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Two new species of the congrid eel genus *Ariosoma* (Anguilliformes, Congridae, Bathymyrinae) from Indian waters

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Abstract

Two new species have been described from Indian waters, based on the materials collected from Kochi coast, Arabian Sea, Gulf of Mannar and West Bengal coast along the Bay of Bengal. *Ariosoma gracile* **sp. nov.** is described, based on five specimens collected from the landings at Kalamukku Fishing Harbour, Arabian Sea. The new species is characterised by longer tail, 55.3–58.7% TL; dorsal-fin origin above pectoral-fin base; no dark or whitish bands on dorsal surface of head, ventral extremities of lower jaw and mid-portion with minute dark pigmentation patch; anus positioned well before the middle of total length; SO canal with 4 pores; 0 or 3 pores on ST canal; pre-dorsal vertebrae 9; pre-anal vertebrae 49–54; total vertebrae 140–142. *Ariosoma gracile* **sp. nov.** is closely related to *Ariosoma dolichopterum* and *Ariosoma emmae* by sharing similar morphometrics and pre-anal vertebral counts. However, it differs by having more total pores (132–135 vs. 121–129 in *A. dolichopterum*, 123–126 in *A. emmae*); fewer pre-anal pores (43–46 vs. 47–51 in *A. dolichopterum*, 50–53 in *A. emmae*); more pre-dorsal pores (9 vs. 5–9 in *A. dolichopterum*, 4–6 in *A. emmae*). Another new species, *Ariosoma kannani* **sp. nov.** is described on the basis of two specimens (157–171 mm TL) from Gulf of Mannar and one specimen (201 mm TL) collected from Shankarpur Fish Landing Centre, West Bengal. This species is similar to *Ariosoma megalops*, but readily differs by having smaller eyes, smaller interorbital distance and exhibits 10.8% genetic divergence from *A. megalops* from the Taiwan waters.

Key Words

Arabian Sea, Bathymyrinae, Bay of Bengal, new eel, systematics

Introduction

The congrid eel genus, *Ariosoma* Swainson, 1838, includes 38 valid species (Fricke et al. 2023). The genus *Ariosoma* along Indian waters was known only by two species till 2021 (Roy et al. 2021). Then, extensive sampling efforts and integrative taxonomic approaches resulted in the description and documentation of an additional six species from the Indian waters (Roy et al. 2021; Kodeeswaran et al. 2021, 2022a, 2022b, 2023; Ray et al. 2022) and also Kodeeswaran et al. (2021) mentioned the existence of a few more undescribed species along the Indian waters. Following sampling along the southern coasts of India, several specimens of an unknown congrid eel were encountered as trawl by-catch, with one unidentified specimen also being collected from the northern part of the Bay of Bengal. Subsequent comparison with existing species from Indian waters suggested that the presently collected specimens were undescribed. Here, we describe two new species of *Ariosoma* from Indian

waters, based on the meristic and morphometric details with the support of molecular analyses.

Materials and methods

Sampling, morphometric and meristic analyses

Eel samples were collected from different landing centres along the India coast viz. Kalamukku Fishing Harbour (9°59'N, 76°14'E), off Kerala coast, west coast of India, Arabian Sea and Rameshwaram Fish Landing Centre (9°16'N, 79°18'E), Tamil Nadu, Gulf of Mannar, east coast of India, Bay of Bengal and Shankarpur Fish Landing Centre, West Bengal, Bay of Bengal, India. Fresh photographs were taken with a Canon 80D Digital Single-Lens Reflex camera (EF-S 18–135mm f/3.5-f/5.6 IS USM Kit Lens) and a small portion of muscle and pectoral fin-clips were incised and preserved in 99.9% ethanol for phylogenetic analyses. Collected specimens were preserved in 10% formaldehyde for taxonomical studies and deposited in the National Fish Museum and Repository of the ICAR–National Bureau of Fish Genetic Resources (NBFGR), Lucknow, India and Estuarine Biology Regional Centre (EBRC), Zoological Survey of India, Gopalpur-on-Sea, Odisha, India.

Morphometric measuring and meristic counting follow Smith and Kanazawa (1977) and Smith (1989) using a Digimatic caliper with accuracy to 0.1 mm. Vertebral counting follow Böhlke (1982) with the help of digital radiographs. Head pores abbreviations are: IO, infraorbital; POM, pre-opercular-mandibular; SO, supraorbital; ST, supratemporal. Details of the comparative material are listed in the "Comparative material examined" section.

Molecular analyses

The DNA isolation, PCR cycle conditions and mtDNA gene amplifications were done, based on the methods followed in Kodeeswaran et al. (2021; 2022a). The obtained PCR products were sent out for sequencing with outsources. Newly-generated sequences were edited and aligned manually using clustalW Multiple alignments implemented in BioEdit version 5.0.9 (Hall 1999) with other sequences retrieved from the public domain (GenBank). Pair-wise distance, nucleotide diversity, nucleotide composition and transition transversion bias (R) were estimated using the Kimura 2 parameter (K2P) model in MEGA X (Kumar et al. 2018). The Maximum Likelihood (ML) phylogenetic tree was reconstructed using IQ-TREE software v.1.6.12 (Nguyen et al. 2015) with the best-fit model: HKY+F+I+G4 chosen according to the BIC score: 8550.210 using ModelFinder (Kalyaanamoorthy et al. 2017) with ultrafast bootstrap (1000 bootstrap replicates) (UFBoot) (Hoang et al. 2018) and the tree diagram was constructed aided by the Interactive Tree Of Life v.5 (Letunic and Bork 2021). *Japonoconger proriger* (MF956462) and *Uroconger lepturus* (ON799405) sequences were used as outgroups for reconstructing the phylogenetic tree.

Comparative materials examined

***Ariosoma albimaculatum*.** NBFGR/CONAALB, holotype, (487 mm TL); paratypes (nine specimens), NBFGR/CONAALB.1–9 (5: 305–401 mm TL), collected from deep-sea trawl by-catch, Colachel Fishing Harbour, off Kanyakumari, Arabian Sea.

***Ariosoma bengalense*.** F12898, holotype (304 mm TL), collected from Petua Ghat, West Bengal, India from the depth of 168 m; EBRC/ZSI/F12899, paratype (216 mm TL), data same as holotype.

***Ariosoma gnanadossi*.** ZSI F7146/2, holotype (283 mm TL), collected from the depth of 250 m, off Madras, east coast of India, Bay of Bengal.

***Ariosoma indicum*.** NBFGR/CONAIND, holotype (362 mm TL); NBFGR/CONAIND.1–2 (2: 355–371 mm TL), EBRC/ZSI/F13597 (2: 337–438 mm TL); NBFGR/CONAIND.3–9 (7: 335–433 mm TL) taken with holotype, all collected from Kalamukku Fishing Harbour, Kochi, Arabian Sea. EBRC/ZSI/F13604 (7: 223–356 mm TL) non-types, collected from Digha Mohana, West Bengal, Bay of Bengal.

***Ariosoma majus*.** EBRC/ZSI/F 11528 (2 specimens: 246–290 mm TL) collected from Deshpran Fishing Harbour, West Bengal, east coast of India, Bay of Bengal.

***Ariosoma maurostigma*.** NBFGR/CONAMAUR, holotype (233 mm TL); NBFGR/CONAMAUR.1–3, paratypes, (3: 202–295 mm TL), NBFGR/CONAMAUR.4 (1: 229 mm TL) taken with holotype. NBFGR/CONAMAUR.5 (15: 181–292 mm TL); EBRC/ZSI/F12905, (4: 206–273 mm TL) all collected from Kalamukku Fishing Harbour, Kochi, Arabian Sea.

***Ariosoma melanospilos*.** NBFGR/CONAMEL, holotype (302 mm TL), Colachel Fishing Harbour, southwest coast of India, Indian Ocean. ZSI F 14502/2, paratype (296 mm TL) same collection details as holotype. EBRC/ZSI/F14040, Colachel Fishing Harbour, southwest coast of India, Indian Ocean.

***Ariosoma* sp.** NBFGR/CONATHO, (440 mm TL), Thoothukudi Fishing Harbour, southeast coast of India, Bay of Bengal.

Results

***Ariosoma gracile* Kodeeswaran, Kathirvelpandian, Mohapatra, Kumar & Sarkar, sp. nov.**

https://zoobank.org/757F2921-E865-4B92-B363-F7C90DB2E241

Figs 1a, 2a, 3, 4, Table 1

Proposed common name: Slender Conger eel

Type material. *Holotype*. NBFGR/CONACOM, 241 mm TL, collected from deep-sea trawl by-catch, Kalamukku Fishing Harbour, off Kerala coast, Arabian Sea, 9°59'N, 76°14'E, P. Kodeeswaran, 19 February 2021.

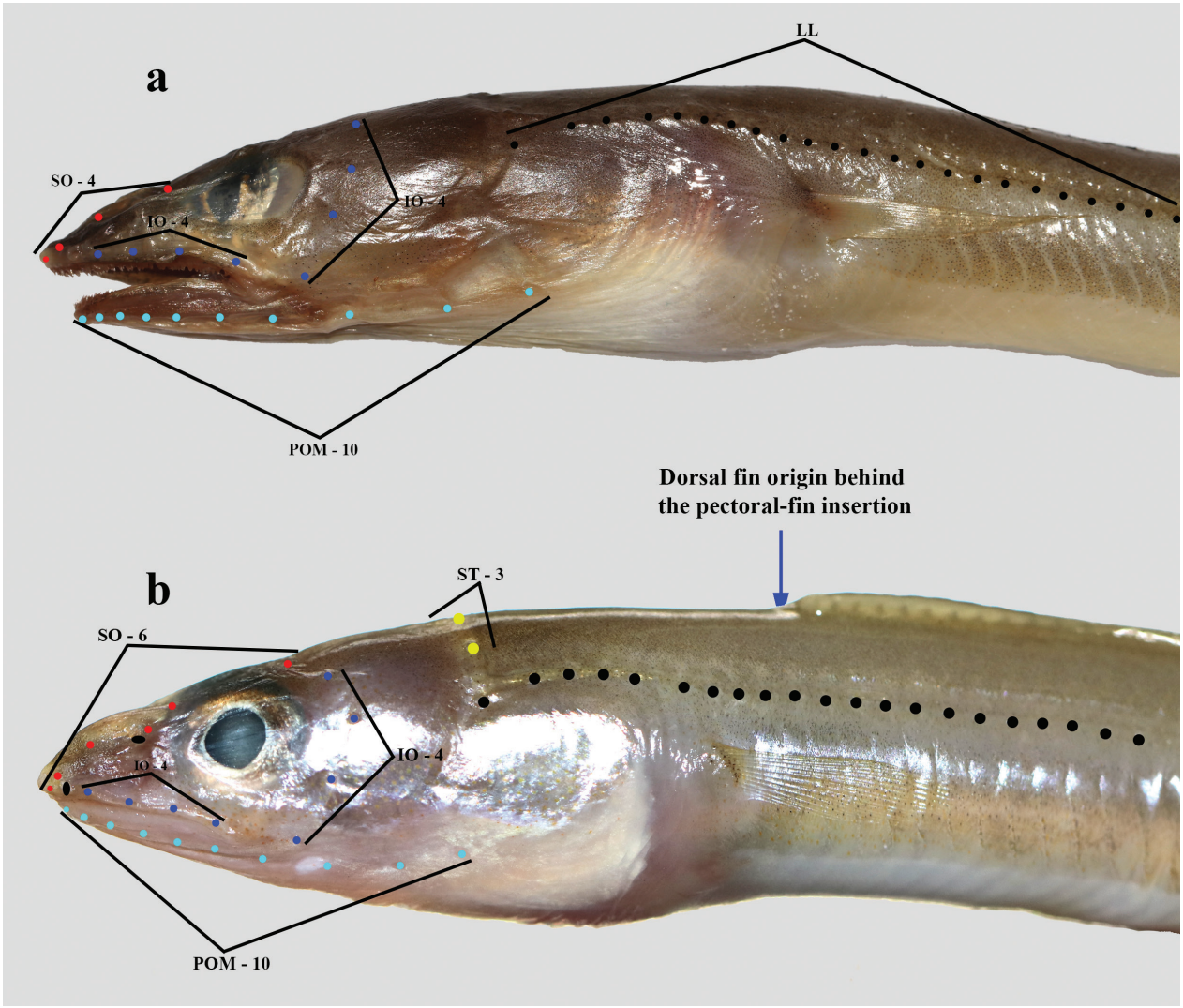

Figure 1. Image showing the head pores and anterior lateral-line pores. **a.** *Ariosoma gracile* sp. nov., NBFGR/CONACOM, holotype (241 mm TL); **b.** *Ariosoma kannani* sp. nov., NBFGR/CONAKAN, holotype, (171 mm TL).

Paratypes. NBFGR/CONACOM.1–2, (2:197–199 mm TL) and EBRC/ZSI/F15709 (2: 206–221 mm TL) taken with holotype.

Diagnosis. A medium-sized slender eel species of *Ariosoma* distinguished from all other species by the following combination of characters: position of anus well-before middle of total length, pre-anal length 43.7% (41.3–44.7%) of TL; tail longer, 55.3–58.7% TL; dorsal-fin above pectoral-fin base; no dark or whitish bands on dorsal surface of head, ventral extremities and mid-portion of lower jaw with minute dark pigmentation patch; short vomerine teeth patch with three or four rows of pointed teeth in anterior portion, intermaxillary teeth patch curved, slightly upturned at anterior end, clearly visible when mouth closed, separated from vomerine and maxillary teeth by a definite gap; SO canal with 4 pores; 0 or 3 pores on ST canal; pre-dorsal vertebrae 9 (9); pre-anal vertebrae 48 (49–54); total vertebrae 141 (140–142).

Description (dimensions in mm). Morphometric and meristic data are provided in Table 1. HL 5.9 (5.5–5.7) in TL; pre-anal length 2.3 (2.2); pre-dorsal length 5.7 (5.6–5.8); trunk length 4.9 (4.1–4.6); tail length 1.7 (1.8); and depth at gill opening 18.2 (18.1–23.4). Snout length 5.1 (4.7–5.3) in HL; eye diameter 5.8 (5.4–6.4); interorbital width 9.9 (8.5–14.9); upper jaw 3.4 (3.1–3.6); gill opening width 5.8 (5.6–9.6); interbranchial width 8.8 (8.0–11.3); and pectoral fin 2.9 (2.7–3.7).

Body slender, cylindrical anterior portion, followed by more laterally compressed caudal portion; tip of caudal fin stiff and blunt or conical; anus positioned well-before mid-point of total length, pre-anal length 43.7% (41.3–44.7%) of TL; dorsal-fin origin above pectoral-fin base, above ninth lateral-line pores, confluent with caudal and anal fin. Origin of anal fin just after anus. Pectoral fin developed, with narrow base and pointed distally. Gill opening medium, slightly larger or equal to eye diameter, its upper origin reaching nearly upper half of pectoral-fin base; interbranchial width smaller than gill opening and eye diameter.

Head fairly large 5.9 (5.5–5.7) in TL, snout very short, anteriorly pointed in dorsal view, its length 1.1 (1.1–1.2) times eye diameter, projecting beyond lower jaw; length of snout relatively shorter than lower jaw; fleshy portion of snout projecting anteriorly beyond the end of

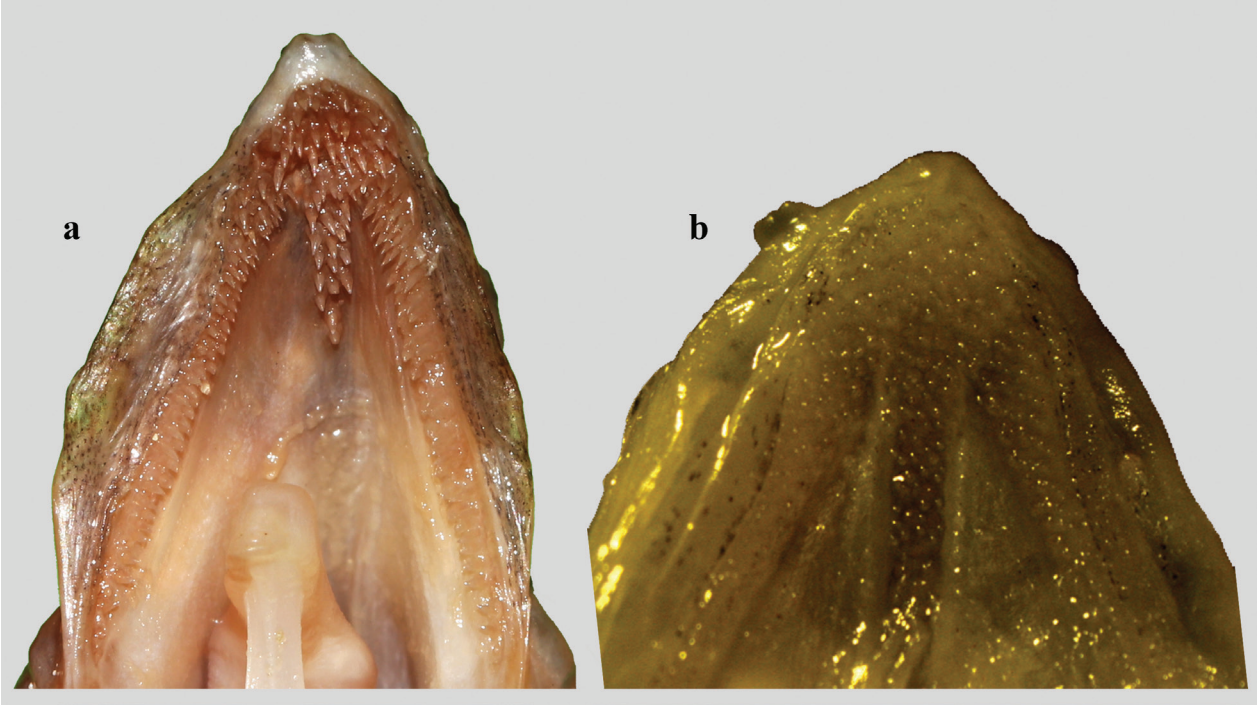

Figure 2. Dentition of upper jaw. **a.** *Ariosoma gracile* sp. nov., NBFGR/CONACOM, holotype (241 mm TL); **b.** *Ariosoma kannani* sp. nov., NBFGR/CONAKAN, holotype, (171 mm TL).

intermaxillary tooth patch; rictus positioned just before middle length of eye. Fairly large tubular anterior nostril at tip of snout and relatively large elliptical pore of posterior nostril in front of mid-eye orbit diameter. Upper and lower jaw with slightly reduced flange. Tongue short and narrow; anterior portion free from mouth with conical or blunt tip.

Lateral-line pores complete; first pore commences moderately at level of supratemporal canal and terminating well before caudal-fin base; 9 (9) pre-dorsal pores; 43 (43–46) pre-anal pores and 132 (132–138) total pores.

Head pores moderate, few pores rather small. SO canal with 4 pores; first (ethmoidal) relatively small, on ventral side of snout tip; second pore medium-sized, in front of anterior nostril; third pore enlarged, on dorsal surface of snout just behind anterior nostril; fourth pore circular and enlarged, no pores in interorbital portion. IO canal with 8 (4+4) pores, first pore large, behind anterior nostril; second pore below posterior end of posterior nostril; third pore below anterior eye-orbit margin; fourth pore at above or slightly before rictus, below mid-eye; fifth pore behind rictus, at posterior margin of eye and 3 pores at infraorbital canal behind eye. POM pores 10; 7 in mandibular section, 6 before rictus and 1 behind rictus; pre-opercular section with 3 pores in a longitudinal row. Small-sized ST pores 0 or 3, (holotype and one paratype does not possess ST pores, 2 specimens with 3 pores and one specimen with 2 pores) (Fig. 3).

Pre-dorsal vertebrae 9 (9); pre-anal vertebrae 48 (49–54); total vertebrae 141 (140–142).

Teeth larger, conical or pointed (no blunt teeth) (Fig. 2a). Curved intermaxillary teeth patch with three or four transverse rows, clearly visible when mouth closed, anterior portion fairly upturned, separated from vomerine and maxillary teeth by a definite gap. Maxillary and mandibular teeth continuous in bands; anterior part of maxillary teeth narrow with three rows, middle portion with two rows, innermost and outermost teeth pointed or conical, followed by uniserial pointed teeth posteriorly. Mandibular teeth wider anteriorly and narrower posteriorly. Vomerine teeth form a short patch, reaching in front of posterior nostril, three or four rows with pointed teeth in anterior portion, followed by four irregular triserial pointed teeth and two conical teeth in a series posteriorly.

Colour (in fresh specimens). Body often bicolour, dark brownish to paler, upper half almost darker and paler ventrally; very minute dark pigmentations irregularly spread over body. Dorsal and anal fin creamy-white with thin black margin; caudal fin dull white with black upper and lower margins (Fig. 1). Head same as body, dorsal surface of head without any dark or whitish bands, extremities of lower jaw under surface and mid-portion with minute dark pigmentation patch (Fig. 4b, c). Eyes bright with dark pupil, surrounded by thick pale golden-yellowish ring. Pectoral fin goldish-yellow (Fig. 4a). Colour in formalin slightly darker than fresh material or almost beige; pectoral fin translucent. Dark pigmentation patch remains on the ventral head.

Distribution. Known from five specimens collected from trawl by-catches landings at Kalamukku Fishing Harbour, off Kerala, south-western Indian coast, Arabian Sea, western Indian Ocean.

Etymology. From the Latin word, '*gracilis* - *gracile*' meaning slender, which denotes the slender-bodied eel.

Figure 3. *Ariosoma gracile* sp. nov., NBFGR/CONACOM, holotype (241 mm TL) fresh colouration. Scale bar: 40 mm.

Comparisons. *Ariosoma gracile* differs from all the congeners but shares similar morphological characters and overlapping pre-anal vertebrae counts with *Ariosoma dolichopterum* Karmovskaya, 2015 from the South China Sea, off Vietnam and Taiwan and *Ariosoma emmae* Smith & Ho, 2018 from Taiwan waters. *Ariosoma gracile* differs from these congeners by having: 132–135 total pores (vs. 121–129 in *A. dolichopterum*, 123–126 in *A. emmae*); 43–46 pre-anal pores (vs. 47–51 in *A. dolichopterum*, 50–53 in *A. emmae*); 9 pre-dorsal pores (vs. 5–9 in *A. dolichopterum*, 4–6 in *A. emmae*); more total vertebrae (140–142 vs. 129–134 in *A. dolichopterum*, 127–133 in *A. emmae*); trunk 38.5–42.6% TL (vs. 26.6–29.8% TL in *A. dolichopterum*, 28.9–32.7% TL in *A. emmae*); short vomerine tooth patch (vs. long in *A. dolichopterum* and *A. emmae*) (Karmovskaya 2015; Smith et al. 2018).

Ariosoma gracile differs from the Indian water congeners, such as *Ariosoma gnanadossi* Talwar & Mukherjee, 1977, *Ariosoma melanospilos* Kodeeswaran, Jayakumar, Akash, Kumar & Lal, 2021, *Ariosoma albimaculatum* Kodeeswaran, Dhas, Kumar & Lal, 2022 and *Ariosoma* sp. nov. Kodeeswaran et al. (in press) in having fewer total vertebrae (140–142 vs. 161–164 in *A. albimaculatum*; 146 in *A. gnanadossi*; 144–153 in *A. melanospilos*; 162–163 in *Ariosoma* sp. nov.); fewer total pores (132–135 vs. 145 in *A. gnanadossi*; 136–144 in *A. melanospilos*; 148–155 in *Ariosoma* sp. nov.). The new species shares similar vertebral counts with *Ariosoma maurostigma* Kodeeswaran, Mohapatra, Dhinakaran, Kumar & Lal, 2022, but readily differs from the latter by the absence of a dark spot on posterior-dorsal margins of eye orbit (vs. present in *A. maurostigma*); tail longer (55.3–58.7% TL vs. 47.8–54.6% TL); shorter pre-anal length (41.3–44.7% TL vs. 44.0–48.8% SL); fewer SO pores (4 vs. 6). Further, the new species differs from *Ariosoma majus* (Asano, 1958) in having more pre-dorsal pores (9 vs. 6–7 in *A. majus*); fewer pre-anal pores (43–46 vs. 50–53); fewer total pores (132–135 vs. 139–142); smaller depth at gill opening (4.3–5.5% TL vs. 6.7–7.3% TL); fewer SO pores (4 vs. 6). Further, the new species shares overlapping vertebral counts with newly-described sympatric species *Ariosoma indicum* Kodeeswaran, Kathirvelpandian, Acharya, Mohanty, Mohapatra, Kumar & Lal, 2022, but the new species differs from the latter in having shorter pectoral fin (26.8–36.9% HL vs. 37.5–46.7% HL in *A. indicum*); smaller interorbital width (6.7–11.8% HL vs. 11.8–15.7% HL); fewer SO pores (4 vs. 5); ST pores (0 vs. 3); pectoral fin grey (vs. blackish or bicoloured).

Figure 4. Lateral (**a**); Dorsal (**b**); Ventral (**c**) view of *Ariosoma gracile* sp. nov., NBFGR/CONACOM, 241 mm TL. Scale bar: 10 mm.

The new species differs from the species viz. *Ariosoma anago* (Temminck & Schlegel, 1846), *Ariosoma anale* (Poey, 1860), *Ariosoma fasciatum* (Günther, 1872), *Ariosoma meeki* (Jordan & Snyder, 1900), *Ariosoma howensis* (McCulloch & Waite, 1916), *Ariosoma shiroanago* (Asano, 1958), *Ariosoma coquettei* Smith & Kanazawa, 1977, *Ariosoma kapala* (Castle, 1990), *Ariosoma ophidiophthalmus* Karmovskaya, 1991, *Ariosoma multivertebratum* Karmovskaya, 2004, *Ariosoma sazonovi* Karmovskaya, 2004, and *Ariosoma sereti* Karmovskaya, 2004 and in having fewer total vertebrae (140–142 vs. 143–144 in *A. anago*; 146–150 in *A. anale*; 155–158 in *A. fasciatum*; 144–155 in *A. meeki*; 151–161 in *A. howensis*; 161–162 in *A. shiroanago*; 152–160 in *A. coquettei*; 147 in *A. kapala*; 150–153 in *A. ophidiophthalmus*;

Table 1. Meristic and morphometrics of *Ariosoma gracile* from Arabian Sea and *Ariosoma kannani* from the Gulf of Mannar, Bay of Bengal.

	***Ariosoma gracile* sp. nov.**		***Ariosoma kannani* sp. nov.**	
	Holotype	**Paratypes**	**Holotype**	**Paratypes**
Total length (mm)	241	197–221 (n = 4)	173	157–201 (n = 2)
%TL				
Head length	17.6	17.1–18.2	16.0	16.1
Depth at gill opening	5.0	4.3–5.5	6.4	5.4–6.1
Depth at anus	4.5	3.4–5.0	6.7	6.2–6.3
Width at anus	3.6	3.2–4.0	4.9	4.7–4.9
Pre-dorsal length	17.6	17.2–17.9	18.9	17.5–17.2
Pre-anal length	43.7	41.3–44.7	46.9	46.0–47.2
Trunk length	22.5	20.3–24.4	28.0	28.0–27.9
Tail length	56.3	55.3–58.7	53.1	52.8–54.0
%HL				
Snout length	19.8	18.7–21.4	20.8	17.7–18.1
Eye diameter	17.4	15.7–18.4	21.1	20.7–20.9
Interorbital width	9.6	6.7–11.8	8.9	10.7–8.5
Upper jaw length	29.5	27.6–31.8	29.5	23.7–28.5
Gill opening width	15.4	10.4–18.0	12.8	10.0–10.8
Interbranchial width	10.4	8.8–12.5	21.5	14.4–14.1
Pectoral-fin length	32.9	26.8–36.9	37.0	29.5–37.4
Meristics				
Pre-dorsal vertebrae	9	9	10	10
Pre-anal vertebrae	48	49–52	45	45–48
Total vertebrae	141	140–142	116	118–116
Lateral-line pores				
Pre-dorsal pores	9	9	11	10
Pre-anal pores	43	43–46	45	47
Total pores	132	133–135	110	111–110

183–189 in *A. multivertebratum*; 146–148 in *A. sazonovi*; 168–172 in *A. sereti*; *Ariosoma gracile* differs from *Ariosoma balearicum* (Delaroche, 1809), *Ariosoma megalops* Fowler, 1938, *Ariosoma scheelei* (Strömman, 1896) and *Ariosoma sokotranum* Karmovskaya, 1991 in having more vertebrae (140–142 vs. 121–135 in *A. balearicum*; 114–118 in *A. scheelei*; 136–141 in *A. sokotranum*).

Remarks. The specimens were directly preserved in formalin; hence this could not be included in the molecular analyses.

Ariosoma kannani Kodeeswaran, Kathirvelpandian, Ray, Kumar, Mohapatra & Sarkar, sp. nov.

https://zoobank.org/AF62080E-7DF4-43AE-BF0C-D83C0440E8AA

Figs 1b, 2b, 5, Table 1

Type material. ***Holotype.*** NBFGR/CONAKAN (171 mm TL), Rameshwaram Fish Landing Centre, Tamil Nadu, Gulf of Mannar, east coast of India, Bay of Bengal (9°16'N, 79°18'E), Coll. P. Kodeeswaran and A. Kathirvelpandian, 4 February 2022.

Paratype. EBRC/ZSI/F15710 **(**157 mm TL**)** taken with holotype, EBRC/ZSI/F15711 **(**201 mm TL**),** Shankarpur Fish Landing Centre, West Bengal, Coll. Dipanjan Ray, 10 November, 2021.

Diagnosis. A small-sized slender eel species of *Ariosoma* distinguished from all other species by the following combination of the characters: dorsal-fin origin behind pectoral-fin insertion, pre-anal length 46.0–47.2% of TL, smaller eye, 20.7–21.1% HL, smaller interorbital distance, 8.9–10.7% HL, no distinct bands on head, pre-opercle whitish, teeth on jaw small, pointed, intermaxillary and vomerine teeth continuous, short vomerine tooth patch; SO canal with 6 pores; 3 pores on ST canal; pre-dorsal vertebrae 10 (10); pre-anal vertebrae 45 (45); total vertebrae 116 (118).

Description. Body stout, anterior portion cylindrical, laterally compressed in tail region; caudal fin tip rounded; anus positioned at mid-point of body, pre-anal length 46.0–47.2% of TL; dorsal-fin origin behind pectoral-fin insertion, above tenth to eleventh lateral-line pores. Pectoral-fin developed, with a narrow base and round or blunt distally. Gill opening small, smaller than eye diameter, interbranchial width larger than gill opening and smaller than eye diameter.

Head moderately large 6.0 (5.5) in TL, snout short, anteriorly pointed in dorsal view, its length 1.1 times eye diameter, projecting beyond lower jaw; snout length shorter than lower jaw; fleshy portion of snout projecting anteriorly beyond the end of intermaxillary tooth patch; rictus positioned just behind middle length of eye. Tubular anterior nostril moderate in size at snout tip and posterior nostril relatively large elliptical pore, in front of mid-eye orbit diameter. Upper and lower jaw with reduced flange.

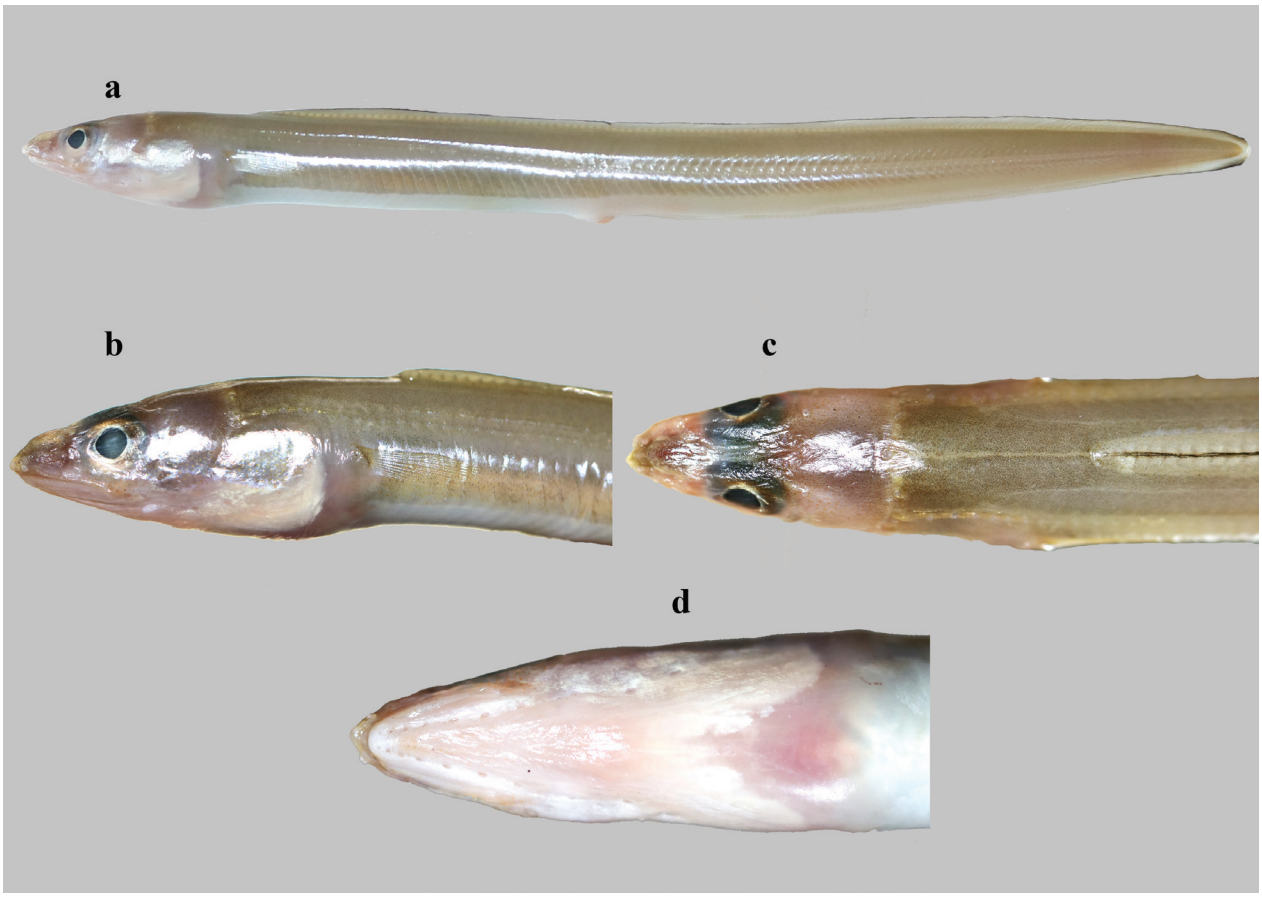

Figure 5. *Ariosoma kannani* sp. nov., NBFGR/CONAKAN, holotype, (171 mm TL). **a.** Lateral view; **b.** Lateral; **c.** Dorsal; **d.** Ventral view of anterior portion of head.

Lateral-line pores complete; first pore commences at level of supratemporal canal and terminates well before base of caudal fin; 10–11 pre-dorsal pores; 45–47 pre-anal pores and 110–111 total pores.

Head pores medium or small. SO canal pores 6; first pore (ethmoidal) smaller, on snout tip; second pore medium, just before anterior nostril; third pore enlarged, on dorsal surface of snout just behind anterior nostril; fourth pore moderate, behind posterior nostril; fifth pore smaller, at anterior interorbital space; sixth pore small at posterior interorbital space. IO canal pores 8 (4+4), first pore moderate, behind anterior nostril; second pore below posterior nostril; third pore below just before orbit eye-orbit margin; fourth pore at slightly before rictus, fifth pore behind rictus and 3 pores at infraorbital canal behind eye. POM pores 10; mandibular section with 7, pre-opercular section with 3 pores in a longitudinal row. ST pores 3, 1 median pore and 1 lateral pore on each side just behind median pore (Fig. 1b).

Teeth on jaws small, pointed; continuous maxillary and intermaxillary teeth; intermaxillary and vomerine teeth continuous; vomerine teeth pointed anteriorly and blunt posteriorly, reach beyond mid-maxillary teeth row (Fig. 2b).

Pre-dorsal vertebrae 10, pre-anal vertebrae 45–48; total vertebrae 116–118.

Colouration. Dorsal body pale brownish; ventral half above anus whitish; dorsal fin margin black; anal fin clear; pre-opercle whitish; head brownish; interorbital region black; pectoral-fin translucent; ventral surface of lower jaw whitish without any black pigmentation (Fig. 5).

Distribution. Indian Ocean: Gulf of Mannar, Bay of Bengal probably widespread in the east coast of India, but rare in catch.

Etymology. The species was named after the late Prof. Dr. L. Kannan, Former Director, CAS in Marine Biology, Annamalai University and Former Vice Chancellor, Thiruvalluvar University for his contribution in Marine Science.

Comparison. *Ariosoma kannani* is closely related to *Ariosoma megalops* from China, Taiwan and Vietnam waters in having the dorsal-fin origin behind the pectoral-fin insertion and similar vertebral counts, but the new species readily differs by having smaller interorbital distance (8.9–10.7% HL vs. 12.1–18.4% HL in *A. megalops*) and smaller mean eye diameter (20.9% HL vs. 22.8–22.9% HL) and the new species show 10.8% genetic divergence from *A. megalops* from the Taiwan waters. The new species shares similar vertebral counts with *Ariosoma scheelei*, a widely distributed species in Indo-West Pacific, but *A. kannani* can be easily distinguished from *A. scheelei* by having fewer POM pores (10 vs. 12 in *A. scheelei*) (Smith et al. 2018) and shows 19.4% genetic differences.

Further, *A. kannani* differs from all the Indian water congeners by having fewer total vertebrae (116–118 vs. 121–164 in others) and dorsal-fin origin behind pectoral-fin insertion (Kodeeswaran et al. 2021, 2022a, 2022b, 2023; Ray et al. 2022).

Molecular analyses

Out of 548 bp studied, conserved and variable sites were found to be 348 bp, 200 bp long, respectively. Amongst variable sites, parsimony informative sites constitute 190 bp, wherein a singleton with 10 bp. The nucleotide composition was found to be A = 26.1%; T = 30%; C = 25.2%; G = 18.7. The transition and transversion bias (R) was documented using substitution patterns and rates were ascertained using the Kimura 2 Parameter model. The obtained R value of 7.48, clearly indicate the sequences of the species used for analyses are delineated in a proper manner. The R value supports the findings of genetic divergence values and phylogenetic tree analyses.

The Maximum Likelihood tree (Fig. 6), obtained using the sequences generated for the new species *Ariosoma kannani* along with other sister species, confirms the species identification as the new species forms a separate cluster and is closely related to the sequences of *Ariosoma megalops* from the Taiwan waters with 10.8% genetic divergence. Further, the new species *A. kannani* exhibits 16.3% distance with the sequences of *Ariosoma kapala*, 17.6% with *A. bowersi*, 18.9% with *A. shiroanago*, 19.2% with *A. balearicum* and 19.3% with *A. anago*.

Discussion

At present, 40 species of the genus *Ariosoma* were described (Fricke et al. 2023 and this study), with at least 74% (31 species) of all species of this genus being described or identified from the Indo-West Pacific, seven species distributed along the Atlantic Ocean and two from the eastern Pacific Ocean (Smith and Kanazawa 1977; Karmovskaya 1991, 2004, 2015, 2018; Shen 1998; Smith et al. 2018; Roy et al. 2021; Kodeeswaran et al. 2021, 2022a, 2022b, 2023; Fricke et al. 2023) and doubtlessly there will be many undescribed species to be discovered. Very few species of the genus *Ariosoma* exhibit an endemic distributional range like a specific locality or around several islands, for example, *Ariosoma bauchotae* Karrer, 1983 collected around western Madagascar (Smith 1989; Fricke et al. 2018); *Ariosoma emmae* Smith

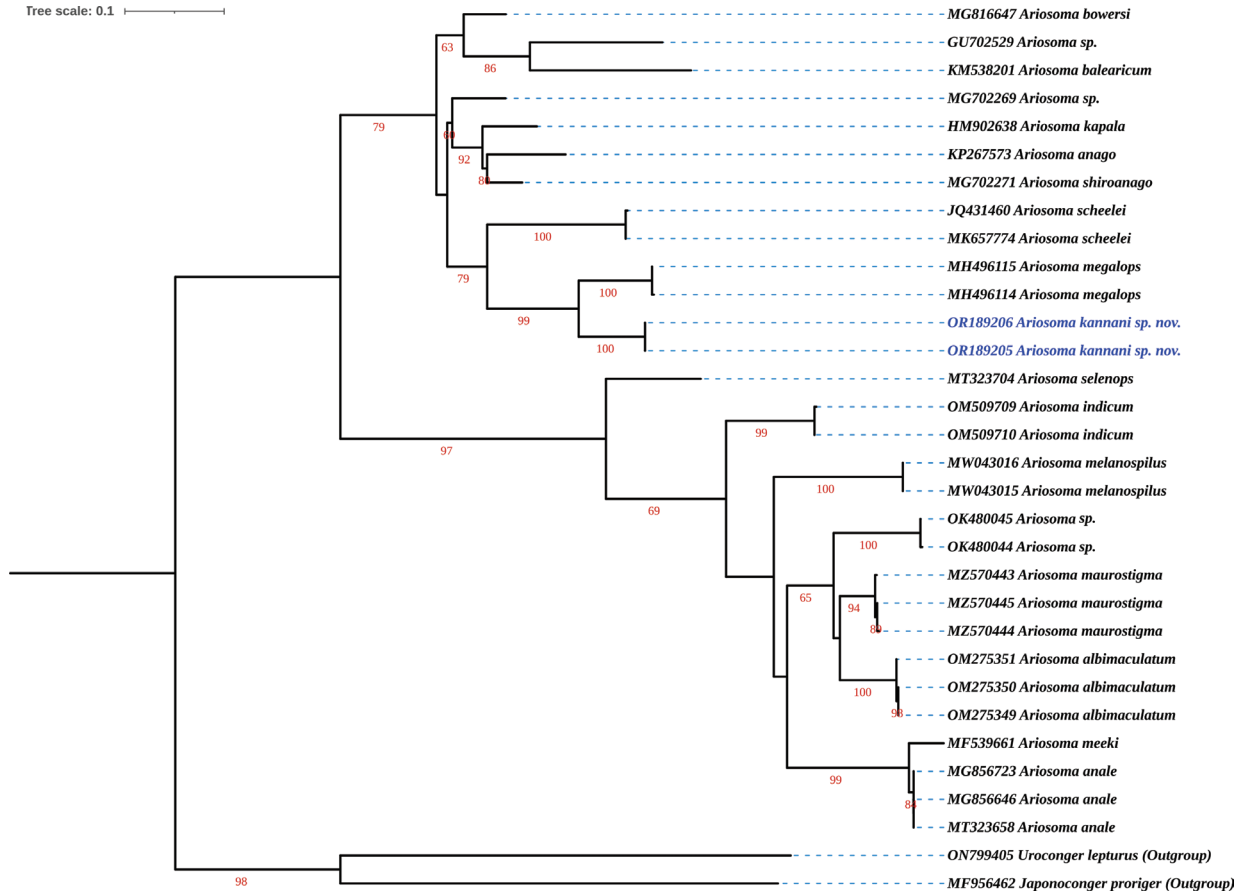

Figure 6. Maximum Likelihood phylogeny tree of the genus *Ariosoma* from analysis of cytochrome c oxidase subunit I gene, including new species, *Ariosoma kannani* collected from the south Indian coast, based on the IQ-Tree. The ML tree was plotted with the HKY+F+I+G4 model using ModelFinder (Kalyaanamoorthy et al. 2017). Each node is labelled with a GenBank accession number and support values (bootstrap probability) are indicated along branches.

& Ho, 2018, known only from Taiwan (Smith et al. 2018); *Ariosoma hemiaspidus* (Wade, 1946), described from the Gulf of California, Mexico (McCosker and Rosenblatt 2010); *Ariosoma mellissii* (Günther, 1870), endemic to Saint Helena, southern-central Atlantic (Smith 2016); *Ariosoma multivertebratum* Karmovskaya, 2004, known only from Marquesas Islands (Karmovskaya 2004; Delrieu-Trottin et al. 2015); *Ariosoma sereti* Karmovskaya, 2004, described only from Hiva Oa Island, Marquesas Islands (Karmovskaya 2004); and *Ariosoma sazonovi* Karmovskaya, 2004, collected and described only from the Philippines (Karmovskaya 2004); these species were known and described only from holotypes or with very few paratypes. Amongst the ten species from Indian waters, *A. majus* was recorded by Roy et al. (2021) along the east coast of India in the Bay of Bengal showing that *A. majus* was widely distributed in the Indo-Pacific. The new species, *Ariosoma kannani* was collected from two different localities from the Bay of Bengal, which might indicate a wider distributional range, but it is rare in landings. Further, *A. indicum* shows a continuous distribution along the coast of the Arabian Sea and Bay of Bengal. The species, *A. albimaculatum* and *A. melanospilos* were previously known only from type locality, but the first author found plenty of specimens in deep-sea trawl landings at Kollam coast, Arabian Sea.

The phylogenetic analyses of this study was based on only one marker due to availability of comparative sequences in public domain. Phylogenetic analyses for most of the species of the genus *Ariosoma* was meagre, hence vast sampling is needed to fulfil the complete genomics of these congrid eel groups. Furthermore, most eels do not possess economic value and are landed mostly as bycatch and sampling on this group was very rare in Indian waters (Kodeeswaran et al. 2021), but extensive sampling is a prerequisite to understand the complete aspects of this conger eel group's biodiversity along the Indian coast. In addition, species in the genus *Ariosoma* dwell in unusual habitats like continental slopes and underwater seamounts (Shen 1998; Karmovskaya 2018) making them rare in landings. Based on our analyses and results, it suggests that future surveys (sampling and collections) will be extended along the entire coast of India including the islands and may reveal many new species which additionally afford detailed insights into the diversity, ecology and evolution of the *Ariosoma* species.

Authors contribution

PK collected, identified, examined the specimens and prepared the manuscript. PK and AK performed molecular analyses and revised the manuscript. AM identified, examined the specimens and revised the manuscript. DR collected and identified specimens from West Bengal. TTA and CR revised the manuscript. UKS provided comprehensive guidance and supported the work. All authors read and approved the final version of the manuscript.

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