
A field guide to the caecilians of the Western Ghats, India

GOPALAKRISHNA BHATTA

Department of Zoology, Sri JCBM College, Sringeri 577 139, India

Caecilians are legless amphibians quite characteristic of the Western Ghats. Fourteen out of 16 Indian species occur in the Western Ghats and all are endemic. The present paper deals with the biology of caecilians with reference to external morphology and general breeding behaviour. It consolidates information on 26 morphological parameters which are used in caecilian identification. Metric multidimensional scaling of 16 species of caecilians using pair-wise euclidian distances calculated on the basis of 11 important morphometric parameters clearly depicts morphological distances between different species and more so the genera, thereby validating the classification. A field guide has been developed for the identification of caecilians based on a survey made all over the Western Ghats, observation of holotypes at the Natural History Museum, London and review of the literature. The study also reveals the microhabitat requirements of the caecilians. Further, the localities of caecilian distribution in the Western Ghats are mapped. The taxonomy of Indian caecilians is discussed.

1. Introduction

Caecilians comprise one of the three surviving orders of amphibians. Due to burrowing, secretive and nocturnal habit, they are encountered in the field only occasionally (Nussbaum and Wilkinson 1989). This led some researchers to believe that caecilians are quite rare, despite being fairly common in certain habitats (Maurice and Burton 1988; Nussbaum 1992). In spite of Taylor's monograph (1968) *The Caecilians of the World* giving a summary of the existing literature and description of many taxa, the diversity of caecilians remains poorly explored (Nussbaum and Wilkinson 1989; Nussbaum 1992; Ravichandran and Pillai 1996).

The Western Ghats have been identified as one of the 18 hotspots of biodiversity in the world, and highly endemic amphibian fauna is an important factor in the selection (WCMC 1988). India is known to harbour around 205 species of amphibians of which 120 occur in the Western Ghats (Inger and Dutta 1987; Daniels 1992, 1997). So far 17 species of caecilians (table 1) are reported from India (Taylor 1968; Pillai 1986), out of which 3 genera and 14 species are endemic to the Western Ghats.

Systematic studies on caecilian ecology in India is limited to the studies of Gundappa *et al* (1981), Balakrishna *et al* (1982a, b) and Bhatta (1986, 1997). One major reason for the limited research is the dearth of a field guide and a resultant scientific and popular ignorance about the subject. Though Daniel (1963) has published *Field Guide to the Amphibians of Western India*, it primarily focuses on anurans. With the background of my study of holotypes of Indian caecilians deposited in the Natural History Museum, London and subsequent field studies (Bhatta 1997), I attempt here to consolidate all the relevant literature on Indian caecilians with focus on the Western Ghats and hope that the field guide would boost interest in this group.

2. Biology

The caecilians are limbless, secretive, burrowing amphibians with a long cylindrical body (figure 1), with rings or annuli on it. They are generally mistaken for giant earthworms or snakes, especially shield tail snakes as both groups share nearly the same habitat and distribution. Shield tails also marginally occur in the drier areas. Caecilians possess small eyes, sometimes covered

Keywords. Field guide; caecilians; microhabitat; morphological and morphometric parameters

with skin, a pair of nostrils at the top of the snout and a pair of sensory tentacles on either side of the head. The terminal or subterminal mouth has two rows of teeth on the upper jaw and one or two rows of teeth on the lower jaw. These teeth are modified for holding and cutting the prey. The tongue is fused with the floor of the buccal cavity and cannot be protruded. The body colour varies considerably across species, having shades of violet, brown, grey and black. Some have bright yellow lateral stripes. The skin is smooth and slimy and in most of the species there are small scales embedded in it. It secretes mucus which is quite toxic to predators. A short tail may or may not be present and the anal opening is longitudinal or transverse. External morphological differences between male and female do not exist. Males have a single protrusible copulatory organ—the phallosome, which is inserted into the vent of the female during copulation, and hence fertilization is internal.

The caecilians reported so far from India are all terrestrial and oviparous. The female lays a clutch of eggs in a burrow near streams. The number of eggs varies across species. The eggs are connected to each other with a gelatinous string. The mother coils her body around the egg clutch until hatching. The larvae have external gills at the time of hatching and soon wriggle into the water where they lose the gills and metamorphose into terrestrial adult forms. Most of the caecilians probably have earthworms as the main diet and a few may eat termites, while others eat soil invertebrates. Caecilians are preyed upon by certain large snakes, birds, wildboars and also domestic chickens and pigs (Nussbaum 1992). Probably the tentacles are used for finding the prey (Nussbaum 1992).

3. Ecology

Caecilians are found at elevations ranging from sea level to over 2500 m ASL. They generally inhabit loose moist soil rich in humus and are found in decaying wood, moist leaf litter and in piles of decaying coconut leaves, arecanut leaf sheaths and their husks. Some of them are seen at varying depths in the cavities at the bases of roots of banana, coconut and arecanut trees and also at the bases of coffee/tea plants in plantations. They do occur in compost heaps/manure pits containing decaying leaves mixed with dung. Caecilians are common in fallow plots of mature areca, banana, coffee, rubber and coconut plantations. Their abundance is linked to low temperature, perennial water availability and high organic content of the soil. During the wet season they come close to the surface of the soil, lie beneath rotting vegetation and move about freely at night, while in the dry season they take refuge at the edges of the small streamlets or irrigation canals running through plantation areas. They form tunnels in the loose soil by pressing their head onto the ground. Caecilians are not uncommon in the backyard of farm houses or on roads at night in the rainy season. The local farmers generally encounter these animals when they use spades to turn over the soil and kill them believing that they are poisonous snakes.

4. Taxonomy

Incorrect taxonomic identity is a serious drawback in much of the Indian literature. As elsewhere in the world, all striped forms of *Ichthyophis* were wrongly classified

Table 1. Classification of Indian caecilians.

Family	Genus	Species
Ichthyophiidae Taylor	<i>Ichthyophis</i> Fitzinger	<i>beddomei</i> Peter* <i>bombayensis</i> Taylor* <i>glutinosus</i> (Linnaeus) <i>longicephalus</i> sp. nov.* <i>malabarensis</i> Taylor* <i>peninsularis</i> Taylor* <i>sikkimensis</i> Taylor <i>subterrestris</i> Taylor* <i>tricolor</i> Annandale*
Uraeotyphlidae Nussbaum	<i>Uraeotyphlus</i> Peters†	<i>malabaricus</i> (Beddome)* <i>menoni</i> Annandale* <i>narayani</i> Seshachar* <i>oxyurus</i> (Dumiri) and Bibron)*
Caeciliidae Rafinesque	<i>Gegeneophis</i> Peters† <i>Indotyphlus</i> Taylor†	<i>carnosus</i> (Beddome)* <i>fulleri</i> (Alcock) <i>ramaswamii</i> Taylor* <i>battersbyi</i> Taylor*

†Endemic to India; *endemic to Western Ghats.

as *Ichthyophis glutinosus* and unicoloured forms as *Ichthyophis monochrous* (Taylor 1961) in India also. In fact these two forms never existed in India at all (Taylor 1968). Gundappa *et al* (1981) reported the occurrence of *I. glutinosus* in India. Taylor (1968) has stated that "very many references on the literature of *Ichthyophis glutinosus* in India refer wholly or in part to *Ichthyophis beddomei*". Dutta (1987) quoting Nussbaum and Gans (1980) stated that the distribution of *I. glutinosus* is restricted to Sri Lanka. Hence Gundappa *et al* (1981) might have mistaken either *I. beddomei* or *Ichthyophis tricolor* for *I. glutinosus*. Despite repeated search for *I. glutinosus* in the localities from where Seshachar (1936) and Gundappa *et al* (1981) have reported them, I failed to find any individual of the above species, whereas individuals of the other species of the yellow striped form i.e., *I. beddomei* were found in these localities. It is therefore possible that earlier authors have mistaken *I. beddomei* for *I. glutinosus*. Balakrishna *et al* (1982b) and Revanasiddaiah *et al* (1982) reported *I. glutinosus* at Somwarpet and Malige range of Karnataka state respectively. However, careful observation is required to confirm the presence of *I. glutinosus* in India.

The widespread confusion in identifying caecilian species arises because of (i) the process of identification often involves only superficial observation of morphological characters, (ii) most of the described species are known only by an individual or two, thus the information

on the variation of their characters is scanty, (iii) non availability of holotypes/paratypes in Indian museums for confirmation and (iv) lack of field guides for confirming minute details. In my view, tackling the last problem by itself would help to overcome the other three.

A survey of caecilians in 10 localities in the Western Ghats was conducted during 1995–96 as a part of the Western Ghats Biodiversity Inventorying Programme (Gadgil 1996). In this survey surprisingly enough, in 8 out of 10 localities I could spot one or other species of caecilian, in some localities 2 and in one locality even six species within a few hours of field work, over a day or two, per locality. Thus my field experience strongly endorses the opinion expressed by Maurice and Burton (1988) and Nussbaum (1992) that caecilians are not as rare as generally believed.

Here, I provide the distinctive features of the four genera of caecilians of India (table 2 and figure 2) and the range of variation amongst different species with respect to various morphological and morphometric characters (table 3). Out of 26 parameters 11 which are more important had information for each species. These include total length, tail length, distance from eye to tentacle, width of head, width of body, length by width, total folds, premaxillary-maxillary teeth, prevomeropalatine teeth, dentary teeth and splenial teeth. I estimated mean values on the above parameters for each of the 16 species and normalized all these values by scaling from 0–100 on each parameter. I then calculated euclidian distance between each pair of species based on these normalized values as follows:

$$ED_{jk} = \sqrt{\sum_{x=i}^s (x_{ij} - x_{ik})^2}$$

where ED = euclidian distance between species j and k , x_{ij} is the value of parameter x for species j and x_{ik} is its value for species k . I then ordinated all the species using metric multidimensional scaling. The first axis explained 38% of the variation while the second explained 32%. Figure 3 clearly illustrates the morphometric differences between the four genera. The tail-less caecilians belonging to the genera *Gegeneophis* and *Indotyphlus* together form one cluster and *Uraeotyphlus* spp. with less number of body folds and short body length form another separate group. Most of the members of the genus *Ichthyophis* with almost similar morphometric values come together into a single group. The largest Indian caecilian *I. malabarensis* which ranks highest on most of the parameters occupies the extreme position in the biplot. If information on all the 26 parameters becomes available, the taxonomic classification may become more objective, using such modern techniques.

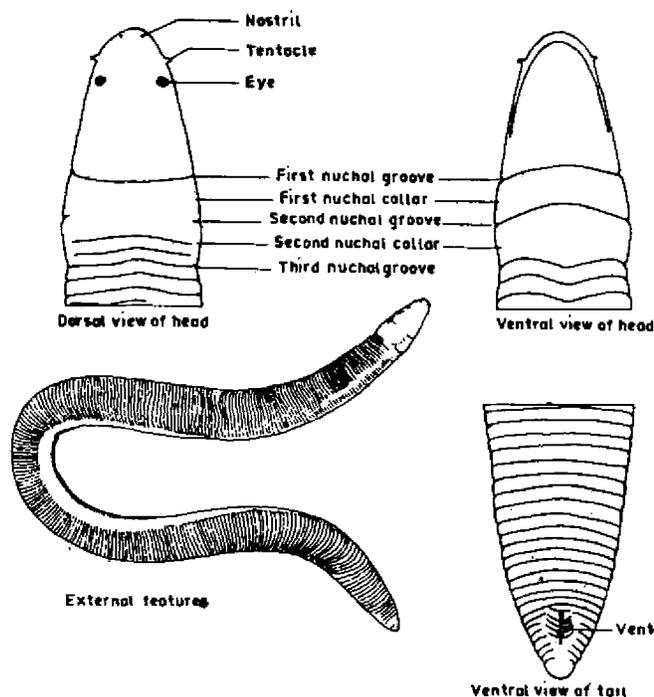


Figure 1. Caecilian morphology showing the key characters used in the identification of species.

Table 2. Key for the identification of different genera of caecilians in India.

	<i>Ichthyophis</i>	<i>Uraeotyphlus</i>	<i>Gegeneophis</i>	<i>Indotyphlus</i>
Colour (in life)	Unicoloured forms are sober coloured with brown or greyish shade. Yellow lateral striped forms are violet brown on dorsal surface and light shaded on the ventral surface	Olive violet, a steel grey on the dorsal and lavender on the ventral surface	Greyish on the dorsal surface and light grey shaded on the ventral surface	Pale flesh coloured on both dorsal and ventral surfaces
Mouth	Terminal	Recessed below the snout	Recessed below the snout	Recessed below the snout
Eyes	Visible	Visible	Not visible	Visible through the skin
Tentacles	Conical, long, near edge of mouth, much closer to eye than to nostrils	Flap like, short, anterior to and below nostril, much closer to nostril than to eye	Cone shaped, very short, close behind and below the nostril, nearer to tip of snout than to eye	Cone shaped, short on a line between eye and nostril, closer to eye than to nostril
Tail	Short and pointed	Short, tip whitish	No tail, body ends in a blunt shield	No tail, body ends in a blunt shield
Vent	Longitudinal	Longitudinal	Transverse	Transverse

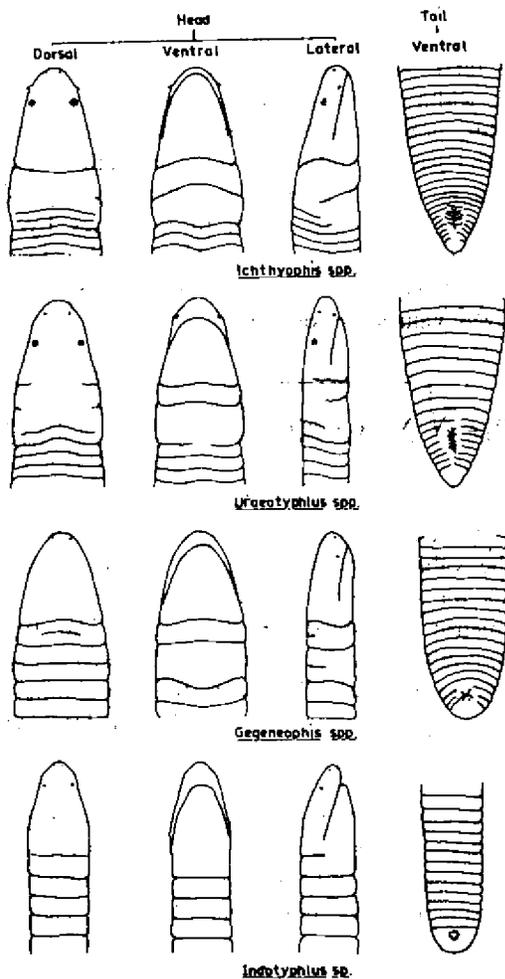


Figure 2. Distinctive features of four genera of caecilians showing relative position of nostrils, tentacles, eyes, nuchal grooves and vent.

Detailed information on all these aspects is based on available literature (Taylor 1968; Pillai 1986) and my own work (Bhatta 1986, 1997). However, I have collected and processed the data from the literature to estimate the mean and standard deviation of values for each parameter regarding each species to facilitate assessment of significance of variation, while confirming old species or proposing new ones. The list of localities of earlier collection and the relevant references are provided in table 4 and figure 4. Further, a brief description of caecilian species of the Western Ghats is also provided so as to enable researchers to identify them without killing. Unfortunately, the data available for each of the species in the literature are too meager to generate a detailed field guide for species level identification. The latter requires detailed surveys, collections, validation of earlier described species and new descriptions, if any.

5. Identifying caecilian genera in the field

The ideal period for searching for caecilians is the rainy season, after the rain water percolates down considerably so as to originate sub-soil springs. The caecilians are generally nocturnal. During the day time they shelter beneath rotten vegetation or in similar ecological conditions described earlier. After sighting an individual, one has to first ascertain that the animal is definitely a caecilian, by confirming that it possesses the rings (annuli) on the body. Taking an animal in the hand is necessary for identification of the species. They wriggle out to escape from our hold, but do not bite. The species belonging to the genera *Ichthyophis* and *Uraeotyphlus* possess pointed tail and longitudinal vent (figure 2) whereas those of the genera *Gegeneophis* and *Indotyphlus*

have blunt terminus with transverse vent. With the exception of unicoloured forms of the genus *Ichthyophis*, all other known species of caecilians are no longer than 30 cm in body length.

6. Description of caecilian species of Western Ghats

The morphological details of caecilians are provided mainly with reference to the body colour, yellow banding pattern, relative position of eye, nostril, tentacle and the status of nuchal grooves based on thorough examination of 9 species. As I did not encounter *I. bombayensis*, *I. subterrestris*, *U. malabaricus*, *U. menoni* and *U. oxyurus* during my field visit, I have summarized their description as given by Taylor (1968). As there is no firm evidence to assume that *I. glutinosus* occurs in India, I refrain from giving its morphological details.

6.1 *Ichthyophis beddomei*

Body is violet brown on the dorsum and light brown on the venter. A yellow lateral stripe passes along the body from tip of tail to the head. The stripe bifurcates at mouth angle, one branch reaches tip of snout along the upper lip and the other reaches the tip of chin along the lower jaw. The yellow stripe widens just opposite the first collar, then becomes narrow and again widens and continues thereafter as such till the tip of tail. Body is short and broad. Eyes are distinct. Tentacular aperture is very close to lip. Its distance from eye and nostril is almost equal. Nostrils nearly terminal but barely visible when viewed from above the head. The snout extends slightly beyond the mouth. The first nuchal groove is distinct on both dorsal and ventral surfaces; second nuchal groove is not clear on dorsal surface and the third nuchal groove is distinguishable on the dorsal but not on the median ventral region. The second collar groove bears two well defined folds dorsally. *Range*: Karnataka, Kerala and Maharashtra.

6.2 *Ichthyophis bombayensis*

It is large unicoloured species with elongate tapering tail. Body is dark brown above and somewhat lighter brown below. Lateral yellow bands are absent. Head is rather small and narrower than the body. Eyes are distinct and surrounded by a whitish ring. Tentacular aperture is close to lip. It is nearer to the eye than the nostril. The first nuchal groove is distinct ventrally, at the sides and preceded dorsally by a distinct strongly curved fold on the back of the head. Second nuchal groove is clear ventrally and laterally but not dorsally. Third groove crosses on the dorsal side visible laterally and partly crosses the venter. *Range*: Bombay provinces (now in Gujarat) and Karnataka.

6.3 *Ichthyophis longicephalus*

Body is dark violet brown on the dorsum and some what lighter on the venter. A yellow lateral stripe extends from tip of tail to posterior margin of second collar. Small yellow patches occur at the sides of second collar, first collar and on the angle of jaws. On the venter each annulus is broken in the middle and results in a longitudinal midventral line extending from collar to vent. Body is short and broad. Head is comparatively longer. Eyes are distinct. Tentacular aperture lies close to lip. It is much closer to eye than to nostril. Nostrils are nearly terminal and visible from above. The snout extends a little beyond mouth. The first nuchal groove is clear ventrally and laterally and dim dorsally. The first collar is completely fused with the second on the dorsum. The second nuchal groove is distinct on the ventral surface and extends up laterally up to the level of angle of mouth. The second collar bears two incomplete folds dorsally. *Range*: Kerala.

6.4 *Ichthyophis malabarensis*

This is the largest known Indian caecilian species. It is unicoloured, dark brown above and light cream white coloured below. The tip of tail is dark, nearly black from the vent to tip. No lateral yellow stripe. Head is narrower than the body. Eyes are visible. Tentacular aperture near the lip and is closer to eye than to nostril. The first nuchal groove is clear ventrally and becomes

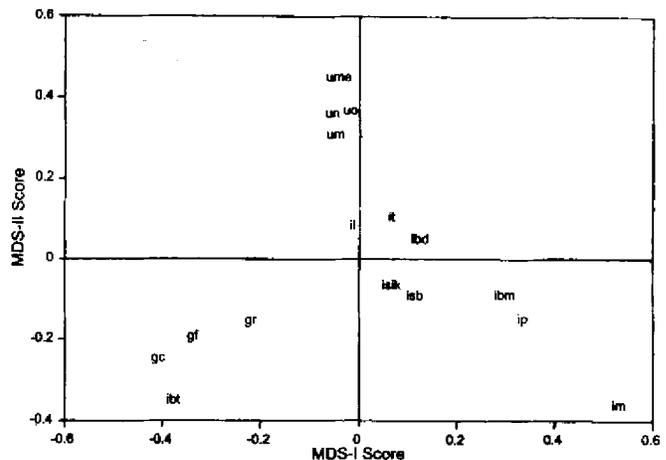


FIG - 3

Figure 3. Metric multidimensional scaling of 16 species of caecilians using pairwise euclidian distances calculated on the basis of 11 morphometric characters. ibd, *Ichthyophis beddomei*; ibm, *Ichthyophis bombayensis*; im, *Ichthyophis malabarensis*; ip, *Ichthyophis peninsularis*; it, *Ichthyophis tricolor*; il, *Ichthyophis longicephalus*; isik, *Ichthyophis sikkimensis*; isb, *Ichthyophis subterrestris*; um, *Uraeotyphlus malabaricus*; un, *Uraeotyphlus narayani*; ume, *Uraeotyphlus menoni*; uo, *Uraeotyphlus oxyurus*; ge, *Gegeneophis carnosus*; gf, *Gegeneophis fulleri*; gr, *Gegeneophis ramsawamii*; ibt, *Indotyphlus battersbyi*.

Table 3. Morphological and morphometrical parameter values for the caecilian species of the Western Ghats.

Attributes	IBD n=10			IBM n=1			IM n=8			IP n=3			
	min	max	mean	SD	n	min	max	mean	SD	min	max	mean	SD
	Total length	210	270	242	21.77	390	340	540	461	64.15	260	330	292
Tail length	4	5	4.23	0.33	15.2	15	20	16.5	1.87	11	15.2	12.73	1.79
Length by tail length	50	64	58.08	4.96	25.6	21.3	32	28	3.07	22	23.8	23.13	0.81
Head length	7.4	7.4	7.4	0	15	9.6	22	15.29	3.75	9.5	16	12.03	2.84
Eye to nostril	1.8	2	1.87	0.08	5.5	5.5	7.3	6.69	0.57	4.6	5	4.77	0.17
Eye to tentacle	3.5	5	4.07	0.36	2.3	2.3	2.9	2.49	0.21	1.6	2.5	2.03	0.37
Eye to eye	3.7	4.4	4.11	0.19	8	7.5	10.6	9.36	1.02	6.3	7.1	6.6	0.36
Eye level to snout tip	2	2.5	2.16	0.14	4	7.2	10	9.17	0.99	6.1	6.4	6.25	0.15
Nostril to tentacle	8.6	11	9.91	0.56	4	4.2	6.2	5.2	0.54	3.3	4	3.65	0.35
Snout tip to 1st groove	11.7	14	12.41	0.69		14.3	24	19.29	2.74	13.1	14	13.55	0.45
Snout tip to 2nd groove	14	17	15.34	0.91		18.2	27.2	24.46	3	17.3	17.8	17.55	0.25
Snout tip to 3rd groove	6.5	9	7.77	0.95		23.3	36	30.94	4.02	21.2	21.5	21.35	0.15
Width of head	5.1	5.1	5.1	0	10	9.6	15.1	13.01	1.87	8.7	14.4	10.63	2.66
Width of head at eye	7	7	7	0	10	8.8	12.3	10.94	1.41	8	8.2	8.1	0.1
Width of head at 1st groove	7.1	7.1	7.1	0	10	9	13.8	11.89	1.76	8.2	9.1	8.65	0.45
Width of head at 2nd groove						9.1	14.5	12.17	1.85	9	9.6	9.3	0.3
Width of body	10.1	15	13.04	1.28	15	11.4	19.2	14.33	2.5	10.9	14.8	12.37	1.73
Length by width	16	26.7	18.78	2.86	26	26.2	41.2	32.6	4.4	22.3	25	23.73	1.11
Width of vent	4.1	4.1	4.1	0		4.4	9.2	7.14	1.59	5	5.3	5.15	0.15
Tail folds (in Nos)	9	9	9	0	14	14	19	18	1.58	18	19	18	0.47
Total folds (in Nos)	256	285	271	10.07	386	340	399	367	16.29	356	376	365	8.29
Premaxillary-maxillary teeth (in Nos)	40	49	42.67	2.98	45	67	67	67	0	49	49	49	0
Prevomeralpalatine teeth (in Nos)	40	58	48.11	5.02	48	69	69	69	0	51	51	51	0
Dentary teeth (in Nos)	38	44	40.33	1.83	40	57	57	57	0	49	49	49	0
Splinal teeth (in Nos)	18	58	41	12.82	18	47	47	47	0	57	57	57	0
Vertebrae (in Nos)	102	121	108.3	7.46	111	110	110	110	0	104	104	104	0

All the measurements are in mm.

IBD, *Ichthyophis beddomi*; IBM, *Ichthyophis malabarensis*; IM, *Ichthyophis peninsularis*; IP, *Ichthyophis bombayensis*; n, number of specimens examined.

Table 3. (Continued).

Attributes	IT n = 7			IL n = 66			ISIK n = 4			ISB n = 5		
	min	max	mean	SD	min	max	mean	SD	min	max	mean	SD
Total length	226	330	265	33.77	192	300	253	31.9	263	276	270	4.64
Tail length	3	6	4.69	0.87	4	5	4.75	0.38	4.5	5.5	4.98	0.48
Length by tail length	49	80	58.02	9.78	42.67	75	53.8	10	4.5	5.5	4.98	0.48
Head length	9.2	13	10.89	1.48	7.6	9.3	8.3	0.57	11	11	11	0
Eye to nostril	4	5.5	4.63	0.65	4.1	5	4.66	0.33	1.7	1.7	1.7	0
Eye to tentacle	2	2.5	2.27	0.18	1.4	2.8	2.15	0.41	1.7	1.7	1.7	0
Eye to eye	4.5	5.7	5.14	0.38	5.1	6.4	5.72	0.41	6.1	6.1	6.1	0
Eye level to snout tip	4.7	6.3	5.43	0.5	4.5	5.2	5.02	0.23	5.2	5.2	5.2	0
Eye level to tentacle	2.5	3.7	2.93	0.49	3.1	3.7	3.28	0.2	2.9	2.9	2.9	0
Nostril to tentacle	11	14.6	12.46	1.03	12	12.5	12.3	0.21	10.4	13.8	11.1	2.01
Snout tip to 1st groove	14.8	18	15.75	1.31	14.5	16.4	15.5	0.74	13.8	17	13.84	2.63
Snout tip to 2nd groove	17.2	21.7	19.21	1.54	17.3	18.8	17.9	0.54	13.8	22	17.54	3.06
Snout tip to 3rd groove	7.1	9.1	8.27	0.75	7.5	9.6	7.95	0.77	6.3	11	8.58	1.84
Width of head	6.1	7.8	6.63	0.68	6.3	7.8	6.94	0.7	10	10	10	0
Width of head at eye	7.3	9.3	7.88	0.83	8	10.1	8.66	0.81	10	10	10	0
Width of head at 1st groove	8.2	10.1	8.68	0.82	8.5	11.4	9.26	1.1	10	12.2	11.1	1.05
Width of head at 2nd groove	11.2	12.8	12.04	0.7	8.5	14.1	10.6	1.71	10	27	24.7	2.36
Width of body	21.7	27.5	23.8	2.26	21.3	26.5	24.2	1.7	22	27	24.7	2.36
Length by width	3	4.9	4.03	0.8	3.2	4.4	3.68	0.4	6	6	6	0
Width of vent	5	10	8	1.95	7	8	8	0.47	6	6	6	0
Tail folds (in Nos)	249	297	280	15.33	324	352	340	9.39	276	292	284	5.72
Total folds (in Nos)	31	38	34.5	3.5	35	35	34.5	3.5	46	46	46	0
Premaxillary-maxillary teeth (in Nos)	49	59	54	5	28	28	54	5	40	42	41.5	0.87
Premeroplatine teeth (in Nos)	30	38	34	4	32	32	34	4	37	42	40.3	1.92
Dentary teeth (in Nos)	4	30	17	13	4	4	17	13	16	18	17.5	0.87
Splenic teeth (in Nos)	108	108	108	0	108	108	108	0	106	107	107	0.5
Vertebrae (in Nos)												

All the measurements are in mm.

IT, *Ichthyophis tricolor*; IL, *Ichthyophis longicephalus*; ISIK, *Ichthyophis sikkimensis*; ISB, *Ichthyophis subterrestris*; n, number of specimens examined.

Table 3. (Continued).

Attributes	UM n = 5			UN n = 10			UME n = 2			UO n = 13		
	min	max	mean	SD	min	max	mean	SD	min	max	mean	SD
Total length	145	234	190	34.87	199	245	230	13.67	245	207	237	54.91
Tail length	3	6	4.72	1.07	4	8	6.1	1.45	6.3	5	7.5	1.29
Length by tail length					30	55	39.73	8.81				
Head length					6.3	11	8.12	1.43				
Eye to nostril					2.3	3.6	3.29	0.37			1.6	0.22
Eye to tentacle	3	3.5	3.28	0.19	2.3	3.7	3.3	0.38	3.6	3.3	4.3	0.53
Eye to eye					3.5	4.5	4.03	0.27				
Eye level to snout tip					4	5	4.63	0.41				
Nostril to tentacle	1	1.2	1.1	0.07	1	1	1	0	1.2	1.1		
Snout tip to 1st groove	6	8.4	7.49	0.93	8.8	10	9.47	0.38	10	8		
Snout tip to 2nd groove					11.4	13.2	12.35	0.54	15.2	13		
Snout tip to 3rd groove	14	14.8	14.47	0.34	14.1	15.5	14.97	0.49			7.25	1.38
Width of head					6	8.5	6.8	0.83			8.8	
Width of head at eye	4.7	5.1	4.93	0.17	5	5.8	5.32	0.26	5.7	5.1		
Width of head at 1st groove	6	6.8	6.3	0.36	6	6.7	6.32	0.22	6.9	7.2		
Width of head at 2nd groove					6.5	7.2	6.82	0.24				
Width of body	6	9	7.67	0.96	9	11	9.9	0.58	12	10	14	2.68
Length by width	20	28	24.52	2.65	21	26.9	23.29	1.8	20.4	20.7	29	3.19
Width of vent					4.3	6	4.75	0.59	6.8	5		
Tail folds (in Nos)					3	9	7	2.3				
Total folds (in Nos)	206	246	234	14.81	169	184	178	3.78	176	172	211	5.91
Premaxillary-maxillary teeth (in Nos)	32	36	34.2	1.47	26	31	28.67	2.06	28	25	35	2.27
Prevomero-palatine teeth (in Nos)	36	43	40	2.37	36	38	37.33	0.94	36	36	45	4.62
Dentary teeth (in Nos)	30	39	35.6	3.38	30	32	31	0.82	27	28	36	3.75
Splenia teeth (in Nos)	10	17	15	2.53	10	16	13.75	2.28	15	15	52	12.27
Vertebrae (in Nos)					10	16	13.75	2.28			105	0

All the measurements are in mm.

UM, *Uraeotyphlus malabaricus*; UN, *Uraeotyphlus narayani*; UME, *Uraeotyphlus metoni*; UO, *Uraeotyphlus oxyurus*; n, number of specimens examined.

Table 3. (Continued).

Attributes	GC n=3			GF n=1			GR n=16			IBT n=8			
	min	max	mean	SD	n	min	max	mean	SD	min	max	mean	SD
Total length	146	172	160	10.71	220	182	340	236	44.3	170	238	210	19.29
Tail length	0	0	0	0	0	0	0	0	0	0	0	0	0
Length by tail length					8.1								
Head length										4.2	5.5	5.15	0.55
Eye to nostril										0.56	0.65	0.61	0.04
Eye to tentacle													
Eye to eye													
Eye level to snout tip													
Nostril to tentacle	1.2	1.2	1.2	0						1.3	1.3	1.3	0
Snout tip to 1st groove	4.8	4.8	4.8	0		7	11	8.17	1.25	4.4	5	4.8	0.24
Snout tip to 2nd groove	5.4	5.4	5.4	0		8.3	14	10.2	1.58	6	6.7	6.33	0.25
Snout tip to 3rd groove	7.7	7.7	7.7	0		11	18	13.8	1.93	7.7	8.5	8.1	0.29
Width of head	3	3.9	3.45	0.45		6	11	7.81	1.41	3	3.8	3.39	0.3
Width of head at eye													
Width of head at 1st groove													
Width of head at 2nd groove													
Length of body	4.2	4.9	4.57	0.29		7.9	13.6	10.3	1.5	3.7	4.9	4.27	0.41
Width by width	35	35	35	0		21	25	22.9	1.25	45.2	53	48.6	2.35
Width of vent	3.9	4	3.95	0.05	9	6.4	11	8.73	1.25				
Tail folds (in Nos)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total folds (in Nos)	118	119	119	0.5	105	109	116	113	1.84	155	168	160	5.43
Premaxillary-maxillary teeth (in Nos)	21	25	23.67	1.89	22	29	37	32.2	2.17	18	28	22.88	2.57
Prevomero-palatine teeth (in Nos)	19	24	22.33	2.36	23	27	37	30	3.05	13	34	25.5	5.57
Dentary teeth (in Nos)	18	20	19	0.82	20	20	28	23.9	2.77	16	23	20	2.18
Splenia teeth (in Nos)	2	8	5	3	6	4	20	7.36	5.26	4	4	4	0
Vertebrae (in Nos)						106	108	107	1				

All the measurements are in mm.

GR, *Gegeneophis ramaswamii*; GF, *Gegeneophis cartosus*; IBT, *Indotyphlus battersbyi*; n, number of specimens examined.

Table 4. Caecilian distribution in India based on the published literature and author's collection.

Species	Localities of collection	References
<i>Ichthyophis beddomei</i>	Kotigehar, Gersoppa, Kigga, Sringeri, Uppinangadi, Kumta, Sirsi, Mala, Neria—Karnataka Nilgiris—Tamil Nadu Mundur—Kerala Supegaon—Maharashtra	Taylor 1960a, 1968 Daniel 1963 Tikader 1964 Rahman and Rajagopal 1978 Balkrishna <i>et al</i> 1982a, b Bhatta 1986, 1997
<i>Ichthyophis bombayensis</i>	Waghii Surat—Bombay Province Sringeri—Karnataka	Taylor 1960a, 1968 Daniel 1963 Balkrishna <i>et al</i> 1982b
<i>Ichthyophis glutinosus</i>	Kotigehar, Somwarpet, Malige Range—Karnataka	Seshachar and Iyer 1932 Abdulali 1954 Balakrishna <i>et al</i> 1982b Revanasiddaiah <i>et al</i> 1982
<i>Ichthyophis longicephalus</i>	Mundur, Muttappanpuzha—Kerala Silent Valley—Kerala	Pillai 1986 Bhatta 1997
<i>Ichthyophis malabarensis</i>	Maduvangard, Mundur—Kerala Mala, Sringeri, Sirsi, Subramanya, Kigga—Karnataka	Taylor 1960a, 1968 Daniel 1963 Seshachar <i>et al</i> 1982 Bhatta 1986, 1997
<i>Ichthyophis peninsularis</i>	Malabar, Vanjikadavu—Kerala Neria—Karnataka Alamcholai—Tamil Nadu	Taylor 1960a, 1968 Daniel 1963 Jaisingh 1978 Das and Whitaker 1990 and author's collection
<i>Ichthyophis sikkimensis</i>	Darjeeling—Sikkim	Taylor 1960a, 1968
<i>Ichthyophis subterrestris</i>	Kottayam, Travancore—Cochin Anamalai, Parambikulam—Kerala Alibag—Maharashtra	Taylor 1960a Daniel 1963 Taylor 1968
<i>Ichthyophis tricolor</i>	Maddathori, Peermade, Parambikulam, Travancore, Mundur—Kerala Nilgiris—Tamil Nadu	Taylor 1960a, 1968 Daniel 1963 Bhatta 1997
<i>Uraeotyphlus malabaricus</i>	Malabar—Kerala Ootacamund—Tamil Nadu	Taylor 1968
<i>Uraeotyphlus menoni</i>	Koduvalli, Cochin, Kottayam, Trichur—Kerala	Daniel 1963 Taylor 1968
<i>Uraeotyphlus narayani</i>	Kannam Emakulum—Kerala Sringeri—Karnataka	Daniel 1963 Taylor 1968 Balakrishna <i>et al</i> 1982a, b Bhatta 1986, 1997
<i>Uraeotyphlus oxyurus</i>	Taliparamba, Wynaad, Tinnivelly, Malabar, Allur, Cochin, Anamalai hills—Kerala	Taylor 1968
<i>Gegeneophis carnosus</i>	Peria peak, Wynaad, Ponmudi hills, Tenmalai, Trivandrum—Kerala Kotigehar, Malige Range—Karnataka	Seshachar 1942 Seshachar and Ramaswami 1943 Daniel 1963 Taylor 1968 Revanasiddaiah <i>et al</i> 1982
<i>Gegeneophis fulleri</i>	Kuttal—Cachar	Taylor 1968
<i>Gegeneophis ramaswamii</i>	Tenmalai, Trivandrum, Bonocord—Kerala	Taylor 1964, 1968 Bhatta 1997
<i>Indotyphlus battersbyi</i>	Khandala, Lonavala, Supegaon—Maharashtra	Taylor 1960b, 1968, 1970 Bhatta 1997

slightly angulate dorsally. The second nuchal groove is convex below and distinct on sides of neck. The third nuchal groove is clear on sides of neck and dim on the dorsal surface. There are three transverse folds on the dorsum of the second collar. *Range: Kerala and Karnataka.*

6.5 *Ichthyophis peninsularis*

Unicoloured form. Dorsal side is greyish lavender and ventral light cream coloured. No lateral yellow stripe. A large species with broad and short head, and relatively long tail. Eyes are visible. Tentacles lie nearer to eyes than to nostrils. The first nuchal groove is clear dorsally, laterally and ventrally. The second nuchal groove is well defined on the ventral surface and on the sides of head. The third groove is more or less distinct, except mesially below. *Range: Kerala, Karnataka and Tamil Nadu.*

6.6 *Ichthyophis subterrestris*

A moderate sized species with dark violet-lavender colour

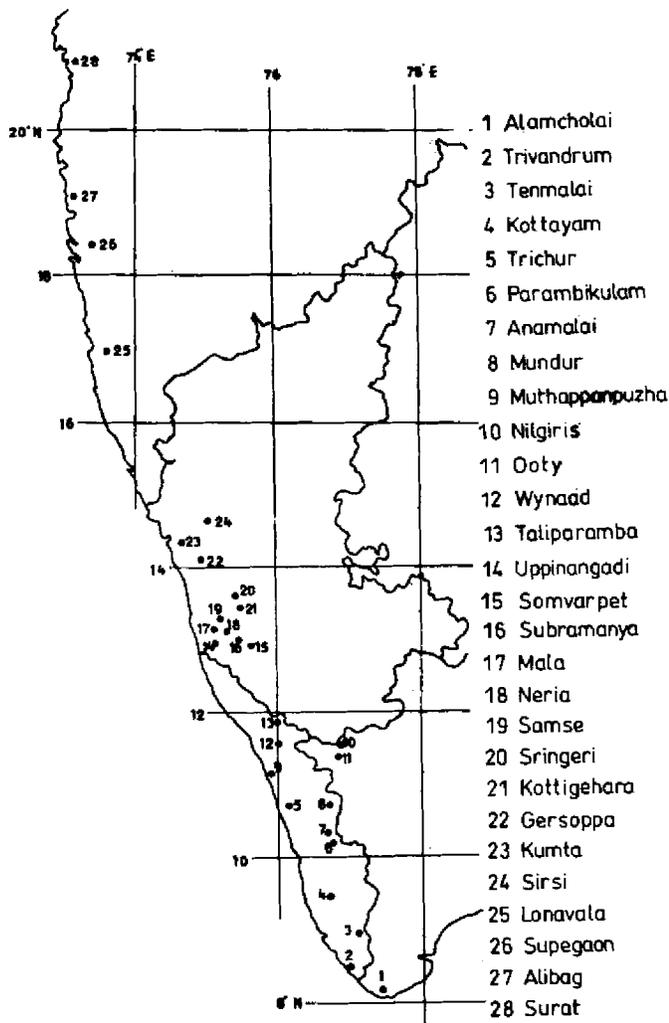


Figure 4. Localities of caecilian distribution.

on the dorsum and lavender brown on the venter. There is no lateral yellow stripe. The head is elevated posteriorly. Eyes are distinct. The tentacle is nearer to eye and close to lip. The first nuchal groove is distinct on both dorsal and ventral surfaces. The second is not clear on the dorsum. *Range: Kerala.*

6.7 *Ichthyophis tricolor*

Body is violet brown above. A yellow lateral stripe extends from the head to the tip of tail, not broken on the neck, but widens on the collars. At the angle of the jaws, it forks, and the yellow band continues along the jaw up to the eye on the dorsal surface of the snout. A broad white ventral stripe is present on the venter. Head with slightly projected snout. Eyes are distinct. Tentacle at the edge of lip, nearer to the eye than to the nostril. The first nuchal groove is distinct on the ventral surface, passes up at the sides, but does not meet on the mid dorsal line. The second nuchal groove is clear on ventral surface and at the sides of neck but not dorsally. There are two transverse folds on the dorsum of the second collar. *Range: Kerala.*

6.8 *Uraeotyphlus malabaricus*

Body is short and stout, violet coloured on the dorsal surface and lighter shade of violet on the ventral. Eye is distinct and surrounded by a cream ring (sometimes one eye distinct and other dim). Tentacle scarcely visible from above, nearer to nostril than to eye. It is closer to mouth than to the nostril. Small cream areas are present at nostril, tentacle, tip of snout and its underside. The upper and lower lip and the two jaws are also cream in colour. A cream white spot is present at vent. The tip of tail is whitish. The first collar is very dim, not distinguishable above and vaguely evident ventrally. The first collar is fused with second collar. Second collar is more clear, incompletely grooved posteriorly with a slightly visible transverse fold across the dorsum. *Range: Kerala.*

6.9 *Uraeotyphlus menoni*

Medium sized species slate-grey on the dorsum and whitish, blotched with grey on the venter. Eyes are distinct and surrounded by a narrow white ring. Tentacle not visible from above, closer to the nostril than to the eye. Nostrils distinctly visible from above. The head is light violet coloured, the tip of the snout above and below cream white with light mottling on top of the head. The chin and throat are with indefinite greyish marks. The tip of tail is cream coloured. The first nuchal groove is less distinct above and clearly defined below. The second groove is not clear dorsally but visible

laterally and ventrally. The second collar is well defined dorsally and laterally, but ventrally it is fused with the first body annulus. *Range*: Kerala.

6.10 *Uraeotyphlus narayani*

Steel grey above, pale and flesh coloured on the ventral surface. In between the chin and tail a median greenish line is present. Eyes are distinct with a whitish areola. Nostril visible directly above the head. The distance from eye to nostril and eye to tentacle almost identical. Tentacular aperture is below the nostril and not visible from directly above head. Tip of tail is whitish. The tip and ventral part of snout cream. No light spot at tentacle or nostril. The first nuchal groove is distinct ventrally and laterally, and less clear dorsally. The second nuchal groove is clear ventrally and extends up on the sides to the level of the mouth. The third nuchal groove is visible on the dorsum and sides of neck. *Range*: Kerala and Karnataka.

6.11 *Uraeotyphlus oxyurus*

A thick bodied species with narrower head and a short tail. Body moderately dark brown. Eyes are very small but distinct with a light white ring. Tentacle below nostril, closer to nostril than to eye. Nostrils are visible from directly above head. The tip of tail is white. The chin and throat are very light brown. The first nuchal groove is very dim across the head. The second collar is fused to first primary fold on venter. A single fold lies across the back part of the second collar. *Range*: Kerala.

6.12 *Gegeneophis carnosus*

A small species with body flesh coloured on both surfaces. Terminal width less than body width. Body ends in blunt shield. Eyes are invisible. The tentacular aperture is below and behind the nostril. Nostrils are nearly terminal and not visible from directly above head. The terminus is narrowed. The first nuchal groove is clear on the ventral surface and dim on the dorsal part. The second collar is distinct above, partly divided by a dorsal transverse groove, while on the ventral surface it is partially fused with the first primary annulus. *Range*: Kerala and Karnataka.

6.13 *Gegeneophis ramaswamii*

Larger species with body greyish on the dorsal surface and light grey on the ventral surface. Terminus of body is wider than elsewhere which ends bluntly. Tentacles lie behind and below the nostrils, not visible from directly above the head. Eyes are invisible. The first and second

nuchal grooves are distinct on the dorsum, venter and at the sides. There is a short transverse groove on the first collar. *Range*: Kerala.

6.14 *Indotyphlus battersbyi*

A species with slender elongate body. Body is pale flesh coloured on both dorsal and ventral surfaces. Eyes are concealed and feebly visible through the skin. Body ends in a blunt shield. The first nuchal groove is distinct on the dorsum, while the second nuchal groove clear on both the surfaces. *Range*: Maharashtra.

Acknowledgements

Prof. Madhav Gadgil, Centre for Ecological Sciences, Indian Institute of Science, Bangalore inspired me to initiate this work. The Principal Investigators of the different sites of the Western Ghats Biodiversity Network provided full cooperation during field study. B Pushpalatha took pains in rearing some species of caecilians for later identification. The Principal and the management of my college extended full support to conduct the survey and study caecilians during my free time. I am grateful to all the above.

References

- Abdulali H 1954 Distribution and habits of the batrachian *Ichthyophis glutinosus* Linn; *J. Bombay Nat. Hist. Soc.* **52** 639.
- Balakrishna T A, Gundappa K R and Katre S 1982a A Note on the Occurrence and Habitat Features of *Ichthyophis beddeomei* (Peters) and *Uraeotyphlus narayani* (Seshachar); *Curr. Sci.* **51** 415-416
- Balakrishna T A, Katre S and Gundappa K R 1982b Taxonomy and Myogen Patterns of some Caecilians on the Indian Subcontinent; *Curr. Sci.* **51** 848-849
- Bhatta G 1986 Some Aspects of Reproduction in the Apodan Amphibian—*Ichthyophis*, Ph.D. thesis, Kamatak University, Dharwad
- Bhatta G 1997 Caecilian Diversity of the Western Ghats: In Search of the rare animals; *Curr. Sci.*, **73** 183-187
- Daniel J C 1963 Field Guide to the Amphibians of Western India; *J. Bombay Nat. Hist. Soc.* **60** 415-438
- Daniels R J R 1992 Geographical Distribution Patterns of Amphibians in the Western Ghats, India; *J. Biogeogr.* **19** 521-529
- Daniels R J R 1997 A Field Guide to the Frogs and Toads of the Western Ghats, India; *Cobra* **27** 1-25
- Das I and Whitaker R 1990 Herpetological investigations in the Western Ghats, South India, Part I. The Vanjikadavu and Nadukani Forests, Kerala State; *Hamadryad* **15** 6-9
- Dutta S K 1987 Misidentification, Wrong Nomenclature and Misspelling of some Indian Amphibians; *J. Zool. Soc. India* **39** 109-113
- Gadgil M 1996 Documenting Diversity: An Experiment; *Curr. Sci.* **70** 36-44
- Gundappa K R, Balakrishna T A and Katre S 1981 Ecology of *Ichthyophis glutinosus* (Linn.) (Apoda, Amphibia); *Curr. Sci.* **50** 480-483

- Inger R F and Dutta S K 1987 An overview of the Amphibian fauna of India; *J. Bombay Nat. Hist. Soc.* **83** 135–146
- Jaisingh P 1978 On the Occurrence of *Ichthyophis peninsularis* Taylor (Gymnophiona: Caecilidae) from Alamcholai (District Kanyakumari, Tamil Nadu, India); *J. Bombay Nat. Hist. Soc.* **75** 501–502
- Maurice and Burton R 1988 Caecilia; in *Encyclopedia of the Animal Kingdom* (London: McDonald)
- Nussbaum R A and Gans C 1980 On the *Ichthyophis* (Amphibia: Gymnophiona) of Sri Lanka; *Spolia Zeylan.* **35** 137–154
- Nussbaum R A and Wilkinson M 1989 On the Classification and Phylogeny of Caecilians (Amphibia: Gymnophiona). A Critical Review; *Herpetol. Monogr.* **3** 1–42
- Nussbaum R A 1992 *Caecilians in Reptiles and Amphibians* (eds Cogger H G and Zweifel R G (New York: Smithmark) pp 52–59
- Pillai R S 1986 Amphibian Fauna of Silent Valley, Kerala, S. India; *Rec. Zool. Surv. India* **84** 229–242
- Rahman M F and Rajagopal K V 1978 Occurrence of *Ichthyophis beddomei* Peters in South Kanara, Karnataka State; *Sci. Cult.* **144** 187–188
- Ravichandran M S and Pillai R S 1996 Present Status of Indian Caecilians (Gymnophiona: Amphibia); *Zoo's Print.* **11** 1 and 3
- Revanasiddaiah H M, Chowdaiah B N and Achar K P 1982 Electrophoretic Patterns of Esterases and Phosphatases in *Ichthyophis glutinosus* (Linn.) and *Gegenophis carnosus* (Beddome) (Apod: Amphibia); *Indian Zoologist* **6** 11–13
- Seshachar B R and Iyer M S M 1932 The Gymnophiona of Mysore; *Half Yearly J. Mysore Univ.* **6** 171–175
- Seshachar B R 1936 The Spermatogenesis of *Ichthyophis glutinosus* (Linn.) Part I. The Spermatogonia and their Division; *Z. Zelforsch.* **24** 662–706
- Seshachar B R 1942 Eggs and Embryos of *Gegenophis carnosus*; *Curr. Sci.* **11** 439–441
- Seshachar B R and Ramaswami L S 1943 *Gegenophis carnosus* (Beddome) from South India; *Half Yearly J. Mysore Univ.* **4** 111–113
- Seshachar B R, Balakrishna T A, Katre S and Gundappa K R 1982 Some Unique Features of Egg Laying and Reproduction in *Ichthyophis malabarensis* (Taylor) (Apoda, Amphibia); *Curr. Sci.* **51** 32–34
- Taylor E H 1960a On the Caecilian Species *Ichthyophis monochrous* and *Ichthyophis glutinosus* and Related Species; *Univ. Kansas Sci. Bull.* **40** 37–120
- Taylor E H 1960b A New Caecilian Genus in India; *Univ. Kansas Sci. Bull.* **40** 31–36
- Taylor E H 1961 Notes on Indian Caecilians; *J. Bombay Nat. Hist. Soc.* **58** 355–365
- Taylor E H 1964 A New Species of Caecilian from India (Amphibia, Gymnophiona); *Senckenbergiana Biol.* **45** 227–231
- Taylor E H 1968 *The Caecilians of the World—A Taxonomic Review* (Lawrence: Kansas University Press)
- Taylor E H 1970 On the Status of the Caecilian *Indotyphlus battersbyi* Taylor; *Univ. Kansas Sci. Bull.* **49** 337–344
- Tikader B K 1964 Miscellaneous notes. Observations on the Caecilian *Ichthyophis beddomei* Peters, from Kotegehar district, Chickmagalore, Mysore; *J. Bombay Nat. Hist. Soc.* **61** 697
- WCMC 1988 *Global Biodiversity—Status of Earth's Living Resources* (World Conservation Monitoring Centre and Chapman and Hall, London)

MS received 24 September 1997; accepted 9 January 1998

Corresponding editor: RAGHAVENDRA GADAGKAR