii*
- Eyes visible externally 5
- 5 Less than 100 primary annuli *fulleri*
- More than 100 primary annuli *carnosus*

Discussion

The description of *Gegeneophis danieli* further expands the known diversity of the Indian (and therefore Asian) caeciliid fauna to seven species in two genera, *Indotyphlus* and *Gegeneophis*. Half of the species of *Gegeneophis* (*danieli*, *krishni*, *seslachari*) have been described since 1999, and three (*danieli*, *fulleri*, *seslachari*) are known from only single specimens. Ravichandran et al. (2003) suggested that the northern part of the Western Ghats was less well explored for caecilians than the southern part, and the recent discovery of *G. danieli* supports this. However, given their secretive, subterranean habits we would not be surprised if additional undescribed caeciliids were to be found from any part of their broad range in the Western Ghats (Fig. 2).

It is unclear whether the South Asian caeciliids are a monophyletic radiation and this merits further attention. Of considerable interest is the apparent diversity in the degree of development of the visual system in *Gegeneophis*. Although the eye in all six species lies under bone, there is substantial variation in its external visibility that might be expected to correlate with sensitivity to light and with ecology. Within the genus, *G. danieli* and *G. ramaswamii* have the most and least externally visible eyes respectively. *G. ramaswamii* appears to be a dedicated burrower in soil that is rarely encountered on the surface (Measey et al. in press). A speculative but testable prediction, based on the greater visibility of the eye, is that *G. danieli* may spend more time on or near the surface.



FIGURE 2. Map of India showing type localities of the six species of *Gegeneophis* and the single species of *Indotyphlus* that comprise the caeciliid fauna of India.

Many caecilian species are known from only one or a few individuals in museum collections, reflecting a lack of dedicated collecting effort. We are profoundly ignorant of the distribution and abundance of *G. danieli*, *G. seshachari* and *G. fulleri* so that their current conservation status must be considered ‘data deficient’.

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