

A new short brown unpatterned moray eel (Anguilliformes, Muraenidae) from the southeast coast of India, Bay of Bengal

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<https://zoobank.org/A86FEFE8-7DFD-458E-9E34-616C17E4D06E>

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Academic editor: Nalani Schnell ♦ Received 12 January 2023 ♦ Accepted 14 March 2023 ♦ Published 23 March 2023

Abstract

Gymnothorax tamilnaduensis sp. nov., a new species of short brown unpatterned moray, is described, based on four specimens ranging from 272–487 mm total length collected from the trawl bycatch landings at Mudasalodai fish landing centre, off Cuddalore coast, Tamil Nadu, southeast coast of India. The new species is distinguished by the following combination of characters: origin of dorsal fin at middle of rictus and gill opening, anus just before mid-body, series of lines of small dark spots present on head and a single line of black spot on mid-line of body, jaw pores with white rim, anal-fin margin whitish, 3 pre-dorsal vertebrae, 56–59 pre-anal vertebrae and 139–150 total vertebrae. The new species differs from its known Indian water congeners by having series of lines of small dark spots present on the head and a single line of black spots on the mid-line of the body (vs. absent in all the three congeners in India), serrated teeth (vs. smooth), jaw pores with white rim (vs. black to brown in others) and higher vertebral count (139–150 vs. 134–138 in others). Our morphological and molecular analyses show that the new species forms a distinct clade from its congeners and these data support the status as a new species.

Key Words

Elopomorpha, molecular analyses, Tamil Nadu, unpatterned moray

Introduction

The family Muraenidae Rafinesque, 1810 encompasses 223 valid species under two subfamilies, Muraeninae (187 species) and Uropterygiinae (36 species), distributed throughout the tropical and subtropical seas of the world (Fricke et al. 2022). The Indo-Pacific brown unpatterned moray eels were reviewed by Böhlke (1997, 2000) and she placed 16 species under two categories, viz. elongate brown unpatterned moray and short brown unpatterned moray with eight species each. Later, six species were added to the elongate unpatterned group and three to the short unpatterned group (Mohapatra et al. 2019). Amongst these, eight brown unpatterned morays viz.

Strophidon sathete (Hamilton, 1822), *S. dorsalis* (Seale, 1917), *Gymnothorax prolatus* Sasaki & Amaoka, 1991 (Mohapatra et al. 2015), *G. mishrai* Ray, Mohapatra & Smith, 2015, *G. indicus* Mohapatra, Ray, Smith & Mishra, 2016, *G. visakhaensis* Mohapatra, Smith, Mohanty, Mishra & Tudu, 2017, *G. odishi* Mohapatra, Mohanty, Smith, Mishra & Roy, 2018 and *G. andamanensis* Mohapatra, Kiruba-Sankar, Praveenraj & Mohanty, 2019 were described or documented from the Indian waters (Mohapatra et al. 2019). During our recent sampling along the southeast coast of India, four moray eels were collected and subsequent examination suggests that the collected specimens are notably different from their congeners by having a series of dark spots on the head and mid-line of

the body (vs. absent in all the Indian water species). The present paper describes the collected specimens as a new short brown unpatterned moray eel from the Tamil Nadu waters, Bay of Bengal.

Materials and methods

Four specimens (ranging from 272–487 mm total length) were collected from the trawl bycatch landings at Mudasalodai fish landing centre (11°29'N, 79°46'E), off Cuddalore coast, Bay of Bengal, southeast coast of India (Fig. 1). The specimens were collected at a depth of about 25–30 metres. Meristic counts, morphometric measurements and terminology follow Böhlke (1989). Johnson et al. (2012) pointed out that the premaxilla is absent in all Anguilliformes, except *Protanguilla*. Meanwhile, Böhlke (1989) considered the premaxilla fused to the ethmovomer. Hence, the dentition terminology follows Böhlke (1989) with replacement of premaxillary teeth with ethmovomerine teeth. Measurements were made using a digimatic caliper to the nearest 0.1 mm. Teeth and cephalic pores were examined using Nikon SMZ1270 stereomicroscopes. Vertebral counts were obtained from the digital radiograph and these follow Böhlke (1989). The holotype and one paratype specimen were deposited in the museum of the ICAR – National Bureau of Fish Genetic Resources (NBFGR/MURGTAM), Lucknow, India and two paratype specimens were deposited in the

Estuarine Biology Regional Centre (EBRC/ZSI/F14687), Zoological Survey of India, Gopalpur-on-Sea, Odisha, India. The study area map has been prepared using the GEBCO Bathymetry data (<https://www.gebco.net/>) on the ArcMap 10.8.1 platform.

Molecular analyses

The genomic DNA was isolated using the salting-out method protocol (Sambrook and Russel 2001). A fragment of 16s rRNA (~ 550 bp) was amplified using a universal primer (Palumbi 1996) and the PCR thermal cycle was completed with the following conditions viz. initial denaturation (95 °C for 5 min), denaturation (94 °C for 30 sec), annealing (52 °C for 30 sec), extension (72 °C for 45 sec) for 35 cycles and final extension at 72 °C for 10 min. The obtained PCR results were visualised on agarose gel electrophoresis (2%) containing ethidium bromide, using Gel Doc XR+ (Bio-Rad, India) and sent for sequencing with outsources. The obtained new sequence and other sequences of the genus *Gymnothorax* retrieved from the public domain, GenBank, were aligned using clustalW Multiple alignments algorithm (Thompson et al. 2003) aiding BioEdit version 5.0.9 (Hall 1999) and the new sequence was deposited in GenBank, accession number: **OQ418115**. The Maximum Likelihood tree was reconstructed using a best-fit model of HKY+G+I (Hasegawa et al. 1985) with 1000 bootstrap replicates and the ge-

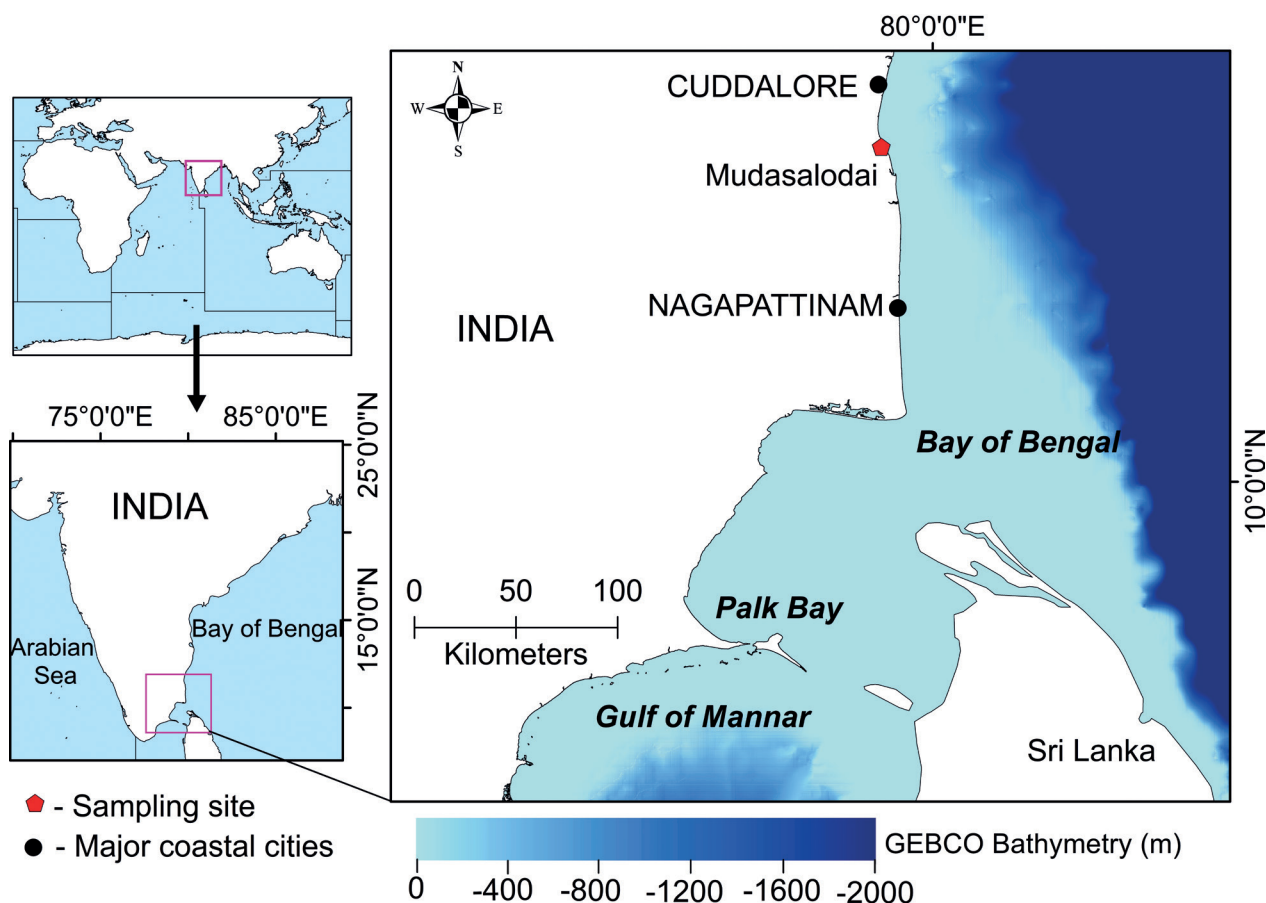


Figure 1. Map showing the collection site of the new species.

netic divergence analysed aiding the Kimura 2 parameter (Kimura 1980) in MEGA X software (Kumar et al. 2018). The sequence of *Conger cinereus* (AB910542) was used as an outgroup for the phylogenetic analysis.

Abbreviations

Total length (TL), head length (HL), supraorbital pores (SO), infraorbital pores (IO), mandibular pores (M), dorsal-fin origin (DFO), posterior nostril (PN), anterior nostril (AN), gill opening (GO), branchial pores (B), ethomovomerine (EV).

Institute acronyms

ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFGR), Zoological Survey of India (ZSI), Marine Aquarium and Regional Centre (MARC), Estuarine Biology Regional Centre (EBRC).

Comparative materials

Gymnothorax mishrai: Holotype – MARC/ZSI F4210; *Gymnothorax odishi*: Holotype – ZSI F 12592/2, Paratypes. – ZSI F 12593/2, EBRC/ZSI/F 9482, F9483, F9484, F9485, F9486, F9487, F9488, F9489, F9490. *Gymnothorax andamanensis*: Holotype – EBRC/ZSI F11227.

Results

Gymnothorax tamilnaduensis sp. nov.

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Figs 2–5, Tables 1, 2

Proposed common name: Tamil Nadu brown moray

Type material. The holotype and paratype specimens are deposited at the National Fish Repository of the ICAR-National Bureau of Fish Genetic Resources (Ministry of Agriculture and Farmers Welfare, Govt. of India). **Holotype.** NBFGR/MURGTAM (487 mm TL), collected from trawl landings at Mudasalodai fish landing centre, off Cuddalore coast, Bay of Bengal, 11°29'N, 79°46'E, 26 June 2022, coll. by G. Kantharajan and P. Kodeeswaran.

Paratypes. Three specimens, NBFGR/ MURGTAM.2 (296 mm TL); EBRC/ZSI/F14687 (2: 272–451 mm TL), were collected along with the holotype.

Diagnosis. A new species of a short brown unpatterned moray eel with the following combination of characters: series of lines of small dark spots present on head and a single line of black spots on mid-line of body, origin of dorsal fin at middle of rictus and gill opening, anus just before mid-body, pre-anal length 45.7–47.4% TL, snout blunt and very short, 6.5–7.7 mm in HL, eye small, teeth serrated, uniserial, ethomovomerine teeth five on each side with one tooth on mid-point, vomerine with eight teeth in a series, jaw pores with white rim, anal-fin margin



Figure 2. *Gymnothorax tamilnaduensis* sp. nov. holotype, NBFGR/MURGTAM, 487.8 mm TL, fresh colouration, collected from Mudasalodai fish landing centre, off Cuddalore, Bay of Bengal.

whitish, 3 pre-dorsal vertebrae, 56–59 pre-anal vertebrae, 139–150 total vertebrae.

Description (all measurements in mm). A medium-sized, moderately elongated eel with tapering body, anus just before mid-body, pre-anal length 45.7–47.4% TL, depth at gill opening 19.8–32.8 in TL, depth at anus 31.1–49.0 in TL. Head moderate, 7.8–8.2 in TL, snout blunt, and very short, 6.5–7.7 in HL, both jaws almost equal, upper jaw 2.5–3.0 in HL, lower jaw 2.4–2.8 in HL, eye small, 9.1–12.2 in HL, at middle of upper jaw, far from rictus, interorbital space 7.0–12.6 in HL. Dorsal-fin origin before gill opening, at mid-length of rictus and gill opening, pre-dorsal length 9.3–11.0 in TL, anal fin starts just after anus, gill opening a minute diagonal slit, 8.0–11.3 in HL. Teeth serrated, uniserial; five pointed ethomovomerine teeth on each side, one tooth on mid-point, three median ethomovomerine teeth, middle tooth larger than other two, maxillary teeth uniserial, 12–13 on each side, uniserial vomerine with eight teeth; lower jaw teeth uniserial, 16–17 teeth on each side, three anterior teeth enlarged (Fig. 3). Head pores moderate-sized, three supraorbital

pores, four infraorbital pores, six mandibular pores before rictus, cephalic pores in white rims. Branchial pores two behind the dorsal-fin origin (Fig. 4). Three pre-dorsal vertebrae, 56–59 pre-anal vertebrae, 139–150 total vertebrae.

Counts and measurements of the holotype in mm: TL 487.8, pre-anal length 223.1, tail length 260.7, trunk length 155, pre-dorsal length 44.4, head length 59.6, depth at anus 15.7, width at anus 12.3, snout length 9.2, eye diameter 5.7, upper jaw length 23.9, interorbital width 8.5, gill opening 6.8. Vertebral formula 3-59-150.

Colouration. In fresh condition, body uniform chocolate brown, head with numerous line marks, ventral-most portion of lower body pale, dorsal fin brown, dorsal-fin margin black, anal-fin margin whitish, head pores with white rim, series of small dark spots forming several lines on head and a single line of black spot-on mid-line of body (Fig. 2). After preservation, body tanned, series of small dark spot lines remain the same in the head and body (Fig. 5).

Distribution. Indian Ocean: off Cuddalore Coast, Bay of Bengal, southeast coast of India. The species were collected at a depth of about 25–30 metres.

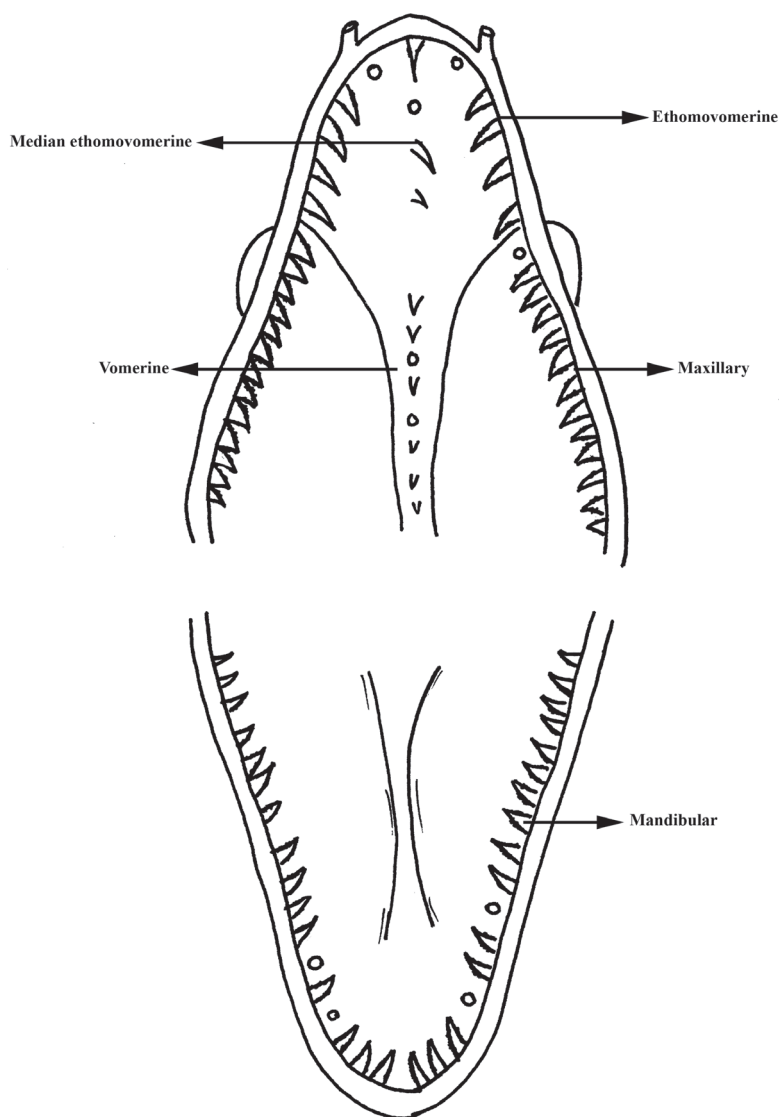


Figure 3. Dentition pattern on upper jaw and lower jaw of *Gymnothorax tamilnaduensis* sp. nov (holotype).

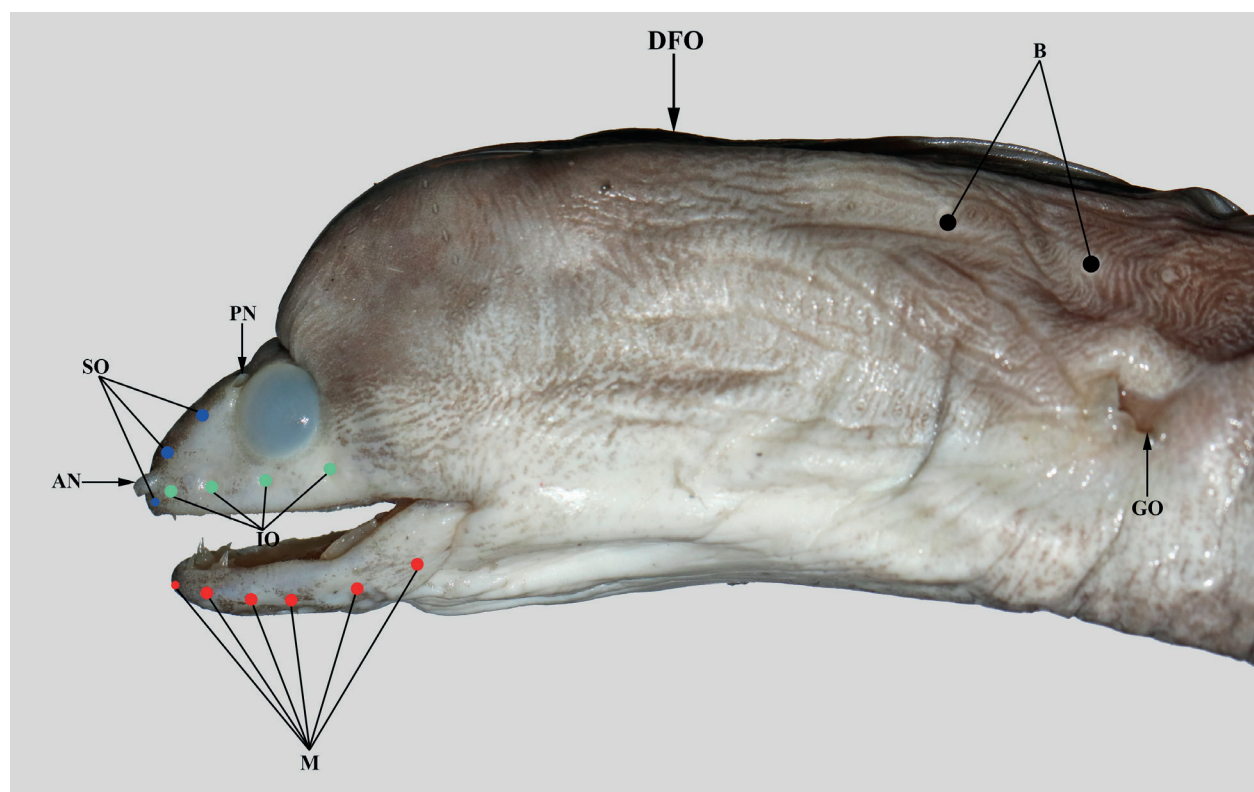


Figure 4. Lateral view of head and cephalic pores of *Gymnothorax tamilnaduensis* sp. nov. (holotype, NBFGR/MURGTAM). Supraorbital pores (SO) – Blue closed dots, Infraorbital pores (IO) – Green, Mandibular pores (M) – Red, Branchial pores (B) – Black; DFO – dorsal-fin origin, PN – Posterior nostril, AN – Anterior nostril, GO – Gill opening.

Table 1. Meristic and morphometric characters of *Gymnothorax tamilnaduensis* sp. nov. compared with other short brown unpatterned moray described from Indian waters.

	<i>Gymnothorax tamilnaduensis</i> sp. nov.				<i>G. andamanensis</i>	<i>G. mishrai</i>	<i>G. odishi</i>
	Holotype	Paratype	Paratype	Paratype	n = 2	n = 1	n = 11
Total length (mm)	487	451	296	272	325–464	324	420–700
In TL							
Pre-anal length	2.2	2.1	2.1	2.2	2.1–2.2	2.0	1.9–2.1
Predorsal length	11.0	9.3	10.9	9.5	9.9–10.8	–	8.4–10.8
Head length	8.2	7.8	8.1	8.2	8.1	6.9	6.7–7.6
Depth at gill opening	19.8	22.1	28.8	32.8	15–17.1	19.0	11.5–18.4
Depth at anus	31.1	31.8	38.7	49.0	16–19.1	24.9	17.3–24.0
In HL							
Snout length	6.5	6.7	7.4	6.6	4.4	6.5	4.3–5.4
Eye diameter	10.3	12.2	9.1	11.6	6.7–7.6	20.2	8.6–10.8
Inter-orbital space	7.0	8.2	12.6	11.1	6.7–8.8	8.7	6.0–7.9
Jaw length	2.5	2.6	2.6	3.0	2.2–2.4	2.9	2.2–2.8
Vertebrae							
Pre-dorsal vertebrae	3	3	3	3	3	9	4
Pre-anal vertebrae	59	56	56	57	57	59	56–58
Total vertebrae	150	143	139	140	135–136	134	134–138

Etymology. The species is named “*tamilnaduensis*” with reference to the state Tamil Nadu from where it was collected.

Remarks. The brown unpatterned groups of morays were divided into two groups by Böhlke (1997, 2000): the long brown unpatterned morays (> 150 vertebrae) and the short brown unpatterned morays (< 150 vertebrae). The species described herein comes under the short brown unpatterned moray. From Indian waters, only three species

of short brown unpatterned morays have been described to date (Mohapatra et al. 2019). All three short brown unpatterned morays reported from India have smooth teeth, and the new species clearly differs from all three species in having serrated teeth. The new species differs from all the Indian water short brown morays by having jaw pores with white rim (vs. black in *G. andamanensis*, brown in *G. mishrai* and dark in *G. odishi*); having more total vertebrae (139–150 vs. 135–136 in *G. andamanensis*,



Figure 5. *Gymnothorax tamilnaduensis* sp. nov. holotype, NBFGR/MURGTAM, 487.8 mm TL preserved colouration.

134 in *G. mishrai* and 133–138 in *G. odishi*); smaller snout (6.5–7.4 in HL vs. 4.4 in *G. andamanensis*, 6.5 in *G. mishrai*, 4.3–5.4 in *G. odishi*); having a distinct series of lines of small dark spots present on head and a single line of black spot on the mid-line of the body (vs. absent in all the other species).

The new species shares serrate teeth with *Gymnothorax atolli* (Pietschmann, 1935), *G. australicola* Lavenberg 1992, *G. panamensis* (Steindachner, 1876) and *G. pindae* Smith 1962, but the new species differs from the species mentioned above by having more total vertebrae (139–150 vs. 127–133 in *G. atolli*, 122–137 in *G. panamensis* and 110–124 in *G. pindae*), fewer predorsal vertebrae (3 vs. 4–6 in *G. atolli*, 5–6 in *G. australicola*, 8–12 in *G. panamensis* and 5–7 in *G. pindae*) and uniserial maxillary teeth (vs. biserial in *G. atolli*, *G. australicola* and *G. panamensis*).

Further, the new species differs from the other unpatterned morays, such as *Gymnothorax herrei* Beebe & Tee-Van, 1933, *G. kontodontos* Böhlke, 2000, *G. microstictus* Böhlke, 2000 and *G. pseudoherreii* Böhlke, 2000 by having serrate teeth (vs. smooth in all the remaining species); more total vertebrae (139–150 vs. 108–122 in *G. herrei*, 126–135 in *G. kontodontos*, 113–121 in *G. microstictus*,

110–118 in *G. pseudoherreii*); more pre-anal vertebrae (56–59 vs. 45–50 in *G. herrei*, 40–43 in *G. kontodontos*, 40–44 in *G. microstictus*, 44–50 in *G. pseudoherreii*) (Table 2).

Molecular analysis. Based on the 16s rRNA gene sequences, the new species exhibits 8.0% genetic divergence with *G. reticularis* sequences in the Kimura 2 parameter. Further, the new species exhibits 10.1% genetic divergence with *G. sagmacephalus*, followed by *G. albimarginatus* by 11.2%–12.1%, *G. castaneus* (11.9%) and *G. pictus* (12.6%). The Maximum Likelihood tree (Fig. 6) shows the new species forms a strongly distinct clade from the congeners with a high bootstrap value supporting the status as a new species.

Discussion

Moray eels are distinguished from other Anguilliformes fishes by having peculiar characters viz. absence of pectoral fins; smaller gill opening like a pore; lack of lateral-line pores (some have at the anterior end); absence of pores behind the eye and supratemporal canal; well-developed pharyngeal jaws (Smith 2012). Most of the morays are cryptic and found at shallow waters, coral reef

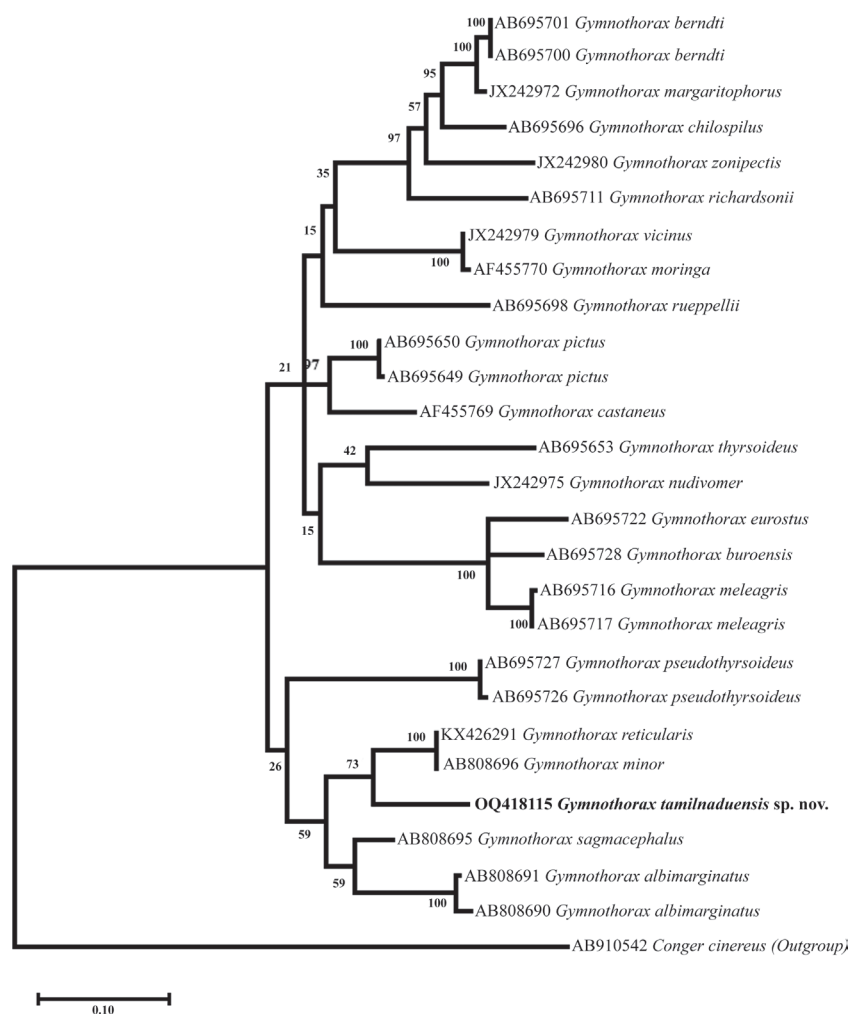


Figure 6. The Maximum Likelihood tree of the genus *Gymnothorax* plotted with a model of HKY+G+I with 1000 bootstrap replicates, based on 16s rRNA sequences (500 bp). Each node represents branch support values.

Table 2. Comparative characters from short brown unpatterned *Gymnothorax* (data obtained from Böhlke (2000) and specimens examined from India).

	<i>G. tamilnaduensis</i> sp. nov.	<i>G. andamanensis</i>	<i>G. atoll</i>	<i>G. australicola</i>	<i>G. herrei</i>	<i>G. kontodontos</i>	<i>G. microstictus</i>	<i>G. mishrai</i>	<i>G. odishi</i>	<i>G. panamensis</i>	<i>G. pindae</i>	<i>G. pseudoherrei</i>
Branchial pores	2	2	1	1	1	2	2	2	2	2	2	2
Pre-dorsal vert.	3	3	4–6	5–6	7–11	7–9	4–5	9	4	8–12	5–7	5–9
Pre-anal vert.	56–59	57	51–54	52–56	45–50	40–43	40–44	59	55–58	50–55	42–46	44–50
Total vert.	139–150	135–136	127–133	141–146	108–122	126–135	113–121	134	133–138	122–137	110–124	110–118
Jaw pores	White rim	Black rim	White rim	White rim	Pale rim	Pale rim	Brown rim	Brown rim	Dark rim	White rim	Brown rim	Brown rim
Median EV teeth	0–3	3	2	2	2–3	2	2	3	3	2	2	2
Inner EV teeth	0	3	8–14	7–12	8–15	9–13	0–7	0	0	9–12	0–10	8–21
MX teeth	Uniserial	Biserial	Biserial	Biserial	Biserial	2–3 series	1–2 series	Uniserial	Uniserial	Biserial	Uniserial	Biserial
DFO/GO	Before	Before	Before	Before	Behind	Behind	Before	Before	Before	Behind	Before	Before
VM teeth	Uniserial	Uniserial	Uniserial	Uniserial	Uniserial	2–3 series	Uniserial	Uniserial	Uniserial	Irregular	Staggered	Staggered
Teeth edge	Serrate	Smooth	Serrate	Serrate	Smooth	Smooth	Smooth	Smooth	Smooth	Serrate	Serrate	Smooth

and rocky environments, like holes and crevices for hiding and appearing outside the bolt-hole for feeding and many species were inhabiting off-shore waters and even up to 500 m depth (Smith 2012). In Indian waters, hitherto 28 species of *Gymnothorax* have been documented

(Mohapatra et al. 2020). Amongst these, eight species belong to the brown unpatterned moray group (three short unpatterned and five elongate brown unpatterned) and the remaining species are colour-patterned with spotted, barred, mottled or irregular markings. The species de-

scribed herein represents the fourth species in the short brown unpatterned moray group and increases the total amount of species of *Gymnothorax* to 29. The present description is the first new species of the genus *Gymnothorax* from the south-eastern coast of India, Bay of Bengal, whereas its congeners were described from the following locations viz. *G. andamanensis* was described from two specimens collected from Port Blair, South Andaman; *G. mishrai* was described, based on a unique holotype specimen collected from the West Bengal, northern Bay of Bengal and *G. odishi* was described from 11 specimens collected along the Odisha, north-eastern coast of India. The new species differs from its known congeners by having serrate teeth (vs. smooth in all three species), by having jaw pores with white rims and more vertebrae counts. The DNA data of most of the brown unpatterned morays from India are not available, so comparing the DNA data of the new species with all Indian brown unpatterned moray is not possible. Most of the brown unpatterned morays from India are described from less than 50 m depth, though few species were described from bycatch fishes and the depth is not certain. This species is the second brown unpatterned moray from the southern region of India, along with the earlier reported *S. sathete*. Mostly, the species of this group were landed as bycatch or trash and do not possess economic value, as well as commercial importance. Few patterned morays secure minimal position in the aquarium trade, but distinct data on the aquarium market are meagre. Hence comprehensive studies on the genus *Gymnothorax* are warranted to find the precise diversity and distribution of this group in Indian waters.

Acknowledgements

The authors are grateful to the Director of ICAR–National Bureau of Fish Genetic Resources (NBFGR), Lucknow, for providing the necessary facilities and support. A.M. thanks Dr. Dhriti Banerjee, Director of the Zoological Survey of India for providing support to carry out the work.

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Band/Volume: [99](#)

Autor(en)/Author(s): Kodeeswaran Paramasivam, Kantharajan Ganesan, Mohapatra Anil, Kumar T. T. Ajith, Sarkar Uttam Kumar

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