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Integrative taxonomy of genus *Strongylura* van Hasselt, 1824 (Belonidae) from Indian waters

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Original Article

Abstract

The genus *Strongylura* (Belonidae) comprises several morphologically similar species, which have historically led to taxonomic ambiguities, particularly in the Indo-Pacific region. The present study addresses these challenges through an integrative taxonomic assessment of three closely related species-*Strongylura incisa*, *S. leiurus,* and *S. strongylura*-collected from Indian waters between 2021 and 2023. Detailed morphometric and meristic analyses were conducted along with mitochondrial DNA (COI) sequencing to examine species boundaries. The results clearly support the distinctiveness of each species. *S. incisa* is characterised by a slender body, relatively longer snout and lower jaw, fewer predorsal scales, and a moderately emarginate caudal fin. *S. leiurus* exhibits a deeper body profile, higher predorsal scale and anal fin ray counts, and lacks caudal pigmentation, setting it apart from its congeners. *S. strongylura* is morphologically robust, with a shorter snout, fewer vertebrae and predorsal scales, and a rounded or truncated caudal fin with dark posterior margins. Pairwise genetic distances (K2P) ranging from 17.8 to 23.7% among the three species of *Strongylura* clearly support the distinctiveness and exceed typical COI divergence thresholds for teleosts. Comparative analysis with previously described species from other ocean basins further highlights these distinctions, reinforcing the reliability of combined morphological and molecular approaches. This study enhances the taxonomic resolution within *Strongylura* in Indian waters and provides a baseline for future biodiversity and fisheries assessments of the group.

Keywords: *Needlefishes, otolith, morphometric analysis, COI, phylogenetic analysis*

Introduction

The genus *Strongylura* van Hasselt, 1824 (Belonidae), comprising elongated, surface-dwelling needlefishes, is widely distributed across tropical and subtropical marine and estuarine environments worldwide (Collette, 1999; 2022). Members of the genus are characterised by a caudal fin rounded or truncated; no keels on the caudal peduncle; no posterior black dorsal-fin lobe at any size; dorsal-fin rays 12 to 21 (Collette and Carpenter, 2003; Collette, 1999). The group exhibits considerable morphological conservatism, often leading to difficulties in species delimitation based solely on external features (Lovejoy, 2000). Globally, *Strongylura* comprises approximately 15 valid species (Lovejoy, 2000; Fricke *et al*., 2025; Froese and Pauly, 2024). Species of the genus *Strongylura* show a broad global distribution, with several species occurring exclusively in the Atlantic Ocean, such as *S. forsythia*, *S. notata*, *S. marina*, *S. timucu,* and *S. senegalensis,* which are primarily restricted to coastal and estuarine habitats of the western and eastern Atlantic (Collette and Carpenter, 2003). In contrast, the Indo-Pacific and Indian Ocean regions host a diverse assemblage including *S. incisa*, *S. leiurus*, *S. strongylura*, *S. krefftii*, *S. anastomella*, and *S. urvillii*, inhabiting coastal lagoons, mangroves, reef flats, and brackish or freshwater systems from East Africa and the Persian Gulf to the western Pacific. Three of these–*S. incisa*, *S. leiurus*, and *S. strongylura*- are currently documented from Indian waters (Fricke *et al*., 2025; Froese and Pauly, 2024; Roul *et al*., 2018, 2019).

Despite their apparent similarity, molecular phylogenetic studies have revealed that *Strongylura* is polyphyletic, with multiple independent lineages emerging within the genus (Banford *et al*., 2004; Lovejoy *et al*., 2004). This underlines the necessity for integrative taxonomic approaches to reassess species boundaries and phylogenetic relationships within the genus. Species of the genus *Strongylura* are of minor commercial importance globally, but are regularly caught in gillnets, hook-and-line, and seine nets (Collette and Carpenter, 2003; Sabrah *et al*., 2018; Toji *et al*., 2024). They are typically marketed fresh, frozen, or smoked and consumed locally despite the green colouration of their bones, with the flesh generally considered palatable (Collette, 1984; Collette and Carpenter, 2003). In India, species of *Strongylura* contribute to small-scale pelagic fisheries and are commonly landed across both coasts and island ecosystems, including riverine and estuarine environments (Toji *et al*., 2024). While *S. incisa* is reef-associated and restricted to the southeast coast, species such as *S. leiurus* and *S. strongylura* are widely distributed, occurring in marine, brackish, and freshwater habitats, enhancing their availability to local fisheries (Toji *et al*., 2024). Despite their low economic value in large-scale commercial markets, their widespread presence and accessibility make them a vital part of local coastal livelihoods and a secondary resource in tropical pelagic fisheries (Collette and Carpenter, 2003; Banford *et al*., 2004; Toji *et al*., 2024).

The taxonomy of the genus *Strongylura* has historically been based primarily on morphological traits, with early revisions recognising a wide range of marine and freshwater species distributed across tropical and subtropical regions (Collette *et al*., 1984). Although these classical studies provided foundational descriptions, they were largely constrained by the limited meristic characters and lacked comprehensive taxonomic revision (Collette, 1974). Subsequent studies on *Strongylura* from Indian waters have also been restricted to a narrow set of morphological characteristics, without incorporating molecular evidence (Roul *et al*., 2018). As a result, several species complexes, particularly within the Indo-Pacific region, remain poorly resolved, highlighting the need for detailed and integrative taxonomic assessments (Lovejoy and Collette, 2001; Banford *et al*., 2004; Choi *et al*., 2016). In this context, a comprehensive reassessment of *Strongylura* from Indian waters is essential to establish a reliable taxonomic framework for future studies. The present study represents a baseline effort to confirm species identities in the region using an integrative taxonomic approach. By combining morphometric, meristic, otolith morphology, and molecular (COI) analyses, this study aims to resolve species boundaries within the genus *Strongylura*, detect potential cryptic diversity, and provide a more accurate understanding of species distribution along the Indian coast.

Material and methods

Specimen collection and identification

Specimens were collected from various locations along the east and west coasts of India, as well as the Andaman and Nicobar Islands and Lakshadweep Islands (Fig. 1), between 2021 and 2023, as part of a systematic survey of belonid fishes (Table 1). Samples were obtained from local fish landing centres where fishermen employed gillnets in shallow coastal waters (0-5 m depth). The specimens were immediately collected after capture and transported to the laboratory following preliminary identification (Thomas *et al*., 2025) and photographic documentation. Tissue samples were preserved in 95% ethanol for molecular analysis.

Table 1. Geographic locations of specimen collection during the current study

No.	Species	Co-ordinate	Collection location
1	*Strongylura incisa* (N=9)	8°53'19.5"N 78°10'23.1"E	Tharuvaikulam, Tuticorin, Tamil Nadu
2	*Strongylura incisa* (N=3)	11°39'33.2"N 92°43'33.6"E	Junghalighat jetty, Sri Vijaya Puram, A& N Islands
3	*Strongylura incisa* (N=3)	16°57'26.4"N 82°16'09.2"E	Kakinada Port Landing Centre, Kakinada, Andhra Pradesh
4	*Strongylura leiurus* (N=5)	9°58'57.3"N 76°14'33.9"E	Kalamukk, Kochi, Kerala
5	*Strongylura leiurus* (N=2)	12°51'36.7"N, 74°49'55.3"E	Dhake, Mangalore, Karnataka
6	*Strongylura leiurus* (N=3)	20°54'07.9"N 70°21'52.4"E	Light house, Veraval, Gujarat
7	*Strongylura leiurus* (N=3)	19°58'48.0"N 86°19'12.0"E	Nuagarh, Astaranga, Odisha
8	*Strongylura leiurus* (N=2)	9°16'50.6"N 79°12'27.3"E	Pamban, Mandapam, Tamil Nadu
9	*Strongylura strongylura* (N=4)	11°39'33.2"N 92°43'33.6"E	Junghalighat jetty, Sri Vijaya Puram, A&N Islands
10	*Strongylura strongylura* (N=3)	19°01'12.6"N 72°49'04.2"E	Worli, Mumbai, Maharashtra
11	*Strongylura strongylura* (N=5)	17°41'44.8"N 83°18'08.8"E	Kavaratti jetty, Kavaratti, Lakshadweep
12	*Strongylura strongylura* (N=3)	10°33'59.1"N 72°38'13.6"E	Jalaripetta, Vishakhapatnam, Andhra Pradesh

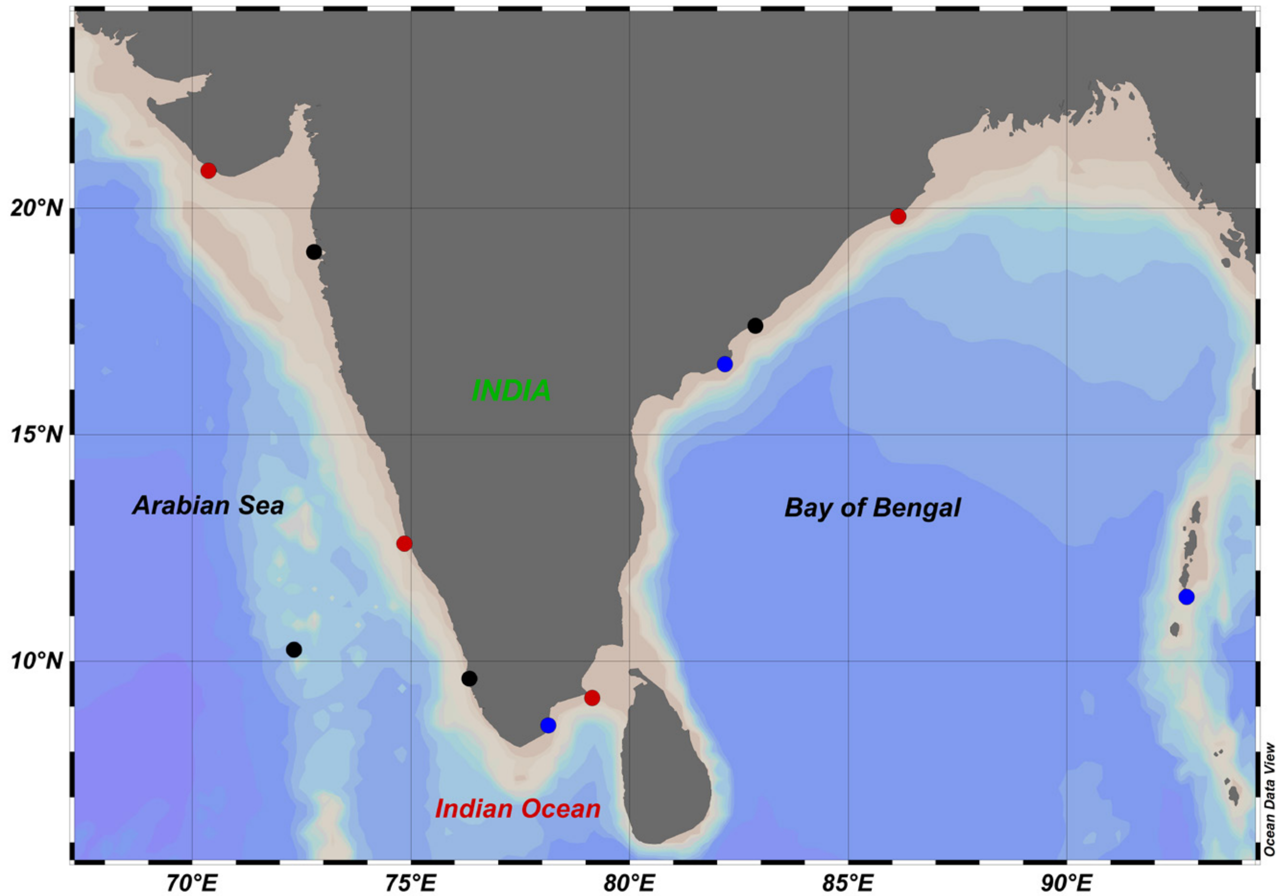

Fig. 1. Map showing the occurrence points of materials examined during the present study (*S. incisa* – blue dots; *S. leiurus* – red dots; *S. strongylura* – black dots)

Morphometric and meristic analysis

Morphological characters, including body colouration, morphometric measurements, and meristic counts, were recorded for all specimens. Measurements were made following standard protocols as described by Collette (1984) and Yankova *et al.* (2023), and identification was confirmed using diagnostic features outlined by Collette and Su (1986). All measurements were taken using vernier callipers with 0.1 mm precision and expressed as percentages of standard length (SL) or head length (HL) following Hubbs and Lagler (1958). A total of 27 morphometric measurements and 7 meristic counts were recorded. Morphometric and meristic data were compared with previously published descriptions (Collette, 1984; Collette, 2003). Details of type specimens and associated museum reference materials examined in this study are provided, and the status of specimens used in previous studies (*e.g.*, FAO, 1983; Roul *et al.*, 2018) is clarified with respect to their designation as type or non-type reference material. Vertebral counts were obtained from X-ray radiographs, following the methodology of Jawad and Jig (2017). Sagittal otoliths were extracted in accordance with Abdussamad (2015) and photographed under high-resolution digital imaging for shape comparison. All identified specimens were preserved and deposited in the Marine Biodiversity Museum at the Central Marine Fisheries Research Institute (CMFRI), Kochi, Kerala, and specimens were given Designated National Repository (DNR) numbers.

Molecular analysis

Total genomic DNA was extracted from ethanol-preserved tissue samples using a commercial DNA extraction kit (Origin), adhering to the manufacturer's protocol. DNA quality and concentration were assessed using a Nanodrop spectrophotometer (Eppendorf). The mitochondrial gene region, cytochrome c oxidase subunit I (COI) (Hebert *et al.*, 2003) was amplified via polymerase chain reaction (PCR) using the primer WARD 1 (Ward *et al.*, 2005). Each PCR reaction was performed in a 25 μl volume comprising 50 ng of template DNA, 3 mM $MgCl_2$, and 0.3 mM of each primer. The thermal cycling profile included an initial denaturation at 94 °C for 3 min, followed by 30 cycles of denaturation at 94 °C for 30 s, annealing at 50 °C for 30 s, and extension at 72 °C for 1 min, with a final extension step of 7 min at 72 °C. The amplified products were visualised on 1.2% agarose gels stained with ethidium bromide.

Post-PCR, sequencing was performed by Genspec, Cochin, India. Sequence quality was assessed using Sequence Scanner v1.0 (Applied Biosystems, 2010). Multiple sequence alignments were conducted using Clustal W (Thompson *et al*., 2003). Comparative molecular analyses were conducted using reference sequences retrieved from GenBank (Benson *et al*., 2013) and the Barcode of Life Data Systems (BOLD) (Ratnasingham and Hebert, 2007). These sequences were aligned with newly generated sequences using the Clustal W algorithm in BIO Edit (Hall *et al*., 1999). Details of published sequences used for alignment are summarised in Table 5. Phylogenetic analysis was performed to determine genetic distances between the sequences using the Maximum Likelihood (ML) method based on the Kimura-2-parameter or K2P (Kimura, 1980) in MEGA 11 (Tamura *et al*., 2021). with 1000 bootstrap replications (Felsenstein, 1985). Mean pairwise genetic distances were calculated using the K2P model (Kimura, 1980). The sequences were submitted to the NCBI GenBank, and accession numbers were obtained (Table 1).

Results

A total of 45 specimens belonging to the genus *Strongylura* were collected as part of this taxonomic investigation. Based on detailed morphological, meristic, otolith, and molecular analyses, these specimens were identified as *Strongylura incisa* (Valenciennes, 1846), *Strongylura leiurus* (Bleeker, 1850), and *Strongylura strongylura* (van Hasselt, 1823).

Systematics

Order: Beloniformes
Family: Belonidae Bonaparte, 1835
Genus: *Strongylura* van Hasselt, 1824

Strongylura incisa Valenciennes, 1846 (Fig. 2a)

Common name: Reef needlefish

Type specimen: *Belone incisa* Valenciennes in Cuvier & Valenciennes 1846, Indian Ocean. Holotype (unique)

Synonyms: *Belone incisa* Valenciennes, 1846; *Belone leiuroides* Bleeker, 1851; *Belone liuroides* Günther, 1866; *Rhaphiobelone robusta* Schultz, 1953; *Tylosurus terebra* Whitley, 1927

Materials examined: The materials examined were from 15 specimens. DNR No: GB 10.2.8.6.1 (437-462mm SL), Collected by Gillnet operation, From Tuticorin (8°53'19.5"N 78°10'23.1" E), Sri Vijaya Puram (11°39'33.2"N 92°43'33.6" E), and Kakinada (16°57'26.4"N 82°16'09.2" E), depth 0-5 m; collected by Toji Thomas, on the period of 2021-2023.

Diagnosis: *Strongylura incisa* can be distinguished from its congeners by a combination of morphological and meristic characters. It possesses a relatively long head and a relatively elongated predorsal region. The dorsal fin typically has 18-19 rays. and the anal fin has 21-22 rays. The dorsal and anal fin origins are closely aligned, with the dorsal fin origin typically between the 4th and 5th anal fin rays. The caudal fin is described as slightly forked or emarginate. This species lacks prominent spots or bars on the body, though it may exhibit a mark on the cheek. Scales are absent at the anal fin and dorsal fin base.

Description: *Strongylura incisa* is characterised by a slender, elongate body with a body depth at the level of the anal fin ranging from 3.9-4.1% of standard length (SL). The head is relatively large, with a head length (HL) measuring 16-17.8 cm, accounting for 36.6-38.5% of SL. The eyes are prominent (Fig. 2b), with an eye diameter of 4.0-4.2% of HL, and the interorbital

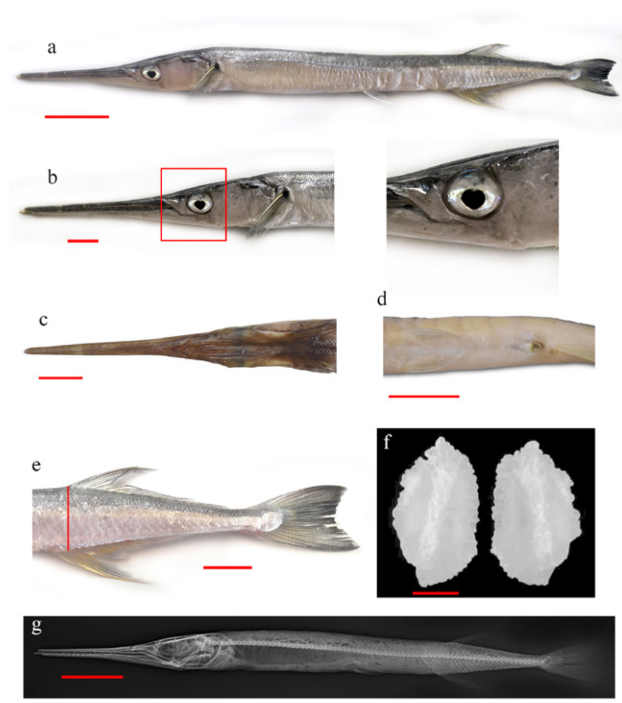

Fig. 2. Morphological and anatomical characteristics of *Strongylura incisa* (DNR No. GB 10.2.8.6.1, SL- 446 mm) (a) Lateral view (Scale bar = 5 cm) (b) Head with pectoral fin (Scale bar = 2 cm) (c) Upper head (Scale bar = 2 cm) (d) Pelvic-Anal (Scale bar = 2 cm) (e) Dorsal, anal and caudal fin shape (Scale bar = 2 cm) (f) Sagittal otolith (Scale bar = 1mm), and (g) Vertebrae (Scale bar = 5 cm)

width ranges from 4.4-4.6% of HL. Cranial proportions include lower jaw and preorbital lengths of 24.6-26.2% and 24.2-26.1% of HL, respectively, and a snout length of 24.7-27% of HL. Head width and head depth measure 5.7-6.1% and 3.8-4.0% of HL, respectively (Fig. 2c). Proportional distances relative to SL include pre-pectoral length (38.4-40.7%), predorsal length (78.7-80.3%), and preanal length (76.7-78.3%). The distance between the origins of the dorsal and anal fins is short, ranging from 1.8-2.0% of SL (Fig. 2e). The dorsal and anal fin base lengths measure 14.8-14.9% and 15.8-16.1% of SL, respectively. Pectoral and pelvic fin lengths are 10.2-10.5% and 6.9-7.1% of SL (Fig. 2d). Fin heights include dorsal height (10.8-11.2%) and anal height (9.3-9.6%) of SL. Body widths include caudal peduncle width (1.3-1.4%), caudal peduncle depth (2.3-2.5%), width at the pelvic fin (5.6-5.8%), depth at the pelvic fin (4.75-4.9%), and width at the anal fin (5.8-6.0% of SL). The dorsal fin comprises 18-19 rays, the anal fin 21-22 rays, and the pectoral fin 10-11 rays. The pelvic fin consistently comprises 6 rays. The predorsal scale count ranges from 120 to 128, and the vertebral count ranges from 74 to 76. The caudal fin is slightly forked or emarginate (Fig. 2e). All morphometric and meristic data are presented in Tables 2 and 3.

Table 2. Detailed morphometric and meristic characteristics of the genus *Strongylura,* available along the Indian coast (Present study)

No.	Characters	*Strongylura incisa* (N=15)				*Strongylura leiurus* (N=15)				*Strongylura strongylura* (N=15)			
		Range	AVG	S. D	S. E	Range	AVG	S. D	S. E	Range	AVG	S. D	S. E
1	Total length (cm)	48-50.3	49.13	1.15	0.66	37.1-52.7	45.1	5.01	1.77	28.1-39.2	34.42	4.48	2
2	Standard length (cm)	43.7-46.2	44.83	1.27	0.73	34.3-48	41.29	4.46	1.58	25.4-35.8	31.06	4.12	1.84
3	Head length (cm)	16-17.8	16.8	0.92	0.53	11.8-15.3	13.58	1.10	0.39	9.5-13.1	11.38	1.36	0.61
A	In % of SL												
1	Head length	36.6-38.5	37.45	0.98	0.57	32-36	32.98	1.43	0.54	35.7-37.6	36.70	0.79	0.35
2	Pre-pectoral length	38.4-40.7	39.23	1.26	0.73	33-37	35.04	1.34	0.51	37-40	38.45	1.10	0.49
3	Predorsal length	78.7-80.3	79.69	0.85	0.49	79.2-81	79.95	0.52	0.20	81.3-83.6	82.70	1.21	0.54
4	Preanal length	76.7-78.3	77.61	0.84	0.49	75-77	75.84	0.71	0.27	78.5-80.3	79.19	0.75	0.34
5	Distance b/w AF org-DF org	1.8-2	1.86	0.08	0.05	3.4-4.7	3.90	0.42	0.16	2.9-4.3	3.50	0.56	0.25
6	Dorsal baselength	14.8-14.9	14.87	0.07	0.04	13.5-14.8	14.09	0.43	0.16	10.2-12	10.76	0.75	0.34
7	Anal baselength	15.8-16.1	15.99	0.17	0.10	15.7-17.9	17.15	0.62	0.23	11.8-13.8	12.62	0.77	0.34
8	Pectoral length	10.2-10.5	10.41	0.21	0.12	7-8.4	7.84	0.40	0.15	5.6-9.4	8.31	1.60	0.72
9	Pelvic length	6.9-7.1	7.03	0.07	0.04	5.1-5.75	5.46	0.22	0.08	5.2-5.9	5.48	0.30	0.14
10	Dorsal height	10.8-11.2	11.01	0.20	0.11	5.7-7	6.43	0.43	0.16	8-9.8	8.56	0.73	0.33
11	Anal height	9.3-9.6	9.44	0.17	0.10	7.9-9.5	8.64	0.51	0.19	10.3-11.8	10.74	0.63	0.28
12	Caudal peduncle width	1.3-1.4	1.38	0.03	0.02	.8-1.1	0.96	0.10	0.04	.73-.86	0.81	0.05	0.02
13	Caudal peduncle depth	2.3-2.5	2.38	0.09	0.05	1.7-2.3	2.11	0.17	0.06	2.95-3.7	3.34	0.30	0.14
14	Width at pelvic	5.6-5.8	5.73	0.10	0.06	3.3-4.1	3.58	0.29	0.11	4.9-5.8	5.31	0.36	0.16
15	Depth at pelvic	4.75-4.9	4.87	0.09	0.06	4.4-5.4	4.75	0.28	0.11	5.5-7.1	6.37	0.58	0.26
16	Width at anal	5.8-6	5.87	0.07	0.04	2.8-3.2	3.02	0.14	0.05	3.4-3.8	3.62	0.18	0.08
17	Depth at anal	3.9-4.1	3.98	0.08	0.04	4.4-5.8	4.98	0.42	0.16	4.7-6.4	5.51	0.65	0.29
B	In % of HL												
1	Snout length	24.7-27	25.55	1.13	0.65	20.8-24	21.98	1.10	0.41	22.9-24.8	23.88	0.77	0.34
2	Head width	5.7-6.1	5.95	0.19	0.11	2.9-4.5	3.72	0.44	0.17	3-3.9	3.40	0.32	0.14
3	Head depth	3.8-4	3.94	0.14	0.08	4.4-5.7	4.90	0.42	0.16	5.3-6.4	5.80	0.41	0.19
4	Eye diameter	4-4.2	4.05	0.06	0.03	2.6-3.3	2.89	0.17	0.06	2.8-3.4	3.16	0.22	0.09
5	Interorbital width	4.4-4.6	4.50	0.07	0.04	2.9-3.7	3.21	0.24	0.09	2.7-3.4	2.91	0.26	0.11
6	Lower jaw length	24.6-26.2	25.19	0.87	0.50	21.4-26	23.18	1.39	0.53	24.2-25.7	25.06	0.64	0.28
7	Preorbital length	24.2-26.1	25.15	0.91	0.53	20.6-23.2	21.81	0.92	0.35	23-26.5	24.50	1.36	0.61
8	Postorbital length	7.5-8.6	8.06	0.50	0.29	7.3-8.2	7.75	0.27	0.10	9.1-10.3	9.62	0.44	0.20

Colouration: The body is predominantly silvery with a faint greenish sheen along the dorsal surface (Fig. 2). Fins are largely hyaline, while the caudal fin is distinctively edged in dark pigment.

Otolith morphology: The sagittal otolith of *Strongylura incisa* has an overall oval shape. The anterior and posterior ends are slightly pointed, giving it an elongated appearance. The dorsal and ventral margins are somewhat rounded. The surface texture appears granular with concentric growth rings.

Meristic formula: DF 18-19, AF 21-22, Pect F 10 - 11, Predorsal scales 120-128, Vertebrae 74-76

Distribution: Present investigations indicated their distribution along Tuticorin (Tamil Nadu), Kakinada (Andhra Pradesh), and the Andaman Islands (Bay of Bengal) (Fig. 1).

Remarks: *Strongylura incisa* (Valenciennes, 1846) was originally described from the Indian Ocean and is commonly recorded from Southeast Asia, including the Philippines (Lovejoy, 2000; Lovejoy *et al.*, 2004; Astakhov, 2023). The species is currently treated as a valid member of the genus and has appeared in molecular phylogenetic studies as a distinct lineage (Banford *et al.*, 2004). In India, reports of *S. incisa* are relatively recent and have primarily been based on morphological identification, with limited molecular confirmation (Roul *et al.*, 2019). Indian records indicate the presence of the species along the southeast coast, though its distribution remains poorly understood due to the historical taxonomic ambiguity within the genus.

Strongylura leiurus Bleeker, 1850 (Fig.3a)

Common name: Banded needlefish

Type specimen: *Belone leiurus* Bleeker, 1850, Jakarta, Java, Indonesia. Syntypes: BMNH 1866.5.2.4, RMNH 6946

Synonyms: *Belone ciconia* Richardson, 1846; *Belone ferox* Günther, 1866; *Belone leira* Bleeker, 1850; *Belone leiurus* Bleeker, 1850; *Belone natalensis* Günther, 1866; *Belone tenuirostris* Blyth, 1858; *Rhaphiobelone dammermani* Fowler, 1934; *Strongylura leiurus leiurus* (Bleeker, 1850); *Strongylura leiyra* (Bleeker, 1850); *Strongylurus leiurus* (Bleeker, 1850); *Tylosurus leiurus* (Bleeker, 1850)

Materials examined: (N=15): DNR No: GB 10.2.8.7.1 (343- 480 mm SL), Collected by Gillnet operation, From; Mangalore (12°51′36.76′′N, 74° 49′ 55.38′′ E), Astaranga (19°58′48.0″N 86°19′12.0″ E), Mandapam (9°16′50.6″N 79°12′27.3″ E) Kochi (9°58′57.3″N 76°14′33.9″ E), Veraval (20°54′07.9″N 70°21′52.4″ E), depth 0-5 m; collected by Toji Thomas, on the period of 2021-2023

Diagnosis: *Strongylura leiurus* is differentiated by its relatively short head and a greater distance between the dorsal and anal fin origins, with the dorsal fin origin typically between the 7th-8th anal fin rays. The dorsal fin has 19-20 rays and the anal fin 23-24 rays. The caudal fin is emarginate. While lacking spots or bars on the main body, it exhibits spots on the anterior part of the body. Scales are present at the anal fin and dorsal fin base.

Description: *Strongylura leiurus* is distinguished by an elongated, slender body, with body depth at the anal fin ranging from 4.4-5.8% of standard length (SL). The head length varies from 11.8-15.3 cm, comprising 32.0-36.0% of SL. The eyes are well-developed (Fig. 3b), with an eye diameter of 2.6-3.3% of head length (HL), and an interorbital width of 2.9-3.7% of HL. The lower jaw measures 21.4-26.0% of HL, while preorbital and snout lengths range from 20.6-23.2% and 20.8-24.0% of HL, respectively. Head width and depth range from 2.9-4.5% and 4.4-5.7% of HL, respectively (Fig. 3c). Measurements relative to SL include pre-pectoral length (33.0-37.0%), predorsal length (79.2-81.0%), and preanal length (75.0-77.0%). The distance between the origins of the anal and dorsal fins ranges from 3.4-4.7% of SL (Fig. 3e). Dorsal and anal base lengths are 13.5-14.8% and 15.7-17.9% of SL, respectively. The pectoral and pelvic fin lengths are 7.0-8.4%

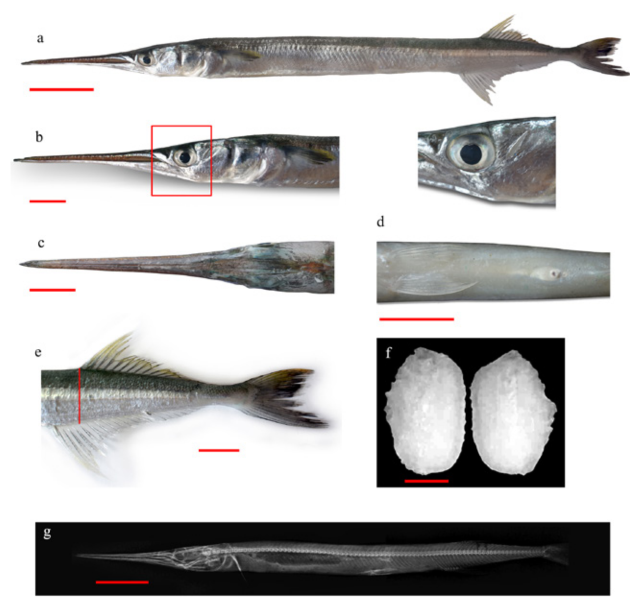

Fig. 3. Morphological and anatomical characteristics of *Strongylura leiurus* (DNR No. GB.10.2.8.7.1, SL- 341 mm) (a) Lateral view (Scale bar = 5 cm) (b) Head with pectoral fin (Scale bar = 2 cm) (c) upper head (Scale bar = 2 cm) (d) Pelvic–Anal (Scale bar = 2 cm) (e) dorsal, anal and caudal fin shape (Scale bar = 2 cm) (f) otolith (Scale bar = 1 mm) , and (g) vertebrae (Scale bar = 5 cm)

and 5.1-5.75% of SL, respectively (Fig. 3d). Fin heights include dorsal height (5.7-7.0%) and anal height (7.9-9.5%) of SL. The caudal peduncle width and depth vary from 0.8-1.1% and 1.7-2.3% of SL, respectively. Width and depth at the pelvic fin measure 3.3-4.1% and 4.4-5.4%, respectively, while the width at the anal fin ranges from 2.8-3.2% of SL. The dorsal fin consists of 19-20 rays, the anal fin of 23-24 rays, and the pectoral fin of 11-12 rays. The pelvic fin consistently bears 6 rays. The predorsal scale count ranges from 169 to 188, and the vertebral count varies from 83 to 85. The caudal fin is emarginate in shape (Fig. 3e). All morphometric and meristic data are summarised in Tables 2 and 3.

Colouration: The body displays a bright silver tone, subtly tinged with green dorsally (Fig. 3). All fins are hyaline, with the caudal fin bearing a thin dark margin.

Otolith morphology: The sagittal otolith of *Strongylura leiurus* is more rounded and less elongated compared to the other two species. It has a more symmetrical, blunt oval shape. The margins, especially the dorsal and ventral sides, are smooth and curved. The overall shape is compact and robust.

Meristic formula: DF 19-20, AF 23-24, Pect F 11 - 12, Predorsal scales 169-188, Vertebrae 83-85.

Distribution: Present records confirm its occurrence along Kerala, Karnataka, and Gujarat (Arabian Sea), as well as Tamil Nadu and Odisha (Bay of Bengal) (Fig.1).

Remarks: *Strongylura leiurus* (Bleeker, 1850) is one of the more widely reported species in the Indo-West Pacific, ranging from the Indian subcontinent to northern Australia (Lovejoy, 2000; Lovejoy *et al.*, 2004; Al-Salim and Ali, 2007). In Indian waters, it has been recorded from both the southwest and east coasts (Aneesh *et al.*, 2013; Roul *et al.*, 2018; Roul *et al.*, 2019; Sheikh *et al.*, 2022). The species has historically been confused with its congeners, especially due to overlapping meristic traits. However, molecular studies have consistently identified *S. leiurus* as a distinct clade, often grouped with *S. incisa* and *S. strongylura* in Indo-Pacific phylogenies (Lovejoy *et al.*, 2004).

Strongylura strongylura van Hasselt, 1823 (Fig. 4a)

Common name: Spottail needlefish

Type specimen: *Belone strongylura*, van Hasselt, 1823:Vizagapatam, India. Holotype (unique): whereabouts unknown.

Synonyms: *Belone caudimacula* Cuvier, 1829; *Belone oculata* Leschenault, 1846; *Belone saigonensis* Sauvage, 1879; *Belone strongylura* van Hasselt, 1823; *Belone strongylurus* van Hasselt, 1823; *Strongylura caudimaculata* van Hasselt, 1824; *Strongylura strongylurus* (van Hasselt, 1823); *Strongylurus strongylura* (van Hasselt, 1823); *Tylosurus strongilurus* (van Hasselt, 1823); *Tylosurus strongylorus* (van Hasselt, 1823); *Tylosurus strongylura* (van Hasselt, 1823); *Tylosurus strongylurus* (van Hasselt, 1823)

Materials examined (N=15): DNR No: GB 10.2.8.8.1 (254-358 mm SL) Collected by Gillnet operation, From: Vizag (17°41′44.8″N 83°18′08.8″ E), Kavaratti (10°33′59.1″N 72°38′13.6″ E), Sri Vijaya Puram (11°39′33.2″N 92°43′33.6″ E), Bombay (19°01′12.6″N 72°49′04.2″ E), depth 0-5 m; collected by Toji Thomas, on the period of 2021-2023

Table 3. Summary of important morphometric and meristic characters of species of *Strongylura* collected during the present study in comparison with previous records

Sl. no	Characters	*Strongylura incisa*			*Strongylura leiurus*			*Strongylura strongylura*		
		FAO (1983)	Roul *et al.* 2018	Present study	FAO (1983)	Roul *et al.*, 2018	Present study	FAO (1983)	Roul *et al.* 2018	Present study
1	Dorsal fin rays	11 - 20	19-20	18-19	17- 21	18-21	19-20	12 - 15	12 - 15	13-14
2	Anal fin rays	21-25	21-23	21-22	23-25	21-26	23-24	15-18	16- 18	17-18
3	DF- AF origin	4th- 6th	4th -5th	4th-5th	7th-10th	7th-9th	7th-8th		6th- 7th	5th-7th
4	Pectoral rays		12	10 - 11	10 - 11	10 - 12	11 - 12	10 - 12	9 - 12	10 - 11
5	Predorsal scales	100-120	100-125	120-128	130-160	130-180	169-188	100-130	97-123	115-136
6	Vertebrae			74-76			83-85	59-65		61-63
7	Caudal fin shape		Emarginate	Slightly forked or Emarginate	Emarginate	Emarginate	Emarginate	Truncate or Rounded	Rounded or Truncate	Rounded or Truncate
8	Spots or bars	Absent	Cheek	Cheek	Absent	Anterior part of body	Anterior part of body	Spot in caudal peduncle	Spot in caudal peduncle	Spot in caudal peduncle
9	Scales in AF- DF base	Absent	Absent	Absent	Present	Absent	Present	Present	Present	Present

Diagnosis: *Strongylura strongylura* is characterised by its relatively short total length and head length. The dorsal fin has 13-14 rays and the anal fin 17-18 rays. The dorsal fin origin is typically between the 5th and 7th anal fin rays. A distinct spot is present on the caudal fin. The caudal fin is rounded or truncated. Scales are present at the anal fin and dorsal fin base.

Description: *Strongylura strongylura* is a slender, elongate species, with body depth at the level of the anal fin ranging from 4.7-6.4% of standard length (SL). Head length varies from 9.5-13.1 cm, constituting 35.7-37.6% of SL. The eyes are distinct and moderately large (Fig. 4b), with diameters of 2.8-3.4% of head length (HL), and interorbital width ranges from 2.7-3.4% of HL. The lower jaw length is 24.2-25.7% of HL, while preorbital length ranges from 23.0-26.5% and snout length from 22.9-24.8% of HL. Head width and depth range from 3.0-3.9% and 5.3-6.4% of HL, respectively (Fig. 4c). Proportional measurements relative to SL include pre-pectoral length (37.0-40.0%), predorsal length (81.3-83.6%), and preanal length (78.5-80.3%). The distance between the origins of the anal and dorsal fins measures 2.9-4.3% of SL (Fig. 4e). Dorsal and anal base lengths measure 10.2-12.0% and 11.8-13.8% of SL, respectively. Pectoral and pelvic fin lengths range from 5.6-9.4% and 5.2-5.9% of SL, respectively (Fig. 4d). Dorsal and anal heights range from 8.0-9.8% and 10.3-11.8% of SL, respectively. The caudal peduncle is narrow, with a width ranging from 0.73-0.86% and depth from 2.95-3.7% of SL. Width and depth at the pelvic fin range from 4.9-5.8% and 5.5-7.1% of SL, respectively, while the width at the anal fin ranges from 3.4-3.8% of SL. The dorsal fin comprises 13-14 rays, the anal fin 17-18 rays, and the pectoral fin 10-11 rays. The pelvic fin consists of 6 rays. Predorsal scales range from 115 to 136, and the vertebral count is between 61 and 63. The caudal fin is either rounded or truncated in shape (Fig. 4e). All morphometric and meristic data are provided in Tables 2 and 3.

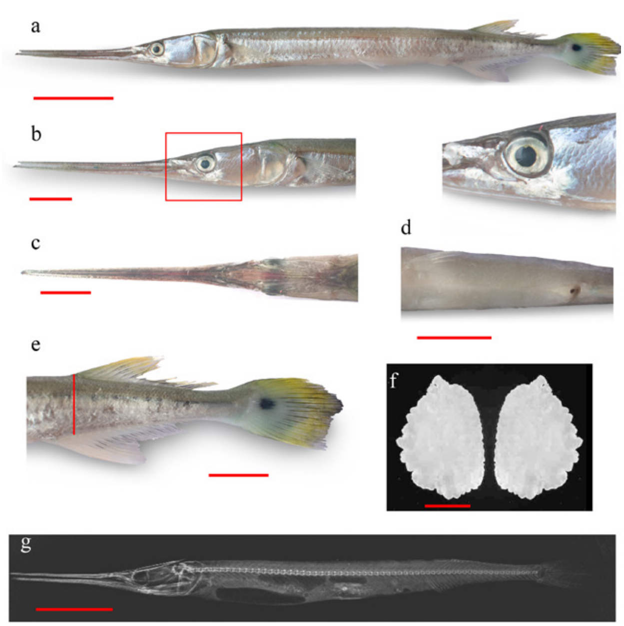

Fig. 4. Morphological and anatomical characteristics of *Strongylura strongylura* (DNR No. GB.10.2.8.8.1, SL- 358 mm) (a) Lateral view (Scale bar = 5 cm) (b) Head with pectoral fin (Scale bar = 2 cm) (c) upper head (Scale bar = 2 cm) (d) Pelvic–Anal (Scale bar = 2 cm) (e) dorsal, anal and caudal fin shape (Scale bar = 2 cm) (f) otolith (Scale bar = 1 mm) , and (g) vertebrae (Scale bar = 5 cm)

Colouration: This species has a bright silvery body with a slight green dorsal hue (Fig. 4). The fins are hyaline, though the caudal fin is notable for its dark edging. The caudal fin bears a distinct dark spot.

Otolith morphology: The sagittal otolith of *Strongylura strongylura* is similar to *S. incisa* in its elongated form but with distinctively serrated or jagged margins. The anterior and posterior ends are pointed, and the dorsal and ventral margins are notably irregular, with small projections. This gives the otolith a more pronounced, "toothed" or saw-like appearance along its edges.

Meristic formula: DF 18-19, AF 21-22, Pect F 10 - 11, Predorsal scales 120-128, Vertebrae 74-76

Distribution: Recorded from Maharashtra and Lakshadweep (Arabian Sea), and from Andhra Pradesh and the Andaman Islands (Bay of Bengal) (Fig. 1).

Remarks: *Strongylura strongylura* (van Hasselt, 1823), originally described from the east coast of India, has a confirmed distribution spanning the eastern Indian Ocean to the Western Central Pacific, including India, Sri Lanka, Southeast Asia, and northern Australia (Collette, 1984; Al-Salim and Ali, 2007). Within India, it is documented from the southwest coast (Rameshkumar *et al*., 2014; Roul *et al*., 2018; Roul *et al*., 2019). Historically, this species has served as a reference point for comparison with closely related taxa and has been considered a representative of the genus in global taxonomic and phylogenetic studies (Banford *et al*., 2004; Lovejoy, 2000).

Key to the genus Strongylura in Indian waters

Modified key adapted from Collette, 1999, and observations during the present study

1a. Body strongly laterally compressed or rounded; with or without vertical bars; Caudal fin distinctly forked; presence or absence of keels on caudal peduncle; presence of expanded black lobe in the posterior part of the dorsal fin; anal-fin rays 13 to 26; dorsal-fin rays 19 to 27, exclusively marine... ***Marine genera (Ablennes, and Tylosurus)***

1b. Body rounded; without vertical bars; caudal fin rounded or truncated; no keels on caudal peduncle; no posterior black dorsal-fin lobe at any size; anal-fin rays 13 to 23; dorsal-fin rays 12 to 21, seen in freshwater, marine, or brackish ....(2)

2a. Dorsal-fin rays 12 to 15; anal-fin rays 15 to 18; bases of dorsal and anal fins covered with scales, prominent black spot at base of caudal fin; predorsal scales 100 to 130 .... ***Strongylura strongylura***

2b. Dorsal-fin rays 17 to 21; anal-fin rays 21 to 27; bases of dorsal and anal fins without scales, no black spot at base of caudal fin .... (3)

3a. Predorsal scales 100 to 125; dorsal-fin origin over anal-fin rays 4 to 6; prominent, elongate spot on cheek between opercle and preopercle; pectoral fin with a yellowish tinge basally; dorsal and anal fin with yellowish rays with blackish tinge at the central region; caudal with yellowish tinge basally and greyish towards margin ....***Strongylura incisa***

3b. Predorsal scales 130 to 180; dorsal-fin origin over anal-fin rays 7 to 10; black bar on cheek between opercle and preopercle, and anterior part of the body; pectoral fins with a distal dark spot, tip of fins yellow in fresh specimens; tip of dorsal and anal-fin lobes yellowish, caudal fin dark with a yellowish tinge on upper lobe .... ***Strongylura leiurus***

Molecular analysis

A total of 14 sequences, including 3 newly generated and 11 retrieved from NCBI GenBank and BOLD, were used in this study (Table 5). Maximum likelihood (ML) phylogenetic analysis of COI sequences recovered three distinct clades corresponding to *Strongylura incisa*, *S. leiurus*, and *S. strongylura* (Fig. 5). Sequences generated in the present study, *S. strongylura* (PP833599), *S. leiurus* (PP833598), and *S. incisa* (PP833600) were grouped with conspecific sequences retrieved from GenBank and BOLD. The *S. strongylura* sequence (PP833599)

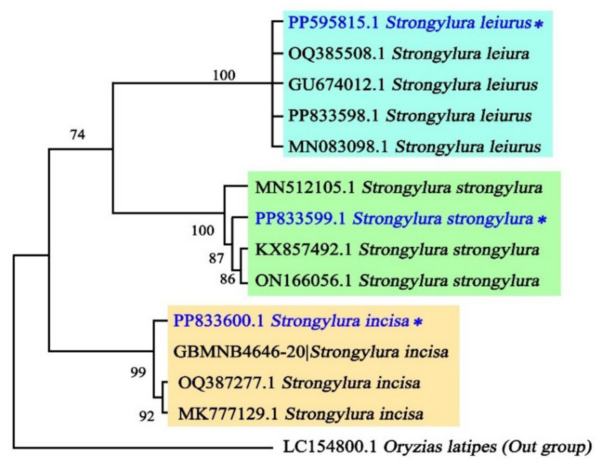

Fig. 5. Maximum Likelihood phylogenetic tree of the genus *Strongylura* using the mitochondrial COI gene

Table 4. Inter-species genetic distances table (K2P Table) based on COI sequences of genus *Strongylura*

	1	2	3	4	5	6	7	8	9	10	11	12	13
PP833599 *Strongylura strongylura*	0												
KX857492 *Strongylura strongylura*	0.004												
ON166056. *Strongylura strongylura*	0.004	0.000											
MN512105 *Strongylura strongylura*	0.006	0.010	0.010										
PP833598 *Strongylura leiurus*	0.181	0.180	0.180	0.184									
GU674012 *Strongylura leiurus*	0.181	0.180	0.180	0.184	0.000								
PP595815 *Strongylura leiurus*	0.181	0.180	0.180	0.184	0.000	0.000							
MN083098 *Strongylura leiurus*	0.184	0.183	0.183	0.187	0.002	0.002	0.002						
OQ385508 *Strongylura leiurus*	0.181	0.180	0.180	0.184	0.000	0.000	0.000	0.002					
PP833600 *Strongylura incisa*	0.182	0.185	0.185	0.178	0.237	0.237	0.237	0.242	0.238				
OQ387277 *Strongylura incisa*	0.181	0.184	0.184	0.178	0.245	0.245	0.245	0.249	0.245	0.004			
MK777129 *Strongylura incisa*	0.185	0.187	0.187	0.181	0.249	0.249	0.249	0.254	0.249	0.006	0.002		
GBMNB4646-20 *Strongylura incisa*	0.182	0.185	0.185	0.178	0.237	0.237	0.238	0.242	0.238	0.000	0.004	0.006	
LC154800 *Oryzias latipes*	0.307	0.307	0.307	0.298	0.322	0.322	0.322	0.318	0.322	0.270	0.275	0.279	0.270

Table 5. List of all comparative sequences (COI) for this study, retrieved from NCBI and BOLD used for phylogenetic tree construction

Sl. No	Species name	BOLD Accession number	NCBI Accession number	Collection location
1	*Strongylura strongylura*		PP833599	India
2	*Strongylura strongylura*	GBMIN121375-17	KX857492	India, Sundarbans
3	*Strongylura strongylura*	GBMNE85305-22	ON166056	Chilka lake, India
4	*Strongylura strongylura*	GBMNE36200-21	MN512105	Pakistan
5	*Strongylura leiurus*		PP833598	India
6	*Strongylura leiurus*	FOAJ581-09	GU674012	Indonesia
7	*Strongylura leiurus*	GBMNB8586-20	MN083098	Bangladesh
8	*Strongylura leiurus*	PHILA220-13	OQ385508	Philippines
9	*Strongylura leiurus*		PP595815	Pakistan
10	*Strongylura incisa*		PP833600	India
11	*Strongylura incisa*	PHIVS216-16	OQ387277	Philippines
12	*Strongylura incisa*	GBMNB7139-20	MK777129	Vietnam
13	*Strongylura incisa*	GBMNB4646-20	MH377852	India
14	*Oryzias latipes*		LC154800	Japan

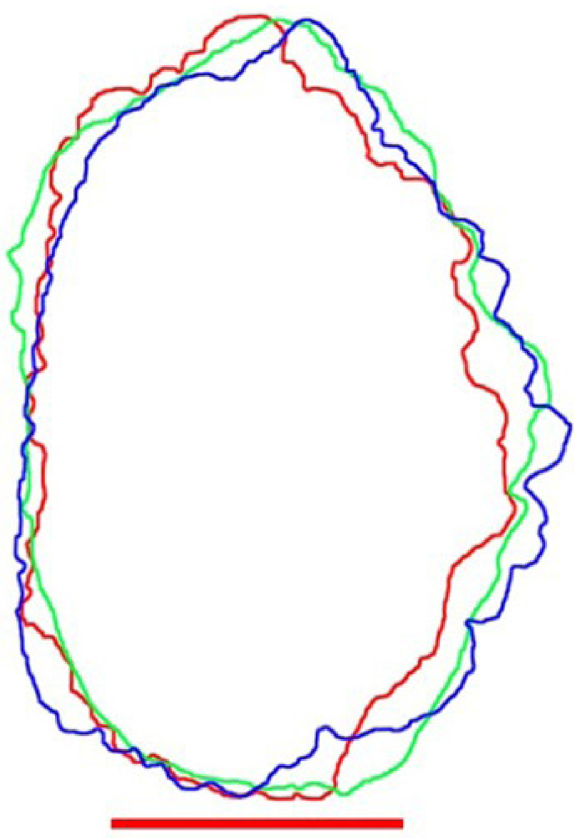

Fig. 6. Comparison of left sagittal otolith shape of genus *Strongylura*–*S. incisa* (green), *S. leiurus* (red), *S. strongylura* (blue) (Scale bar = 1 mm)

clustered with reference sequences KX857492 and ON166056 (India) and MN512105 (Pakistan). The *S. leiurus* sequences (PP833598) clustered with sequences from Pakistan (PP595815), Indonesia (GU674012), Bangladesh (MN083098), and the Philippines (OQ385508). Similarly, *S. incisa* (PP833600) was grouped with reference sequences from the Philippines (OQ387277) and Vietnam (MK777129). Each clade was consistently resolved with no overlap among the three species.

Pairwise genetic distances (K2P model) further supported species-level distinctiveness (Table 4). Minimum interspecific distances were 17.8% between *S. strongylura* and *S. incisa*, 18.0% between *S. strongylura* and *S. leiurus*, and 23.7% between *S. incisa* and *S. leiurus*. These values represent clear genetic gaps among the three taxa and align with species-level divergence thresholds commonly used in teleost COI barcoding studies.

Discussion

Integrated taxonomy has played a pivotal role in resolving species boundaries and revealing cryptic diversity in marine fishes globally (Hata *et al*., 2022; Pante *et al*., 2015; Zarei *et al*., 2022), with similar successes reported from India in both freshwater and marine taxa, including the discovery of new species and resolution of species complexes (Laskar *et al*., 2024; Singh *et al*., 2022; Abdussamad *et al*., 2022; 2023). Within Belonidae, recent integrative work has further refined species limits, highlighting its effectiveness (Toji *et al*., 2024). Despite the ecological and commercial importance of *Strongylura* and the occurrence of its type species (*S. strongylura*) from Indian waters (van Hasselt, 1823), the genus remains taxonomically challenging due to morphological conservatism, overlapping meristic characters, and its reported polyphyletic nature (Mees, 1962; Collette, 1968; Lovejoy, 2000; Banford *et al*., 2004; Lovejoy *et al*., 2004). These issues have led to frequent misidentifications and unclear species boundaries, emphasising the need for an integrative approach. Accordingly, the present study employs combined morphological and molecular analyses to resolve taxonomic ambiguities and provide a comparative account of *S. incisa*, *S. leiurus*, and *S. strongylura* from Indian waters.

Of the 15 recognised species within the genus *Strongylura*, six are restricted to the Atlantic Ocean, including *S. marina*, *S. notata*, *S. forsythia*, *S. timucu*, *S. hubbsi*, and *S. senegalensis* (Collette, 1974). Among the remaining nine species, three species, *S. exilis*, *S. fluviatilis*, and *S. scapularis,* are confined to the eastern Pacific region (Collette, 1999). Of the rest, *Strongylura krefftii* is a strictly freshwater species endemic to freshwater systems of Oceania. *S. incisa*, *S. leiurus*, *S. strongylura*, *S. anastomella*, and *S. urvillii* are primarily distributed in the Indo-Pacific region and share several overlapping morphological traits. To confirm the identities of the three species examined in this study (*S. incisa*, *S. leiurus*, and *S. strongylura*), we compared key meristic and external characters with literature descriptions of the other two taxa (Collette, 1984, 1999; Masuda *et al.*, 1984; Roul *et al.*, 2018). The dorsal fin ray counts ranged from 18-19 in *S. incisa*, 19-20 in *S. leiurus*, and 13-14 in *S. strongylura*, whereas *S. anastomella* showed 17-21 rays and *S. urvillii* 12-15. Anal fin rays were counted as 21-22 in *S. incisa*, 23-24 in *S. leiurus*, 17-18 in *S. strongylura*, 21-25 in *S. anastomella*, and 15-18 in *S. urvillii*. The position of the dorsal-fin origin also varied, occurring between the 4th-5th anal fin rays in *S. incisa*, 7th-8th in *S. leiurus*, 5th-7th in *S. strongylura*, 8th-9th in *S. anastomella*, and 8th-9th in *S. urvillii*. The presence or absence of scales at the base of the dorsal and anal fins was consistent across species: *S. strongylura* and *S. urvillii* retained basal scales, while *S. incisa*, and *S. anastomella* lacked them (Collette, 1984, 1999; Masuda *et al.*, 1984; Roul *et al.*, 2018).

Further differences were observed in vertebral and predorsal scale counts. *S. incisa* exhibited 74-76 vertebrae and 120-128 predorsal scales; *S. leiurus* had 83-85 vertebrae and 169-188 predorsal scales (Collette, 1989; Roul *et al.*, 2018); *S. strongylura* showed 61-63 vertebrae and 115-136 predorsal scales (Collette, 1989; Roul *et al.*, 2018); *S. anastomella* was reported with intermediate values (Masuda *et al.*, 1984), and *S. urvillii* possessed 59-65 vertebrae with similarly low scale counts (Collette, 1983; 1999). Caudal fin morphology was also diagnostic: *S. incisa* and *S. leiurus* displayed emarginate to slightly forked caudal fins; *S. strongylura*, *S. anastomella*, and *S. urvillii* exhibited truncate to rounded caudal fins. Pigmentation traits further supported species distinctions. A dark cheek bar was observed in both *S. incisa* and *S. leiurus*, while *S. strongylura* bore a distinct dark blotch on the caudal peduncle. *S. anastomella* and *S. urvillii* were both unmarked, with *S. urvillii* further distinguished by its combination of unpigmented body, truncate caudal fin, low fin ray counts, and presence of scales at the fin bases (Collette, 1984, 1999; Masuda *et al.*, 1984; Roul *et al.*, 2018). These diagnostic features, taken together, provide clear support for recognising *S. incisa*, *S. leiurus*, and *S. strongylura* as distinct and valid species within the Indian marine fish fauna.

The otolith shape and its distinguishing features are valuable tools in the taxonomy of the genus *Strongylura* from Indian waters. Although Vignon and Morat (2010) demonstrated that otolith contours undergo clear ontogenetic changes in tropical reef fishes, they emphasised that the underlying taxonomic signal remains preserved, allowing reliable species-level discrimination. The analysis of sagittal otoliths reveals key similarities and dissimilarities that can be used to differentiate species (Abdussamad, 2015). While all three species share a basic elongated, oval structure, variations in elongation and marginal characteristics serve as critical distinguishing features. For example, the moderately elongated otolith with smooth, rounded margins of *Strongylura incisa* can be used to differentiate it from the other two species. In contrast, the more compact and rounded otolith of *S. leiurus*, which has noticeably smoother and more symmetrical margins, provides a clear morphological basis for its taxonomic separation. The most unique otolith shape belongs to *S. strongylura*. Its elongated form is accompanied by prominent serrated or jagged edges, offering a distinct and reliable characteristic for species identification within the genus.

The present findings align with the established efficacy of the cytochrome c oxidase subunit I (COI) gene as a robust marker for species identification and delimitation in fishes (Hebert *et al.*, 2003; Ward *et al.*, 2005). The maximum likelihood phylogeny successfully resolved each species into a distinct clade with no overlap. A clear barcode gap was evident, characterised by minimal intraspecific K2P distances (0.0–0.6%) and comparatively high interspecific distances (17.8–23.7%). Although these interspecific values are higher than typically expected for congeneric teleosts, they likely reflect the polyphyletic nature of the genus *Strongylura*, as previously reported (Lovejoy, 2000; Lovejoy and Collette, 2001; Lovejoy *et al.*, 2004), wherein certain species exhibit closer phylogenetic affinities with genera such as *Tylosurus* and *Xenentodon*. This deep lineage divergence may contribute to the elevated genetic distances observed. Furthermore, the strong phylogenetic clustering of our Indian specimens with conspecific sequences from geographically distant regions of the Indo-Pacific (e.g., Pakistan, Indonesia, and the Philippines) not only validates species identification but also supports their broad distribution and genetic cohesion.

The present study establishes the taxonomic distinctness of *Strongylura incisa*, *S. leiurus*, and *S. strongylura* from Indian waters through an integrative approach combining detailed morphometric and meristic analyses with COI-based molecular data. Clear diagnostic differences were observed in fin ray counts, scale patterns, body proportions, and pigmentation, while phylogenetic analyses revealed well-supported clades with high interspecific and low intraspecific genetic divergence. These findings provide a robust framework for species delimitation within the genus and offer essential baseline data for future research on population structure, evolutionary relationships, and species-specific conservation strategies in Indian marine ecosystems. However, the study is based on a representative but limited sample size and geographic coverage, and further extensive sampling is recommended to validate and expand upon these findings.

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Author contributions

Conceptualisation: TT, Methodology: TT., Data Collection: TT., Writing Original Draft: TT., Supervision: TT.; Writing Review and Editing: EMA, BS; Supervision: EMA; Data Amalysis: TT, BS

Data availability

The data are available and can be requested from the corresponding author.

Conflicts of interest

The authors declare that they have no conflict of financial or non-financial interests that could have influenced the outcome or interpretation of the results.

Ethical statement

No ethical approval is required as the study does not include activities that require ethical approval or involve protected organisms/ human subjects/ collection of sensitive samples/ protected environments.

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References

Abdussamad, E. M. 2015. Age determination in fishes using hard parts. ICAR-Central Marine Fisheries Research Institute, p. 87-90.

Abdussamad, E. M., A. Gopalakrishnan, K. G. Mini, S. Sukumaran, P. R. Divya, T. B. Retheesh, and K. D. Jacob. 2022. Description of a new species of queenfish, *Scomberoides pelagicus* from Indian seas. *J. Environ. Biol.*, 43 (1): 105-114.

Abdussamad, E. M., T. B. Retheesh, R. Thangaraja, K. K. Bineesh and D. Prakasan. 2015. *Sphyraena arabiansis* a new species of barracuda (Family: Sphyraenidae) from the south-west coast of India. *Indian J. Fish.*, 62 (2): 1-6.

Al-Salim, N. K. and A. H. Ali. 2007. First record of three hosts infected by the plerocercoid of *Otobothrium penetrans* Linton, 1907 (Cestoda: Trypanorhyncha) in Khor Ummia, Arabian Gulf. *Basrah J. Agric. Sci.*, 20 (1): 16-26.

Aneesh, P. T., K. Sudha, A. K. Helna, K. Arshad, G. Anilkumar and J. P. Trilles. 2013. Simultaneous multiple parasitic crustacean infestation on banded needlefish, *Strongylura leiurus* (Belonidae) from the Malabar Coast, India. *Int. J. Sci. Res. Publ.*, 3 (7): 367-375.

Applied Biosystems 2010. *Sequence Scanner Software v1.0*. Thermo Fisher Scientific, Foster City, CA, USA. Available at: https://www.thermofisher.com

Astakhov, D. A. 2023. Hunting of the reef needlefish *Strongylura incisa* (Belonidae) for small schooling pelagic fishes on shallow lagoonal reefs of Innafushi Mini-Atoll (Indian Ocean, Maldives, Ari Atoll). *J. Ichthyol.*, 63 (4): 843-847.

Banford, H. M., E. Bermingham and B. B. Collette. 2004. Molecular phylogenetics and biogeography of transisthmian and amphi-Atlantic needlefishes (Belonidae: Strongylura and Tylosurus): Perspectives on New World marine speciation. *Mol. Phylogenet. Evol.*, 31 (3): 833-851.

Benson, D. A., K. Clark, I. Karsch-Mizrachi, D. J. Lipman, J. Ostell and E. W. Sayers. 2013. GenBank. *Nucleic Acids Res.*, 42 (Database issue), D32 pp.

Choi, H. Y., T. W. Kim and S. Kim. 2016. The complete mitochondrial genome of the Pacific needlefish *Strongylura anastomella* (Belonidae, Beloniformes) from Korea. *Mitochondrial DNA Part A*, 27 (4): 2479-2480.

Collette, B. B. 1968. *Strongylura timucu* (Walbaum): A valid species of western Atlantic needlefish. *Copeia*, 1968 (1): 189-192.

Collette, B. B. 1974. *Strongylura hubbsi*, a new species of freshwater needlefish from the Usumacinta province of Guatemala and México. *Copeia*, p. 611-619.

Collette, B. B. 1984. Family Belonidae. In: *FAO species identification sheets for fishery purposes. Western Indian Ocean (Fishing Area 51)*, p. 1-8.

Collette, B. B. 1999. Belonidae (needlefishes). In: Carpenter, K. E. & Niem, V. H. (eds.) *FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific*, Bony fishes part 2 (Mugilidae to Carangidae). FAO, Rome, 4: 2151-2161.

Collette, B. B. 2022. Family Belonidae. In: Carpenter, K. E. & De Bruyne, N. (eds.) *Coastal fishes of the Western Indian Ocean*, pls. 63-64. Makhanda: SAIAB, 2: 374-380.

Collette, B. B. and K. E. Carpenter. 2003. Order Beloniformes, Belonidae. In: *The living marine resources of the Western Central Atlantic*, 5: 1104-1115.

Collette, B. B. and J. Su. 1986. The halfbeaks (Pisces, Beloniformes, Hemiramphidae) of the far east. *Proc. Acad. Nat. Sci. Phila.*, 138: 250-302.

Collette, B. B., G. E. McGowen, N. V. Parin and S. Mito. 1984. Beloniformes: development and relationships. In: Moser, H. G. (ed.) *Ontogeny and systematics of fishes*. American Society of Ichthyologists and Herpetologists, Spec. Publ. No. 1, p. 335-354.

Felsenstein, J. 1985. Confidence limits on phylogenies: An approach using bootstrap. *Evolution*, 39 (4): 783-791.

Fricke, R., W. N. Eschmeyer and J. D. Fong. 2025. *Eschmeyer's Catalog of Fishes: Genera/ Species by Family/Subfamily*. California Academy of Sciences. Available at: http://researcharchive.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp (Accessed: 23 May 2025).

Froese, R. and D. Pauly. 2024. *FishBase*. Available at: http://www.fishbase.org (Accessed: 23 May 2025).

Hall, T. A. 1999. BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series*, 41: 95-98.

Hata, H., S. Lavoue and H. Motomura. 2022. *Thrissina katana* sp. nov., a new thryssa from the western Pacific Ocean, and redescription of *Thrissina hamiltonii* (Gray, 1835) (Teleostei: Clupeiformes: Engraulidae). *Mar. Biodivers.*, 52 (1): 11.

Hebert, P. D., A. Cywinska, S. L. Ball and J. R. DeWaard. 2003. Biological identifications through DNA barcodes. *Proc. R. Soc. B: Biol. Sci.*, 270 (1512): 313-321.

Hubbs, C. L. and K. L. Lagler. 1958. *Fishes of the Great Lakes Region* (2nd ed.). Cranbrook Institute of Science Bulletin. 26: 1-213.

Jawad, L. A. and L. Jig. 2017. Comparative osteology of the axial skeleton of the genus *Pampus* (Family: Stromateidae, Perciformes). *J. Mar. Biol. Assoc. U.K.*, 97 (2): 277-287.

Kimura, M. 1980. A simple method for estimating evolutionary rates of base substitutions through comparative studies of nucleotide sequences. *J. Mol. Evol.*, 16 (2): 111-120.

Laskar, B. A., D. Banerjee, S. Chung, H. W. Kim, A. R. Kim and S. Kundu. 2024. Integrative taxonomy clarifies the historical flaws in the systematics and distributions of two *Osteobrama* fishes (Cypriniformes: Cyprinidae) in India. *Fishes*, 9 (3): 87.

Lovejoy, N. R. 2000. Reinterpreting recapitulation: Systematics of needlefishes and their allies (Teleostei: Beloniformes). *Evolution*, 54 (4): 1349-1362.

Lovejoy, N. R. and B. B. Collette. 2001. Phylogenetic relationships of New World needlefishes (Teleostei: Belonidae) and the biogeography of transitions between marine and freshwater habitats. *Ichthyol. Herpetol.*, 2001 (2): 324-338.

Lovejoy, N. R., M. Iranpour and B. B. Collette. 2004. Phylogeny and jaw ontogeny of beloniform fishes. *Integr. Comp. Biol.*, 44 (5): 366-377.

Masuda, H., T. Uyeno and T. Yoshino. 1984. *The fishes of the Japanese Archipelago* . K. Amaoka, & C. Araga (Eds.). Tokyo: Tokai university press. 1: 437.

Mees, G. F. 1962. A preliminary revision of the Belonidae. *Zool. Verh.*, 54 (1): 1-92.

Pante, E., C. Schoelinck and N. Puillandre. 2015. From integrative taxonomy to species description: one step beyond. *Syst. Biol.*, 64 (1): 152-160.

Rameshkumar, G., S. Ravichandran and K. Sivasubramanian. 2014. A new record of parasitic isopod for the Indian fauna (*Mothocya karobran* Bruce, 1986) from *Strongylura strongylura* in the Pazhayar region, Southeast coast of India. *J. Parasit. Dis.*, 38 (3): 328-330.

Ratnasingham, S. and P. D. Hebert. 2007. BOLD: The Barcode of Life Data System (http://www.barcodinglife.org). *Mol. Ecol. Notes*, 7 (3): 355-364.

Roul, S. K., R. Kumar, S. Rahangdale, T. B. Retheesh, E. M. Abdussamad, P. Rohit and A. K. Jaiswar 2019. Extending geographical distribution range of reef needlefish *Strongylura incisa* (Valenciennes, 1846) (Teleostei: Beloniformes: Belonidae) in the Eastern Indian Ocean with a key to the species of needlefish occurring in the area. *Thalassas*, 35: 209-214.

Roul, S. K., T. B. Retheesh, U. Ganga, E. M. Abdussamad, P. Rohit and A. K. Jaiswar. 2018. Length-weight relationships of five needlefish species from Kerala waters, south-west coast of India. *J. Appl. Ichthyol.*, 34 (1): 190-192.

Sabrah, M. M., A. M. Amin and A. O. Attia. 2018. Family Belonidae from the Suez Canal, Egypt: Age, growth, mortality, exploitation rate and reproductive biology. *Egypt. J. Aquat. Res.*, 44 (1): 29-35.

Sheikh, G. F., P. Bamnelkar and P. C. Mankodi. 2022. The occurrence and redescription of cymothoids (Wägele, 1989) parasites in commercially available fishes from markets of Vadodara, Gujarat, India. *Int J. Entomol. Res.*, 7: 49-54.

Singh, M., T. K. Jayakumar, T. T. A. Kumar, S. Murali, A. Mishra, A. Singh and K. K. Lal. 2022. Integrative taxonomy-based discovery of *Dussumieria modakandai* sp. nov. from India. *J. Fish Biol.*, 100 (1): 268-278.

Tamura, K., G. Stecher and S. Kumar. 2021. MEGA11: molecular evolutionary genetics analysis version 11. *Mol. Bio. Evol*, 38: 3022-3027.

Thomas, T., E. M. Abdussamad, T. M. Amrutlal, E. Tomy and A. A. Mohammed. 2024. Distribution and diversity of needlefishes (Belonidae) and halfbeaks (Hemiramphidae) of the order Beloniformes in India. *J. Mar. Biol. Assoc. India*, 66 (2): 41-52.

Thomas, T., E. M. Abdussamad, B. Sijad, S. George and T. B. Retheesh. 2025. Confirming the occurrence of two fish (Family: Hemiramphidae) species, *Euleptorhamphus viridis* (van Hasselt, 1823) and *Oxyporhamphus micropterus* (Valenciennes, 1847) by morpho-meristic and molecular characterization from the Indian Coast. *Mar. Biodivers.*, 55 (3): 48.

Thompson, J. D., T. J. Gibson and D. G. Higgins. 2003. Multiple sequence alignment using ClustalW and ClustalX. *Curr. Protoc. Bioinform*, 1: 2-3.

Toji, T., E. M. Abdussamad, S. Ameri, B. Sijad and K. K. Sajikumar. 2024. An integrative taxonomic study on needlefishes (Belonidae) unveils two new species within the genus *Ablennes* from the Indian Ocean. *Reg. Stud. Mar. Sci.*, 74: 103522.

Vignon, M. and F. Morat. 2010. Environmental and genetic determinant of otolith shape revealed by a non-indigenous tropical fish. *Mar. Ecol. Prog. Ser.*, 411: 231-241.

Ward, R. D., T. S. Zemlak, B. H. Innes, P. R. Last and P. D. Hebert. 2005. DNA barcoding Australia's fish species. *Philos. Trans. R. Soc. B: Biol. Sci.*, 360 (1462): 1847-1857.

Yankova, M., V. Raykov, P. Ivanova, N. Dzhembekova, C. Turan and Y. Raev. 2023. Morphological and genetic characteristics of garfish *Belone belone* (L., 1760) (Belonidae, Teleostei) population from the southern Bulgarian Black Sea coast. *Nat. Conserv.*, 54: 1-12.

Zarei, F., S. M. A. Jufaili and H. R. Esmaeili. 2022. *Oxyurichthys omanensis* sp. nov., a new Eyebrow Goby (Teleostei: Gobiidae) from Oman. *Zootaxa*, 5182 (4): 361-376.