

Ascetoaxinus ravichandrani sp. nov., a new species of deep-water Thyasiridae (Mollusca: Bivalvia) from the northern Indian Ocean

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Abstract. A new species of deep-sea thyasirid (Bivalvia: Thyasiridae), *Ascetoaxinus ravichandrani* sp. nov., is described and illustrated from material collected in the northern Indian Ocean during the FORV *Sagar Sampada* deep-sea cruise no. 404. Specimens were collected from a depth between 1007 m and 1038 m off Kanyakumari, Gulf of Mannar, Tamil Nadu, South India. This is the first record of the genus *Ascetoaxinus* from the Indo-West Pacific. The new species is compared to *A. quatsinoensis* P.G. Oliver & Frey, 2014 from the Northeast Pacific and *A. ovoideus* (Dall, 1890) from the Northwest Atlantic. It can be distinguished from these species by its external shell characters. Further comparisons are made between the new species and other larger thyasirids recorded from deep waters around India, notably *Channelaxinus investigatoris* E.A. Smith, 1895. The distinctions and similarities among these species are discussed, highlighting the key features that set *A. ravichandrani* apart from related species.

Key words. Deep Ocean Mission, Samudrayaan program, taxonomy, marine biology, Gulf of Mannar

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INTRODUCTION

The family Thyasiridae, established by Dall (1900), encompasses 21 genera and 140 species (MolluscaBase Eds 2024). They are commonly found in deep-sea environments down to hadal depths exceeding 10,000 m (Kamenev 2023a). Most of the larger species are chemosymbiotic and typically live in cold-seep environments (Taylor & Glover 2010). Conchologically, thyasirids characteristically have thin, fragile, translucent or opaque shells that are rather featureless and poorly sculptured but often posteriorly sinuate.

Deep-water molluscs from around India were first collected by the exploring expeditions of the late 19th century, mostly during the voyages of HMS *Investigator*. Two species, *Channelaxinus investigatoris* (E.A. Smith, 1895) and *Thyasira acuticarinata* (E.A. Smith, 1895), were described from southern India and Sri Lanka (Smith 1895; Oliver 2015; Subba Rao 2017). Several species have been recorded from the Arabian Sea (Oliver 2015), south of Oman and off Pakistan, including *Leptaxinus indusarium* P.G. Oliver & Levin, 2006, *Thyasira anassa* P.G. Oliver, 2015, *Parathyasira bam-*

beri P.G. Oliver, 2015, *Axinulus* aff. *croulinensis* (Jeffreys, 1847), and *Mendicula* aff. *ferruginosa* (Forbes, 1844). Recent deep-sea exploratory surveys conducted by the Indian vessel FORV *Sagar Sampada* have obtained deep-sea samples from the northern Indian Ocean. Amongst these were examples of a relatively large, oblique, strongly sinuate thyasirid with affinities to the genera *Conchocele* Gabb, 1866, *Channelaxinus* Valentich-Scott & Coan, 2012, and *Ascetoaxinus* P.G. Oliver & Frey, 2014. The presence of a toothed margin around the lunule suggests affinity to *Ascetoaxinus*. The genus *Ascetoaxinus*, was erected to include two species, neither of which have been recorded from the Indian Ocean (Oliver & Frey 2014). We describe the Indian shells as a new species, *Ascetoaxinus ravichandrani*. Comparisons are made with *A. quatsinoensis* P.G. Oliver & Frey, 2014 from the Northeast Pacific and *A. ovoideus* (Dall, 1890) from the Northwest Atlantic.

MATERIALS AND METHODS

The specimens of *Ascetoaxinus ravichandrani* sp. nov. were collected during deep-sea exploratory fishery surveys con-

ducted by the FORV *Sagar Sampada* operated by the Centre for Marine Living Resources and Ecology (CMLRE) and part of the Deep Ocean Mission (Samudrayaan program). The collection took place in the Gulf of Mannar (northern Indian Ocean), off Kanyakumari, Tamil Nadu, South India. The specimens were acquired using an epibenthic dredge pulled at a speed of 2.5 knots, starting at 07°24.367'N, 076°46.889'E and ending at 07°29.623'N, 076°45.144'E, at depths of 1007–1038 m. Five paired shells and six single right valves were collected from the locality. All were dead shells, and no soft parts were available for study. Cleaned samples were photographed, and shell length (SL), shell height (SH), timidity (thickness) of a single valve (t), lunule length (lun), ligament length (lig), and anterior adductor-muscle-scar length (aa) were measured in millimetres (mm) using digital vernier callipers. The holotype, paratypes, and additional non-type materials were photographed using a Fujifilm GFX 100s mirrorless camera equipped with a 120 mm microlens. The high-resolution three-dimensional micro-computed tomography (micro-CT) of holotype material was performed under the following conditions: FOV 36 mm, using a copper–aluminium filter, and at high-resolution mode for 14 min, and 3D images were captured in the Quantum GX2 micro-CT imaging system. The samples are stored at the National Zoological Collections of CMLRE, Cochin, India. Identifications of the specimens were made using Oliver & Frey (2014), Oliver (2015), and Huber (2015). A map showing the type localities of *Ascetoaxinus* species (Fig. 1) was generated using <https://www.geomapapp.org>. A diagrammatic representation (Fig. 2) of the morphometric measurements was adapted from Oliver & Frey (2014).

Abbreviations of collections: CMLRE = Centre for Marine Living Resources and Ecology, Kochi, India; IO/SS/BIV = Indian Ocean Biodiversity Information System, FORV *Sagar Sampada*, bivalves (sample number); NMWZ = National Museum of Wales, Cardiff, Wales, UK; RBCM = Royal British Columbia Museum, Victoria, Canada; USNM = Smithsonian National Museum of Natural History, Washington DC, USA; ZSI = Zoological Survey of India, Kolkata, India

Abbreviations of shell characters: aa = anterior adductor scar; h = height; l = length; lig = ligament; lun = lunule; pa = posterior adductor scar; pds = posterior dorsal sinus; sms = submarginal sulcus; ss = submarginal sinus.

SYSTEMATICS

Order Lucinida J.E. Gray, 1854

Superfamily Thyasiroidea Dall, 1900 (1895)

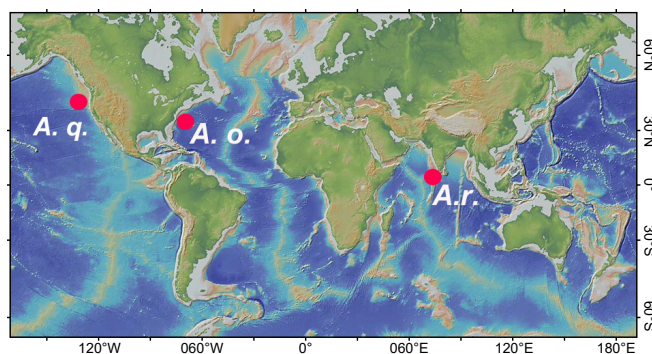


Figure 1. Geographical distribution of the genus *Ascetoaxinus*: A.q. = *Ascetoaxinus quatsinoensis*; A.o. = *A. ovoideus*; A.r. = *A. ravichandrani*.

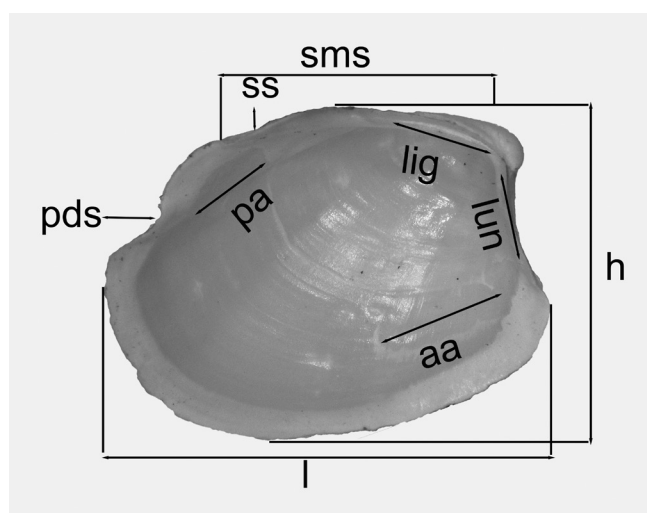


Figure 2. Diagram showing the morphometric measurements of the shell. Abbreviations: aa = anterior adductor scar; h = height; l = length; lig = ligament; lun = lunule; pa = posterior adductor scar; sms = submarginal sulcus; pds = posterior dorsal sinus; ss = submarginal sinus.

Family Thyasiridae Dall, 1900 (1895)

Genus *Ascetoaxinus* P.G. Oliver & Frey, 2014

Type species. *Ascetoaxinus quatsinoensis* P.G. Oliver & Frey, 2014. Fig. 2A–D. Holotype: RBCM 010-00221-005.

Ascetoaxinus ravichandrani sp. nov.

Figures 3, 4, 5I–K

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Type locality. Gulf of Mannar (northern Indian Ocean), off Kanyakumari, Tamil Nadu, South India; 07°24.367'N, 076°46.889'E; dredged at 1007–1038 m; 4 April 2024; leg. R. Ravinesh.

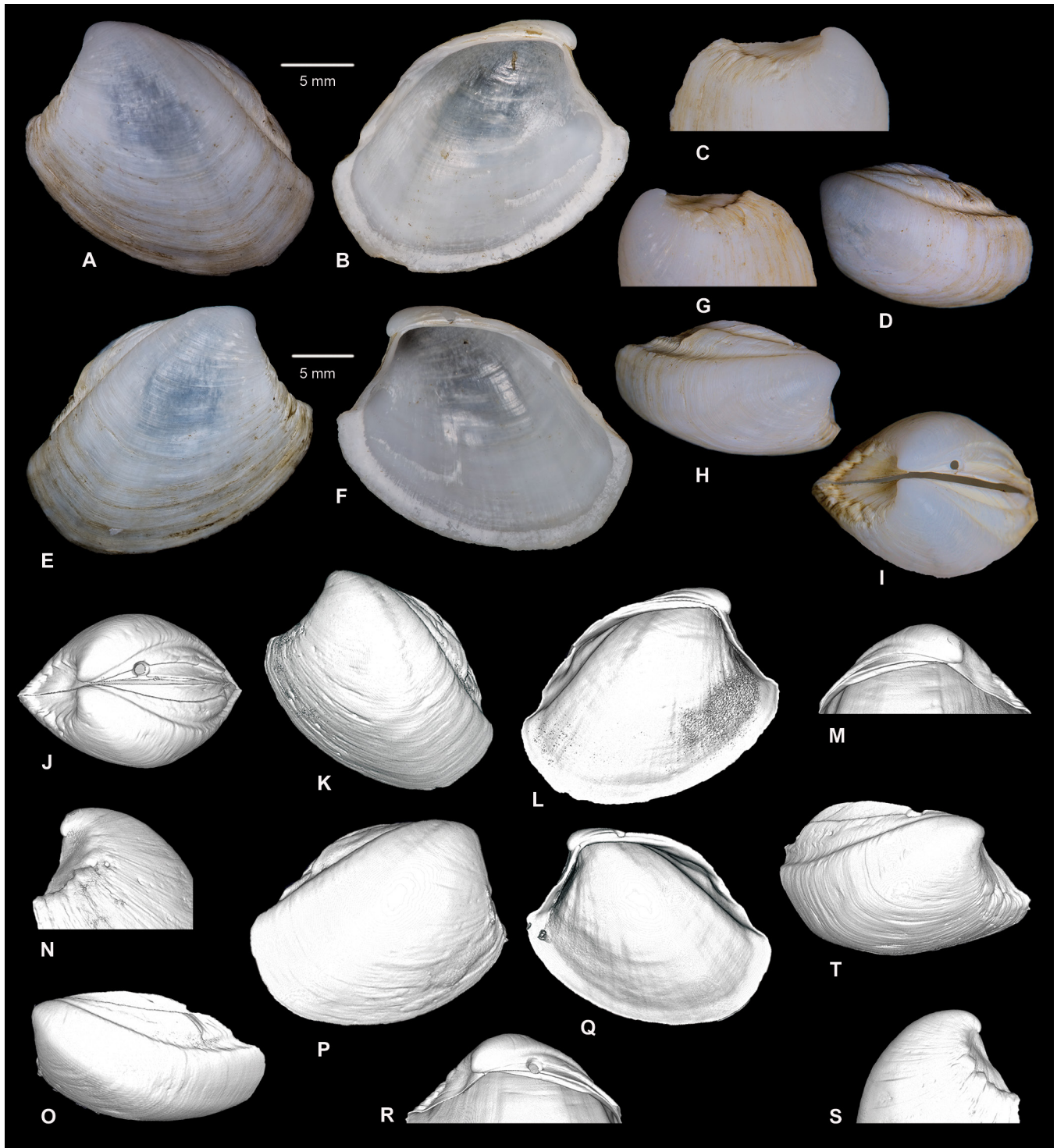


Figure 3. *Ascetoaxinus ravichandrani* sp. nov., holotype (IO/SS/BIV/00001). A–I, under normal photography: (A) external view of left valve; (B) internal view of left valve; (C) edge of lunule and projections of left valve; (D) oblique dorsal view of left valve showing posterior and submarginal sulci; (E) external view of right valve; (F) internal view of right valve; (G) edge of lunule and projections of right valve; (H) oblique dorsal view of right valve showing posterior and submarginal sulci; (I) dorsal margin and view of lunule. J–T, false-colour volume-rendering using micro-CT: (J) dorsal margin and view of lunule and ligament; (K) external view of left valve; (L) internal view of left valve; (M) oblique view of left valve lunule; (N) edge of lunule and projections of left valve; (O) oblique dorsal view of left valve showing posterior and submarginal sulci; (P) external view of right valve; (Q) internal view of right valve; (R) oblique view of right valve lunule; (S) edge of lunule and projections of left valve; (T) oblique dorsal view of left valve showing posterior and submarginal sulci.

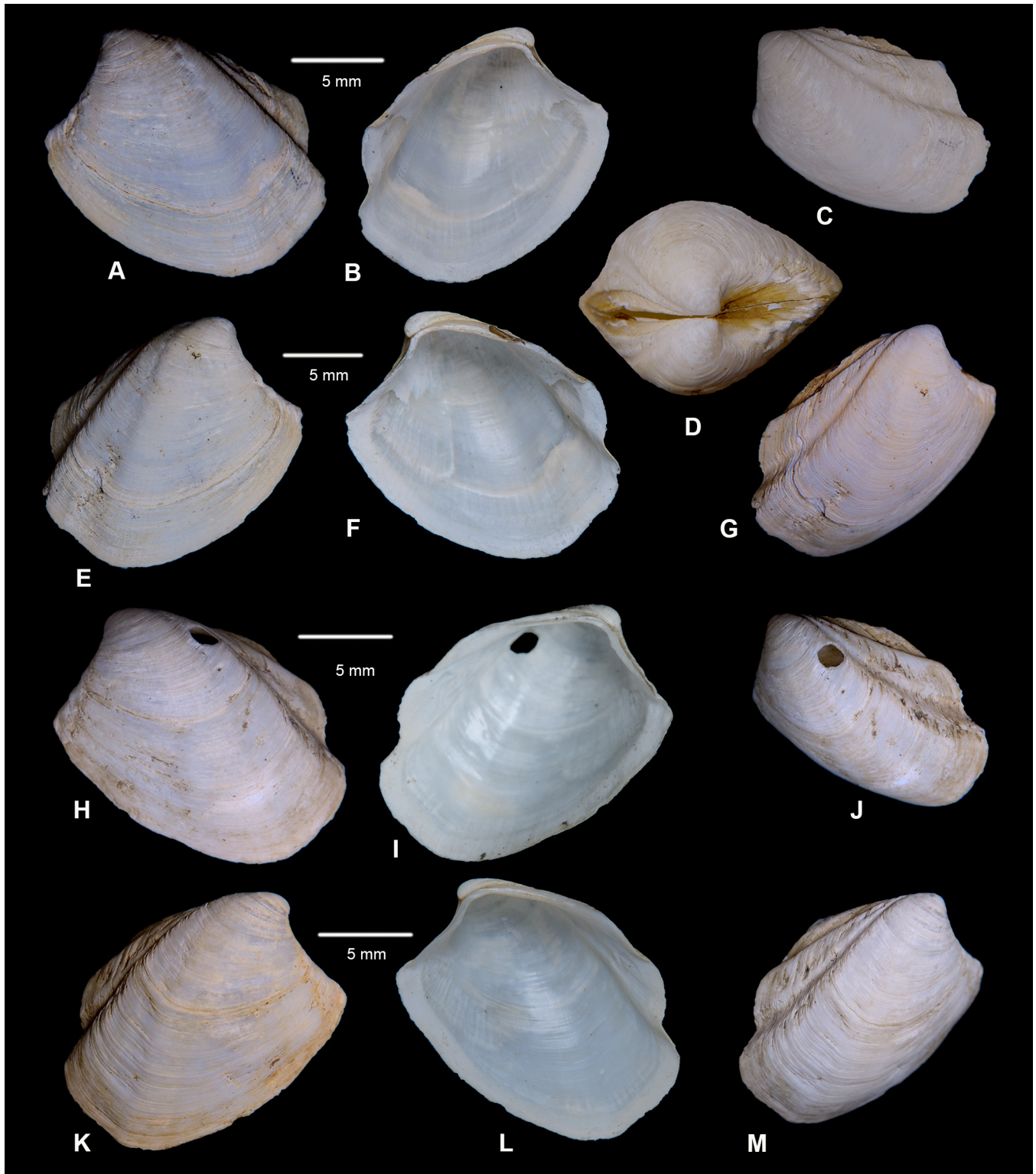


Figure 4. *Ascetoaxinus ravichandrani* sp. nov. **A–G**, paratype 1 (IO/SS/BIV/00002): (**A**) external view of left valve; (**B**) internal view of left valve; (**C**) oblique dorsal viewing of left valve posterior and submarginal sulci; (**D**) dorsal margin and view of lunule and ligament; (**E**) external view of right valve; (**F**) internal view of right valve; (**G**) oblique dorsal viewing of right valve posterior and submarginal sulci. **H–M**, paratype 2 (IO/SS/BIV/00003): (**H**) external view of left valve; (**I**) internal view of left valve; (**J**) oblique dorsal viewing of left valve posterior and submarginal sulci; (**K**) external view of right valve; (**L**) internal view of right valve; (**M**) oblique dorsal viewing of right valve posterior and submarginal sulci.

Materials examined. Holotype (Fig. 3): 1 complete shell, dead collected; IO/SS/BIV/00001.

Paratypes: from the type locality; dead collected. Paratype 1 (Fig. 4A–G): IO/SS/BIV/00002 Paratype 2 (Fig. 4H–M): IO/SS/BIV/00003.

Non-type material: from the type locality; 2 complete shells and 6 right valves, all dead collected; IO/SS/BIV/00004.

Diagnosis. Shell medium-sized, thin, brittle, translucent, equivalve, strongly inequilateral. Beaks prosogyrous, close to anterior margin. Outline obliquely oval. Anterior margin steeply sloping, almost straight, bounding deeply impressed lunule with toothed margin. Edge of lunule with six weakly rounded projections. Shell surface with well-defined growth lines. Ligament partially sunken. Posterior sulcus sharply defined; submarginal sulcus distinct; escutcheon medially raised. Hinge teeth lacking.

Description. Shell to 21.8 mm long, very thin, brittle, translucent, equivalve, moderately tumid, strongly inequilateral. Beaks prosogyrate located close to anterior margin. Outline obliquely subovate; anterior margin almost straight, bounding a large excavated lunule with toothed margin; ventral margin long, almost straight; posterior margin broad, sulcate. Posterior dorsal sinus distinct; submarginal sinus indistinct. Posterior sulcus sharply defined, relatively narrow; submarginal sulcus clearly delineates a raised escutcheon. Posterior ventral slope, located anterior to posterior

sulcus, slightly flattened, creating a weak secondary ridge. Hinge teeth lacking; ligament partially sunken, relatively short, its length less than half that of escutcheon. Sculpture of well-defined growth lines; lunule margin with six weak, rounded teeth. Adductor-muscle scars prominent; anterior scar elongate, mostly separate from pallial line, parallel to ventral margin; posterior scar ovate. Shell creamy-white or white.

All specimens were dead collected, and no preserved soft parts were available for study.

Remarks. The strongly oblique outline and deeply excavated lunule with toothed margin and weakly rounded projections in the new species allies it to the genus *Ascetoaxinus*. Only three species of *Ascetoaxinus* are known, and *A. ravichandrani* is the first to be recognised from the Indo-Pacific Ocean. The new species differs from the two other *Ascetoaxinus* species by its more pronounced escutcheon. From the Atlantic *A. ovoideus* the new species a greater number of lunule teeth, and from the Northeast Pacific *A. quatsinoensis* it differs having the lunule teeth less developed.

The only other large obliquely outlined thyasirid in the western Indian Ocean is *Channelaxinus investigatoris*, but that species lacks teeth around the lunule, has a straight, slightly sulcate anterior margin, and has a distinct median flattening of the shell (Fig. 6A–D). *Channelaxinus* aff. *excavatus* (Dall, 1901), illustrated by Oliver (2014) from the Oman Margin, is not oblique and lacks the rimmed lunule margin (Fig. 6E, F). The differences are summarised in Table 2.

Table 1. Morphological measurements of *Ascetoaxinus ravichandrani* sp. nov. and comparison with other *Ascetoaxinus* species. Specimens 1–6 are non-type material.

Species	Shell Length (SL), mm	Shell Height (SH), mm	Timidity Single valve, mm	Lunule length (lun), mm	Ligament length (lig), mm	Anterior adductor scar length (aa), mm
<i>A. ravichandrani</i> sp. nov.						
Holotype	21.8	16.1	6.2	4.1	6.2	6.0
Paratype 1	15.5	11.0	4.6	3.3	3.9	3.6
Paratype 2	15.9	9.6	4.1	3.6	4.1	3.8
Specimen 1	14.9	9.5	3.8	3.3	3.8	3.4
Specimen 2	15.0	9.6	3.9	3.4	3.9	3.6
Specimen 3	15.6	10	4.0	3.5	3.8	3.5
Specimen 4	15.0	9.6	3.9	3.4	3.9	3.6
Specimen 5	15.0	9.5	3.8	3.4	3.9	3.6
Specimen 6	14.1	9.0	3.7	3.1	3.6	3.1
<i>Ascetoaxinus ovoideus</i>						
Holotype	25	20	14	—	—	—
<i>Ascetoaxinus quatsinoensis</i>						
Holotype	31.3	24.3	9.7	12.0	9.7	10.5

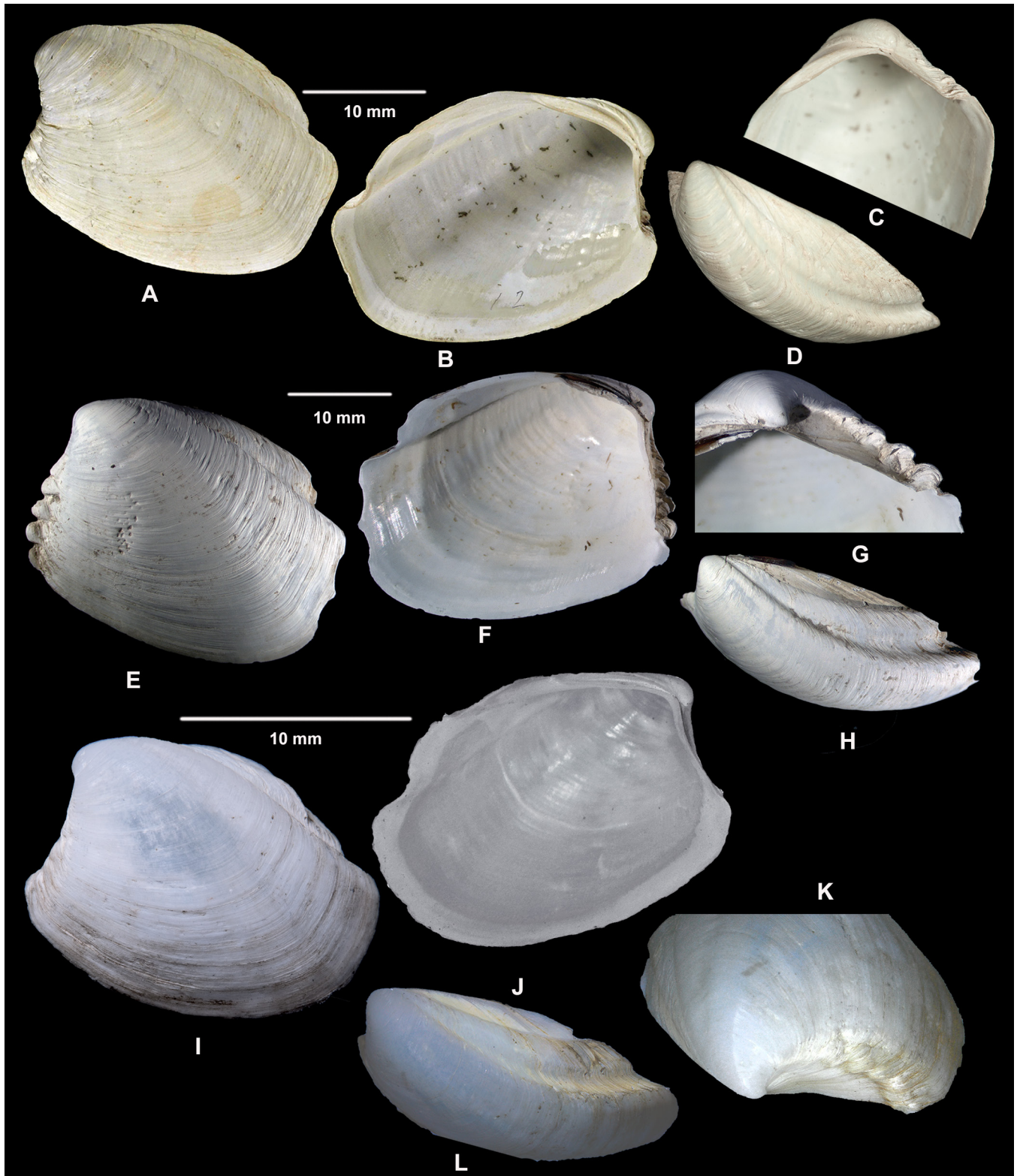


Figure 5. Shells of *Ascetoaxinus* species. **A–D**, *A. ovoideus* (USNM 64226): **(A)** external of left valve; **(B)** internal of left valve; **(C)** oblique view of lunule; **(D)** oblique dorsal view showing posterior and submarginal sulci. **E–H**, *A. quatsinoensis* (RBCM 010-00221-005): **(E)** external of left valve; **(F)** internal of left valve; **(G)** oblique view of lunule; **(H)** oblique dorsal view showing posterior and submarginal sulci. **I–L**, *A. ravichandrani* sp. nov., non-type material (IO/SS/BIV/00004): **(I)** external view of left valve; **(J)** internal view of left valve; **(K)** oblique view of lunule; **(L)** oblique dorsal view showing posterior and submarginal sulci.

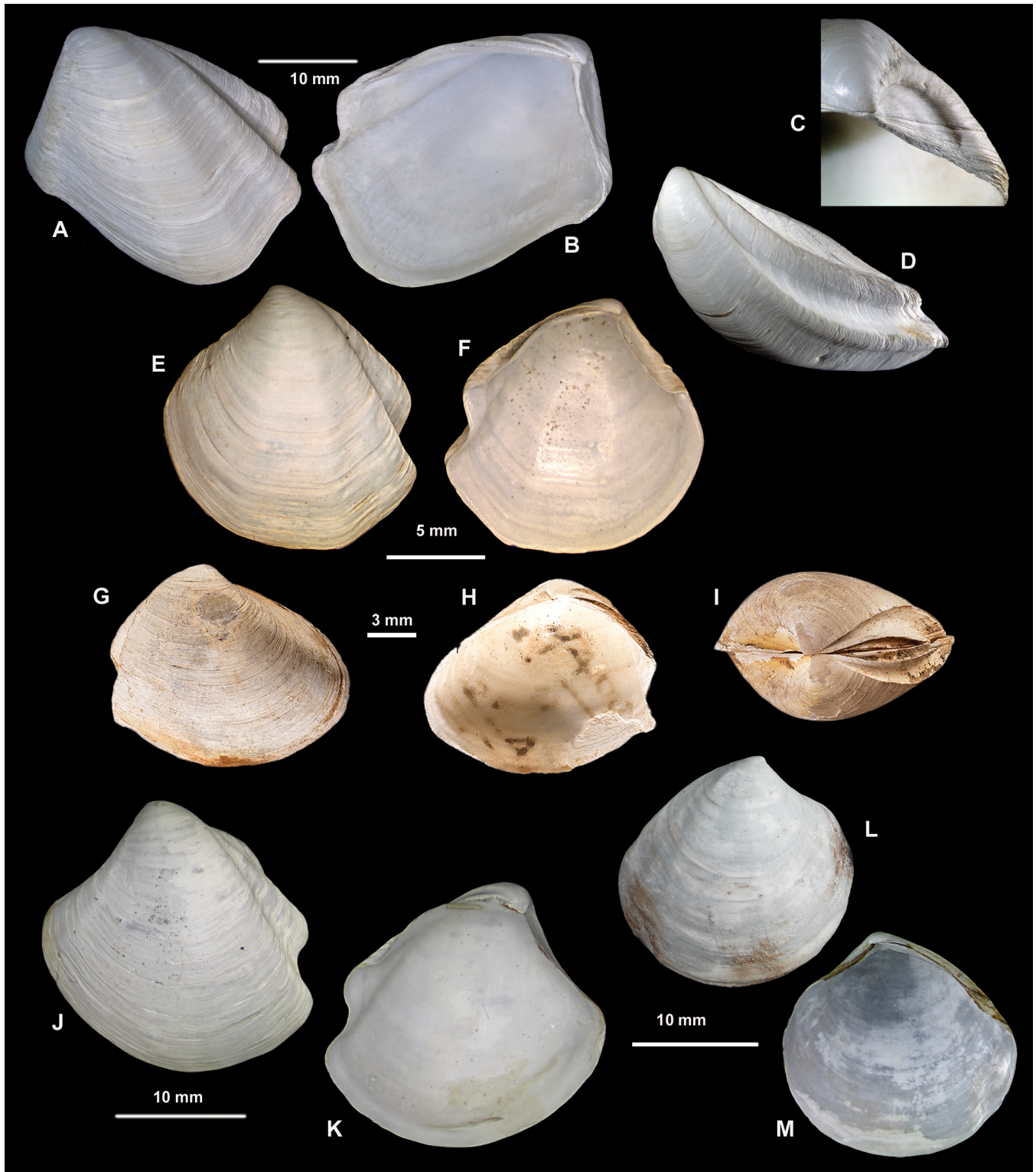


Figure 6. Larger thyasirids in the western Indian Ocean. **A–D**, *Channelaxinus investigatoris* (NMWZ 1955.158.11399): (**A**) external of left valve; (**B**) internal of left valve; (**C**) oblique view of lunule; (**D**) oblique dorsal view showing posterior and submarginal sulci. **E, F**, *C. aff. excavatus*: (**E**) external of left valve; (**F**) internal of left valve. **G–I**, *Thyasira acuticarinata*, holotype (ZSI M 224/1): (**G**) external of right valve; (**H**) internal of left valve; (**I**) dorsal margin and view of lunule and ligament. **J, K**, *T. anassa* (NMW.Z.1995.009.15): (**J**) external view of right valve; (**K**) internal view of right valve. **L, M**, *Parathyasira bamberi* (NMW.Z.1995.009.13): (**L**) external view of right valve; (**M**) internal view of right valve.

Table 2. Geographical distributions and morphological comparisons within the genus *Ascetoaxinus* and larger thyasirids in the northern Indian Ocean.

	<i>A. ravichandrani</i> sp. nov.	<i>A. ovoideus</i>	<i>A. quatsinoensis</i>	<i>Chandelaxinus investigatoris</i>	<i>Chandelaxinus</i> aff. <i>excavatus</i>
Geographical distribution	Gulf of Mannar, off Kanyakumari, South India (northern Indian Ocean)	North Carolina, USA (Northwest Atlantic Ocean)	Vancouver Island, British Columbia, Canada (Northeast Pacific Ocean)	South India, Off Kanyakumari to Gulf of Mannar (Northern Indian Ocean)	Off Oman Margin (Northern Indian Ocean)
Maximum l (mm)	21.8	25.0	31.3	40.0	11.0
Maximum h (mm)	16.1	20.0	24.3	—	11.5
Shell structure	Translucent	Opaque	Opaque	Robust	Opaque
Symmetry	Strongly inequilateral	Strongly inequilateral	Strongly inequilateral	Strongly inequilateral	Equilateral
Shell outline	Obliquely subovate	Obliquely oval	Obliquely oval	Obliquely polygonal	Polygonal
Anterior margin	Steeply sloping	Steeply sloping	Steeply sloping	Steeply sloping	Broadly curving
Lunule	Deeply impressed	Large excavated	Deeply impressed	Deeply excavated	Impressed
Edge of the lunule	Six weakly rounded projections	Two rounded projections	Five rounded projections	Smooth, rounded ridge, not toothed	Low not toothed
Surface sculpture	Well-defined growth lines	Well-defined growth lines	Well-defined growth lines	Multi-contoured lines	Commarginal growth lines and weak ridges
Ligament	Partially sunken	Partially sunken	Partially sunken	Partially sunken	Partially sunken
Posterior sulcus	Sharply defined	Sharply defined	Sharply defined	Prominent defined by rounded carina	Sharply defined
Submarginal sulcus	Distinct, escutcheon medially raised	Distinct, escutcheon not raised	Distinct, escutcheon not raised	sharply defined, escutcheon a little raised	Distinct, narrow
Hinge teeth	Lacking	Lacking	Lacking	Lacking	Lacking
Muscle scar	Prominent	Prominent	Indistinct	Weakly developed	Small
Shell colour	Creamy-white	Creamy-white	White	Chalky white	Creamy white

Other larger thyasirids recorded from the western Indian Ocean include *Thyasira acuticarinata* (E.A. Smith, 1895) (Fig. 6G–I), *T. anassa* P.G. Oliver, 2014 (Fig. 6J, K), and *Parathyasira bamberi* P.G. Oliver, 2014 (Fig. 6L, M). None of these species have an excavated, rimmed lunule. *Thyasira acuticarinata* is an atypical thyasirid in being expanded anteriorly and is similar to *T. borshengi* Okutani & Lan, 1999 from Japan. *Thyasira anassa* is trigonal, while *P. bamberi* has a scabrous texture.

Distribution. Known only from the type locality.

Etymology. The species is named in honour of Dr Muthalagu Ravichandran, Secretary, Ministry of Earth Sciences, India. He is the coordinator of the Deep-Sea Biodiversity Exploration and Conservation program and a renowned physical oceanographer and meteorologist in India.

DISCUSSION

The malacofauna of the deep waters around India remains largely unexplored, and there is a need for focused research to describe and document the taxonomic diversity (Biju Kumar & Ravinesh 2015; Patterson Edward *et al.* 2022). Most deep-sea molluscs were described as a result of expeditions of HMS *Investigator* (1881–1906) and the Royal Indian Marine Ships (1892–1934). *Channelaxinus investigatoris* and *Thyasira acuticarinata* were described from southern India and Sri Lanka (Smith 1895; Oliver 2015; Subba Rao 2017), and much later Oliver (2006; 2015) recorded several thyasirid species from the Arabian Sea off Oman and Pakistan, namely *Leptaxinus indusarium* P.G. Oliver & Levin, 2006, *Thyasira anassa* P.G. Oliver, 2015, *Parathyasira bamberi* P.G. Oliver, 2015, *Axinulus* aff. *croulinensis* (Jeffreys, 1847), and *Mendicula* aff. *ferruginosa* (Forbes, 1844). The diversity of thyasirids in the Indian Ocean is much less than that recorded from the Pacific and Atlantic oceans (Kamenev 2023b). Allen (2008) enumerated more than 75 species living at depths greater than 500 m in the deep Atlantic, and 30 of these were recorded from abyssal depths. This suggests that the Indian Ocean is understudied and that many more species may be encountered with further sampling.

Thyasirids inhabit both oligotrophic and chemosynthetic environments, and *Ascetoaxinus* is associated with the latter. The discovery of *A. ravichandrani* sp. nov. in the Indian Ocean suggests that this genus has a global distribution, but associated with cold methane seeps. This poses interesting questions about the evolution and dispersal of seep-asso-

ciated taxa. Such seemingly isolated occurrences suggest that *Ascetoaxinus* may be overlooked or have an unusual dispersal history. Similar questions have been posed about the dispersal of deep-sea vent- and seep-dwelling Bathymodiolinae (Mytilidae) (Kyuno *et al.* 2009), and there is much less known on this group, too, in the Indian Ocean. While cold methane seeps are known in Indian waters, such as that in the Bay of Bengal (Sandogkar *et al.* 2023), their faunas remain taxonomically understudied.

Addressing these challenges through increased exploration, improved technologies, and focused conservation efforts can help uncover the true diversity of thyasirids, and bivalves in general, in this vast and underexplored ocean basin. Further research and exploration are needed to fully understand the diversity, distribution, and ecological significance of thyasirids across different habitats within the Indian Ocean. Such efforts are crucial for informing conservation strategies to protect these unique and often overlooked components of marine biodiversity.

The latest discovery of a deep-sea thyasirid provides a valuable addition to the ongoing Deep Ocean Mission (Samudrayaan program) and contributes to our understanding of the natural world and underscores the importance of conserving deep-sea environments. This discovery represents a significant milestone for the future of Indian malacological research, and we suggest that additional deep-sea biological surveys off India will uncover new species, or rediscover previously described ones.

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