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Description of a new species of hound shark of the genus *Iago* (Carcharhiniformes: Triakidae) from the northern Indian Ocean

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Abstract

Sharks of the genus *Iago* Compagno and Springer, 1971 (Carcharhiniformes: Triakidae) that commonly occur in the deep waters of the Indo-Pacific, are an interesting group phylogenetically. Currently, three nominal species of *Iago* are known globally, namely, *Iago garricki*, *I. omanensis* and *I. mangalorensis*. In this study, we describe a new species of hound shark, *Iago gopalakrishnani* sp. nov. from the deep waters of eastern Arabian Sea, India. *Iago gopalakrishnani* sp. nov. is distinct in its dark chocolate brown to blackish colouration and low fins; pre-oral length 4.7–6% TL, 22.4-25% head length; first dorsal height 5.8-7% TL, first dorsal length 10.6–14.1% TL, first dorsal base length 6.7-9.8% TL, second dorsal length 8.9-10.9% TL and vertebral counts 117-123. *Iago gopalakrishnani* sp. nov. is genetically distinct from congeners. COI based analysis of *Iago gopalakrishnani* sp. nov formed a distinct clade in phylogenetic reconstruction with a genetic distance of 4.5-5.2% when comparing K2P parameters with congeners.

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Introduction

Sharks of the genus *Iago* Compagno and Springer, 1971 (Carcharhiniformes: Triakidae), known as houndsharks, are small deep-water sharks (less than 1 m TL in size) that are widely distributed in tropical waters of the Indo-Pacific region and inhabit continental shelves and upper continental slopes. Currently, this genus comprises three nominal species, *Iago garricki* Fourmanoir and Rivaton, 1979, from the South China Sea to Australia; *Iago omanensis* (Norman, 1939) from the Red Sea to the south-eastern Arabian Sea, India and *Iago mangalorensis* (Cubelio, Remya and Kurup, 2011) described from the south-eastern Arabian Sea with an uncertain status (Ebert *et al,* 2013; Akhilesh *et al.,* 2014; Fernando *et al.,* 2019; Ebert *et al.,* 2021; Ng *et al.,* 2022), warranting further investigation. Genus *Iago* contains species complexes with lookalike species with high genetic variability from different geographic locations covering different habitats of the northern Indian Ocean (Naylor *et al.,* 2012; Henderson *et al.,* 2016; Fernando *et al.,* 2019; Ebert *et al.,* 2021; Haque *et al.,* 2021; James and Ebert, 2022).

Compagno (1988) provided a detailed account of the taxonomic complexity of *Iago* and suggested the need for a major revision in the family. The *Iago* complex in the northern Indian Ocean contains at least 3-5 species, according to the biogeography of the region, Oman (2), the Red Sea (1), Pakistan (2-3), India and Sri Lanka (3-4) (Compagno, 1984; 1988; Moron *et al.,* 1999; Compagno *et al.,* 2005; Naylor *et al.,* 2012; Psomadakis *et al.,* 2015; Henderson *et al.,* 2016; Bineesh *et al.,* 2017) and the Bay of Bengal (Psomadakis *et al.,* 2020; Sen *et al.,* 2020; Haque *et al.,* 2021). The taxonomy of the genus *Iago* is complicated due to its undescribed diversity and poor resolution in the species complex (Fernando *et al.,* 2019; James and Ebert, 2022). Historically, *Iago* species complex in the northern Indian Ocean region has often been misidentified or being reported

as *Mustelus* sp., *M. mangalorensis*, *Iago omanensis* or *Iago* cf. *omanensis* and *Hypogaleus hyugaensis* due to poor taxonomic resolution (Nair and Lal Mohan, 1973; Manojkumar, 2010; Padate *et al.,* 2017; Sen *et al.,* 2020). In this study, we describe *Iago* sp. A. of Bineesh *et al.* (2017), as a new species, *Iago gopalakrishnani* sp. nov. from the northern Indian Ocean.

Materials and methods

Morphological analysis and species description

Specimens of *Iago gopalakrishnani* sp. nov were collected from the landings of deep-sea shrimp trawlers operated at deep waters off south-west India at 300-400 m depths and landed at Sakthikulangara Fisheries Harbour, Kollam, Kerala, south-west coast of India. Comparative analyses of external morphology were performed based on specimens that were fixed in 10% formalin and preserved in 70% ethanol. The maturity of the specimens was macroscopically determined. Measurements, counts and terminology followed those of Compagno (1984) and Ebert *et al.* (2021). Measurements were taken using a digimatic caliper to the nearest 0.1 mm. Total length (TL) was used throughout, except where indicated. Vertebral counts were taken from radiographs taken at a commercial medical Xray facility at Chennai, Tamil Nadu. The tooth count was taken from the holotype and the paratype specimens and were examined using a stereomicroscope (Axiocam 305 colour). Data on *I. omanensis* were obtained from Compagno and Springer (1971), and data on *Iago garricki* from Ng *et al.* (2022). The type specimens were deposited and registered in the national zoological collections of the Marine Biology Regional Centre, Zoological Survey of India, Chennai, Tamil Nadu, India.

DNA extraction, PCR amplification and sequencing

DNA was isolated from the lateral muscle tissue of the specimens using Qiagen Dneasy Tissue kit. FishF1 (5'TCAACCAACCACAAAGACATTGGCAC-3') and FishR1 (5'TAGACTTCT GGGTGGCCAAAGAATCA -3') (Ward *et al.*, 2005) was the primer pair used for the PCR amplification of COI fragment. Amplification reaction was carried out in a 25 µl reaction volume which contained 1.5 units of Taq DNA polymerase, 1x PCR buffer, 1.5 mM $MgCl_2$, 0.2 mM of each dNTP, 5 pmol of each primer and 2 µL l (25-50 ng) of genomic DNA. The PCR amplification was carried, out in an Eppendorf thermal cycler. Amplification reactions were performed with the initial denaturation at 94°C for 5 min followed by 35 cycles at 94°C for 30 s, annealing at 50°C for 30 s followed by extension at 72°C for 1 min and a final extension at 72°C for 10 min. PCR products were checked using 1% agarose gel electrophoresis and purified with Qiagen PCR purification kit. The sequencing reactions were performed on an ABI 377 Genetic Analyser. The partial COI mtDNA gene sequences of the new species were deposited in NCBI GenBank.

Data analysis

Obtained sequences from tissue samples were aligned using the BioEdit program (Hall, 1999) and checked by visual inspection. Sequences were authenticated to find out the identity through BLASTn (Basic Local Alignment Search Tool) (https: https://blast.ncbi.nlm.nih.gov). The forward and reverse sequences derived were aligned and edited using Bioedit. For the comparison of our sequences with other closely related species, we downloaded sequences from NCBI GenBank. Phylogenetic analyses were performed by using the Maximum Likelihood method and Kimura 2-parameter model using MEGA X. The bootstrap consensus tree inferred from 1000 replicates is taken to represent the evolutionary history of the taxa analysed. A discrete Gamma distribution was applied to model evolutionary rate differences among sites (5 categories) (+G, parameter = 0.5343). The phylogenetic tree obtained was edited in FigTree v1.4.4 (Rambaut, 2009).

Results and discussion

Iago gopalakrishnani New species

Class: *Elasmobranchii*

Order: Carcharhiniformes

Family Triakidae Gray, 1851

Genus: *Iago* Compagno and Springer, 1971

Species: *Iago gopalakrishnani* sp. nov Bineesh, Sweta & Akhilesh *(http://zoobank.org:pub:0A1AD119–8EF6–4360–AE04–4C19A8 6C2F6E)*

(Figs. 1-7; Table 1)

Proposed common name: Indian houndshark

Material examined

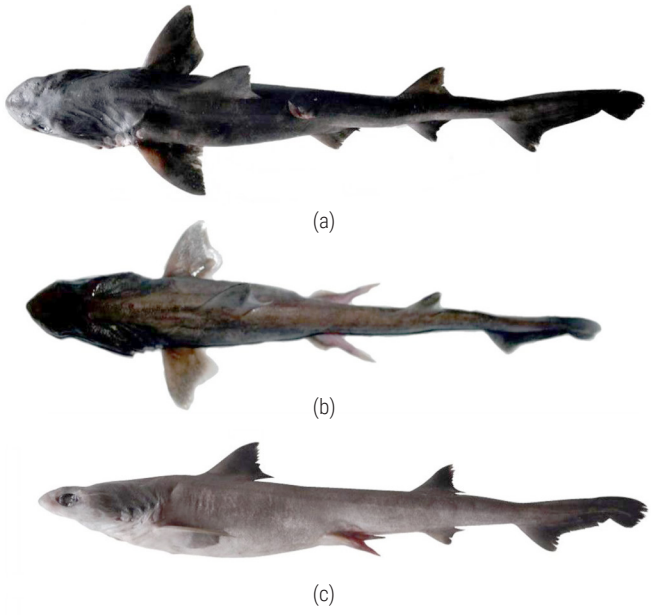
Holotype: ZSI/MBRC/F/3164, adult female, 447 mm TL, caught at Kollam slope, depth 320 m, 08°3'53.77"N, 75°37'58.48"E, landed as a deep-sea shrimp trawler bycatch at Sakthikulangara Fisheries Harbour, collected on 14 January 2023 by Bineesh. K. K and Sweta Beura (Fig. 1a; 2a).

Paratype: ZSI/MBRC/F/3165, adult male, 450 mm TL, caught at Kollam slope, depth 320 m, 08°3'53.77"N, 75°37'58.48"E, landed as a deep-sea shrimp trawler bycatch at Sakthikulangara Fisheries Harbour, collected on 16 January 2023 by Bineesh. K. K. ZSI/MBRC/F/3166, adult female, 884 mm TL, caught at Kollam slope, depth 320 m, 08°3'53.77"N, 75°37'58.48"E, landed as deep-sea shrimp trawler bycatch at Sakthikulangara Fisheries Harbour, collected on 16 January 2023 by Bineesh. K. K and Sweta Beura (Fig. 1b, c; 2b).

Non-types: ZSI/MBRC/F/3167, 445-650 mm TL, caught at Kollam slope, depth 360 m, 08°42'44.77"N, 75°45'58.48"E, landed as a deep-sea shrimp trawler bycatch at Sakthikulangara Fisheries Harbour, which was collected on 22 February 2023 by Bineesh. K. K. and Sweta Beura. ZSI/MBRC/F/3167A 4 nos. 432-550 mm TL, caught at Kollam slope, depth 300 m, landed as a deep-sea shrimp trawler bycatch at Sakthikulangara Fisheries Harbour, which was collected in 2014 by Bineesh. K. K.

Diagnosis

A species of *Iago* with a moderately pointed, narrow snout, pre-oral length 22.4-25% head length, 0.6-0.9 in mouth width; pre-second dorsal length 52.1-59.3% TL; eye length 15-19.7% head length; gill slit rather short, first gill-slit height

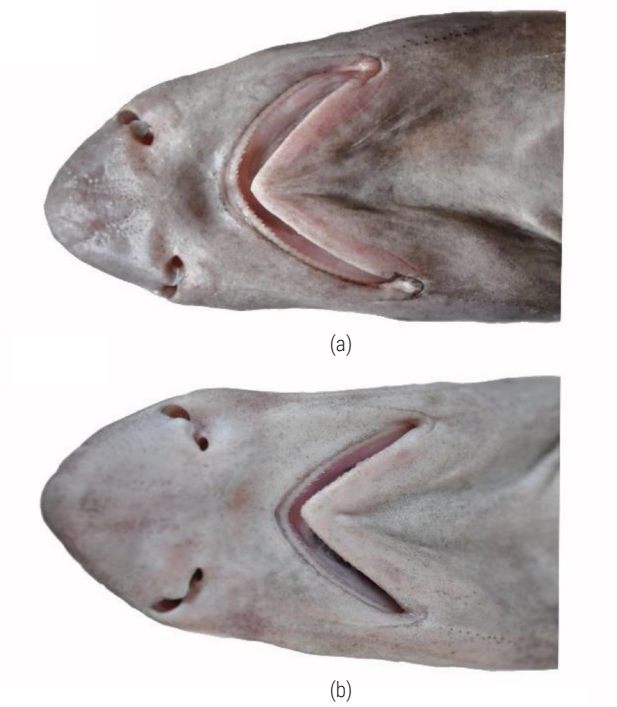


(a)

(b)

(c)

Fig. 1. *Iago gopalakrishnani* sp. nov. (a) Holotype dorsal view, Reg. No. MBRCF3164, adult female, 447 mm TL. (b) Paratype Dorsal view, Reg. No. MBRCF3165, adult male, 450 mm TL, (c) Paratype lateral view



(a)

(b)

Fig. 2. *Iago gopalakrishnani* sp. nov. (a) Holotype, Regd. No. MBRCF3164, adult female, 447 mm TL, ventral view of head. (b) Paratype 1, Regd. No. MBRCF3165, adult male, 450 mm TL, ventral view of head

41.5-47.1% eye length; antero-lateral teeth straight to slightly oblique, blade-like, with 1-3 broad, smooth distal cusplets; upper labial furrows slightly longer than lower labial furrows, upper 1.6-2.2% TL; first dorsal fin anterior margin 9.5-11.9% TL, height 5.8-7% TL, first dorsal height 2.8-3.7 in head length; pre-dorsal, inter-dorsal or post-dorsal ridges or raised skin absent; inter-dorsal space 18.8-23.5% TL; first dorsal-fin origin posterior or over vertical line through pectoral-fin insertion; Body colour dark chocolate brown to black, dusky to dark brown dorsally and gradually paling to dusky laterally in the lower half and ventrally, dusky to black dorsal fins.

Description

The morphometric data are provided in Table 1. Data are provided for the holotype, followed by paratypes and non-types in parentheses.Body elongate and slender, tapering towards posterior; subtriangular to rounded in dorsolateral view at first dorsal-fin base; pectoral-pelvic space 19.5% (18.7-22.2%) TL; pre-caudal space 77.6% (74.8-77.8%) TL; inter-dorsal space 23.5% (18.8-23.5%) TL; second dorsal to caudal fin origin 1.4% (1.3-1.8) times second dorsal base length; pelvic-caudal space 24.2% (24.9- 27.5%) TL; anal-caudal space 8.8% (8.7-10.8%) TL; anal fin base length 5.8% (4.5-5.8%) TL; pre-dorsal, inter-dorsal and post-dorsal ridges and raised skin or structures absent. Caudal peduncle long, slender, tapering towards caudal fin, caudal peduncle height 3.5 (3.2-3.5) in dorsal to caudal space. Lateral keel and precaudal pits absent.

Head short, head length 23.2% (18.9-24.6%) TL, 0.9-1.3 in pectoral pelvic space, 119.1% (85.1-131.9%) pectoral-pelvic space; head above the orbit slightly depressed, rather flat in lateral view, slightly convex over eye, post-oral head straight. Snout moderately pointed in the dorsoventral and lateral views; pre-oral snout smaller than the mouth width, pre-oral snout 24.6% (22.4-25%) of the head length and mouth width 0.8 (0.6-0.9) in pre-oral length. Eyes are elliptical and large, eye length 15% (16.2-19.7%) of the head length, 6.7 (5.1-6.2) in head length and placed laterally on the head; subocular ridges vestigial, anterior notch absent, posterior notch not prominent; nictitating lower eyelids external. Spiracles very small, slit-like and positioned horizontally below the middle level margin of the eye.

Gill slits short; fourth and fifth gill slits above the pectoral base; third and fourth gill slits largest, fifth smallest; height of the fifth gill

Table 1. Morphometric data of *Iago gopalakrishnani* sp. nov. and comparisons of morphometric data of *Iago garricki* and *I. omanensis* from Compagno and Springer (1971) and Ng *et al.* (2022)

Measurements (%TL)	*Iago gopalakrishnani* sp. nov	*Iago gopalakrishnani* sp. nov	*I. omanensis*	*I. garricki*
	Holotype	Range	Range	Range
	ZSI/MBRC/F/3165			
	M			
Total length, TL (mm)	447	445-884 mm (n=4)	224-582 mm (n=16)	244-515 mm (n=8)
PD1, Pre-first dorsal length	25.7	23.4 – 27	24.0 – 29.5	25.0 – 28.2
PD2, Pre-second dorsal length	59.3	52.1 – 58.4	56.8 – 59.9	55.6 – 61.4
HDL, Head length	23.2	18.9– 24.6	23.0 – 27.5	20.2 – 22.2
PG1, Pre-branchial length	16.8	14.1– 16.7	16.2 – 20.0	16.7 – 17.8
PSP, Pre-spiracular length	11.2	11– 11.8		12.2 – 14.3
POB Pre-orbital length	7.0	5.6– 6.2		6.9 – 8.4
POR, Pre-oral length	5.7	4.7– 6	7.4 – 8.3	7.4 – 8.3
PP1, Pre-pectoral length	21.2	16.6– 20.8	21.2 – 25.9	19.2 – 22.8
PP2, Pre-pelvic length	44.4	41.1– 43.4	41.6 – 46.5	41.2 – 46.2
SVL, Pre-vent length	46.5	45.8– 46.1	43.5 – 49.1	43.4 – 47.6
PAL, Pre-anal fin length	60.4	53.3– 60.2	58.3 – 63.4	58.9 – 64.1
IDS, Inter-dorsal space	23.5	18.8– 23.5	21.4 – 25.3	23.6 – 26.8
DCS, Dorsal (D2) - Caudal space	10.3	9.9– 12		9.7 – 12.2
PPS, Pectoral - Pelvic space	19.5	18.7– 22.2	13.7 – 20.0	18.1 – 24.1
PAS, Pelvic - Anal space	10.3	10.3– 15.3	10.4 – 14.8	10.4 – 14.8
ACS, Anal - Caudal space	8.8	8.7 – 10.8	10.1 – 11.1	10.1 – 11.1
PCA, Pelvic - Caudal space	24.2	24.9 – 27.5	23.9 – 28.1	23.9 – 28.1
VCL, Anterior vent - Caudal tip length	52.9	52 – 53.1		
PINL, Pre-narial length	3.8	3.8 – 4		
EYL, Eye length	3.5	3.5 – 4	3.6 – 5.1	3.6 – 5.1
INO, Inter-orbital space	7.6	5.9 – 7.7		5.4 – 7.6
ING, Inter-gill length	6.9	6.6 – 6.9		
NOW, Nostril width	1.5	1.5 – 1.8		
MOL, Mouth length	3.5	3.5 – 4		
MOW, Mouth width	7.2	6.1 – 8.6	6.4 – 8.4	5.6 – 8.4
GS1, 1st Gill slit height	1.6	1.6 – 1.8		1.6 – 2.0
GS5, 5th Gill slit height	2.0	1.2 – 1.5		0.9 – 1.5
P1A, Pectoral anterior margin length	12.4	11.7 – 13.5	12.7 – 16.6	11.3 – 13.8
P1B, Pectoral base length	4.4	4.2 – 4.8	4.5 – 5.6	4.0 – 5.1
P1I, Pectoral inner margin length	5.0	5.8 – 6.9		5.6 – 7.0
P1P, Pectoral posterior margin length	6.6	5.4 – 9.3		7.0 – 9.9
P1H, Pectoral height	10.4	10.4 – 14.8		
P1L, Pectoral length	12.3	10.8 – 12.3		
D1L, D1 Total length	13.7	10.6 – 14.1		10.9 – 12.8
D1A, D1 Anterior margin length	11.9	9.5 – 11.9		9.5 – 12.2
D1B, D1 Base length	9.8	6.7 – 9	8.3 – 11.6	6.6 – 10.2
D1H, D1 Vertical height	6.3	5.8 – 7	6.0 – 8.8	5.7 – 7.7
D1I, D1 Inner margin length	3.7	3.5 – 4.4		3.6 – 4.9
D1P, D1 Posterior margin length	8.0	4.9 – 6.9		4.4 – 6.9
D2L, D2 Total length	10.1	8.9 – 10.9		9.3 – 11.0
D2A, D2 Anterior margin length	9.0	7 – 9.3		4.0 – 9.9
D2B, D2 Base length	7.2	6.7 – 7.6	7.3 – 9.7	3.4 – 9.9
D2H, D2 Vertical height	6.0	4.4 – 5.5	4.5 – 6.5	2.6 – 6.0
D2I, D2 Inner margin length	3.1	2.5 – 3.3		1.2 – 3.0
D2P, D2 Posterior margin length	5.7	3.9 – 5.8		2.9 – 6.1
P2L, Pelvic total length	7.6	7.6 – 8.3		
P2A, Pelvic anterior margin length	4.2	3.8 – 4.8		4.1 – 5.8
P2B, Pelvic base length	5.2	4 – 5.3		

Contd.....

P2H, Pelvic height	2.4	2.1 – 2.9		2.1 – 3.9
P2I, Pelvic inner margin length	2.2	2 – 3.6		3.1 – 5.1
P2P, Pelvic posterior margin length	3.8	3.4 – 5.1		3.4 – 5.0
ANL, Anal fin total length	8.0	7.6 – 8		
ANA, Anal fin anterior margin length	6.5	4.5 – 6.2		4.9 – 5.8
ANB, Anal fin base length	5.8	4.5 – 5.8	4.9 – 6.6	4.6 – 6.2
ANH, Anal fin vertical height	3.5	3.2 – 3.8	2.6 – 4.0	1.2 – 3.6
ANI, Anal fin inner margin length	2.6	2.3 – 2.8		1.8 – 3.1
ANP, Anal fin posterior margin length	3.9	3.4 – 4.4		2.6 – 4.8
CL, Caudal fin length (Nakaya *et al.,* 2008)	24.6	24.5 – 24.7		
CH, Caudal fin height (Nakaya *et al.,* 2008)	7.6	7.6 – 8		
CPrV, Caudal fin pre-ventral margin from caudal origin (Nakaya *et al.,* 2008)	8.5	8.5 – 9.1		
CPoV, Caudal fin post-ventral margin (Nakaya *et al.,* 2008)	12.3	11.7 – 12.3		
CTH, Caudal fin terminal lobe height (Nakaya *et al.,* 2008)	3.2	3.2 – 3.6		
CTL, Caudal fin terminal lobe length	7.2	4.2 – 7.7		4.2 – 6.2
HDH, Head height at P1 origin	5.6	6.2 – 8.7		4.6 – 7.2
TRH, Trunk height at P1 base end	7.3	6.7 – 9.7		5.4 – 8.7
ABH, Abdomen height at D1 base end	6.6	6.6 – 8.6		
TAH, Tail height at pelvic base end	5.0	5. – 5.2		
CPH, Caudal peduncle height at C origin	3.0	1.2 – 3.1		1.6 – 2.5
HDW, Head width at middle gill slits	10.0	8.7 – 12		6.8 – 10.7
TRW, Trunk width at P base ends	9.1	7.6 – 10.5		6.1 – 9.9
ABW, Abdomen width at D1 base end	8.2	6.6 – 8.2		
TAW, Tail width at pelvic base ends	4.7	4.5 – 4.7		
CPW, C peduncle width at C origin	2.0	2 – 2.5		
CLO, Clasper outer margin length	7.2	6.4 – 7.2		
CLI, Clasper inner margin length	11.2	10.3 – 10.5		
CLB, Clasper base width	1.8	1.6		

slit 80.4% (106-147%) height of the first gill-slit; height of the first gill slit 7.1% (7.3-8.2%) of head length and 47.1% (41.5-46.9%) eye length. The interspace between the first to second and second to third gill openings greater.

Nostrils somewhat large, possessing circular incurrent apertures and are well separated from mouth; nostril width 1.5% (1.5-1.8) of TL, nostril width 39.5% (32.9-48.8%) of internarial space, smaller than eye length; excurrent apertures very small, anterior nasal flaps broadly triangular and large. Mouth considerably arched, width 31.2% (27.8-45.2%) of head length; mouth length 48.5% (48.8–50%) width; mouth length 48% (43.7-57.7%) of eye length; tongue flat and blunted apically, covering almost the entire floor; buccal papillae absent. Labial furrows moderately elongate; lower furrows distinctly shorter than upper furrows; length of lower furrows 74% (70-75%) uppers; anterior tip of upper furrows anteriorly reaching to vertical mid-orbit, reaching nearly the level of the lower jaw symphysis.

First dorsal fin falciform; anterior margin concave basally, slightly convex distally; apex narrowly rounded; posterior margin concave to the free rear tip; free rear tip narrowly pointed; inner margin nearly straight; first dorsal fin origin vertically at the middle pectoral fin inner margin; free rear tip slightly posterior at the mid space between the pectoral-pelvic space; first dorsal height 0.6 (0.7-0.9) times the length, 63.6% (69.9-86.2%) of the base length; first dorsal-fin base 41.8% (35.9-39.1%) of the inter-dorsal space, 50.5% (36-48%) of the pectoral-pelvic fin space; inner margin 59.2% (56.7-64.3%) of the height, 37.7% (45-52.6%) of the base length.

Second dorsal fin slightly curved, smaller than the first dorsal fin, its height 95% (64.3-80.5%) of the first dorsal fin height; height 82.5% (59.7-74.6%) of the base length; 43.4% (37.5-45%) of the base length; base length 73.3% (82.5-98.8%) of the length of the first dorsal base; the anterior margin of second dorsal fin slightly concave; the apex narrowly rounded, posterior margin somewhat upright and concave before the free rear end tip; free rear tip pointed and elongated, terminating barely in line with the free rear tip of anal fin; inner margin is straight, origin slightly anterior to the anal-fin origin; insertion posteriorly positioned to the apex of the fin, opposite to the anal-fin insertion; inner margin 52.6% (54.6-68.7%) of the height.

Pectoral fins broadly triangular; slightly larger than first dorsal fin; anterior margin nearly straight to slightly convex; posterior margin concave at its mid-length, 53.6% (46.0-69.1%) of anterior margin; base narrow, length 36% (34-38.4%) of anterior margin; apex broadly rounded in lateral view; posterior margin moderately concave inner margins moderately straight; its origin at the base of fourth gill opening. Pelvic fins subtriangular; anterior margin somewhat convex, 33.6% (31.6-40.9%) of pectoral fin anterior margin; apex rounded; posterior margin concave; free rear tip acutely pointed; inner margins straight. The claspers of adult males are long, slender and narrowly pointed at the tip; the inner length 11.2% (10.3-10.5%) of the total length, 48.1% (41.9-47.9%) of head length, apex narrowly rounded, extending nearly midway through the pelvic-anal space (Fig. 3).

Anal fin very low and weakly falcate, smaller than the second dorsal fin; its height 58.6% (67.6-74.3%) of second dorsal fin height; its base length 80.7% (58.4-78.2%) of second dorsal fin base length;

Fig. 3. *Iago gopalakrishnani* sp. nov. Claspers Paratype 1, Regd. No. MBRCF3165, adult male, 450 mm TL

anterior margin slightly convex with the apex rounded; posterior margin concave; free rear tip very short and pointed, well separated from lower ventral caudal fin origin; inner margin nearly straight; insertion slightly posterior to fin apex and opposite to second dorsal fin insertion; anal fin base length 66% (42.4-66.3%) of anal-caudal space, 5.8% (4.5-5.8%) of total length; fin height 60% (65.6-73.6%) base length; inner margin 73.1% (69.8-83.8%) height, 43.9% (45.8-61.7%) base length; pre-anal ridges absent.

Caudal fin asymmetrical, upper lobe moderately convex; terminal lobe enlarged, pre-ventral caudal margin to slightly convex; dorsal caudal fin margin moderately long, 27.2% (27-29.0%) pre-caudal length, slightly concave above terminal lobe, without lateral undulations; pre-ventral caudal margin 10.9% (9.5-12.2%) in pre-caudal length, apex broadly rounded; lower post-ventral margin very short, moderately concave; upper post-ventral margin slightly concave anteriorly, slightly convex near the subterminal notch; subterminal notch very short and deep; subterminal margin weakly convex, terminal margin slightly convex with the anterior half end tip somewhat rounded; subterminal caudal fin margin length 81.8% (61.7-91.7%) of terminal margin; terminal lobe margins straight to slightly concave; terminal lobe length 69.7% (35.1-77.8%) of dorsal-caudal margin.

Teeth structure and counts

Teeth including symphysials in 50/45 (48-56/45-52) rows with 3-4 functional series. Tooth formula for upper jaw is 24+3+23 (23-27+3+21-26) and lower jaw is 21+3+21 (21-24+3-4+21-24). Lower jaw teeth are slightly longer than the upper jaw; upper and lower jaw lateral teeth are similar in size and shape. Upper jaw anterior teeth symphyseal are slightly smaller than the anterolateral teeth. Anterolateral teeth straight to slightly oblique, sharp and blade–like, with 1-3 broad, smooth distal cusplets. Upper jaw symphyseal teeth cusp somewhat oblique towards postero-lateral

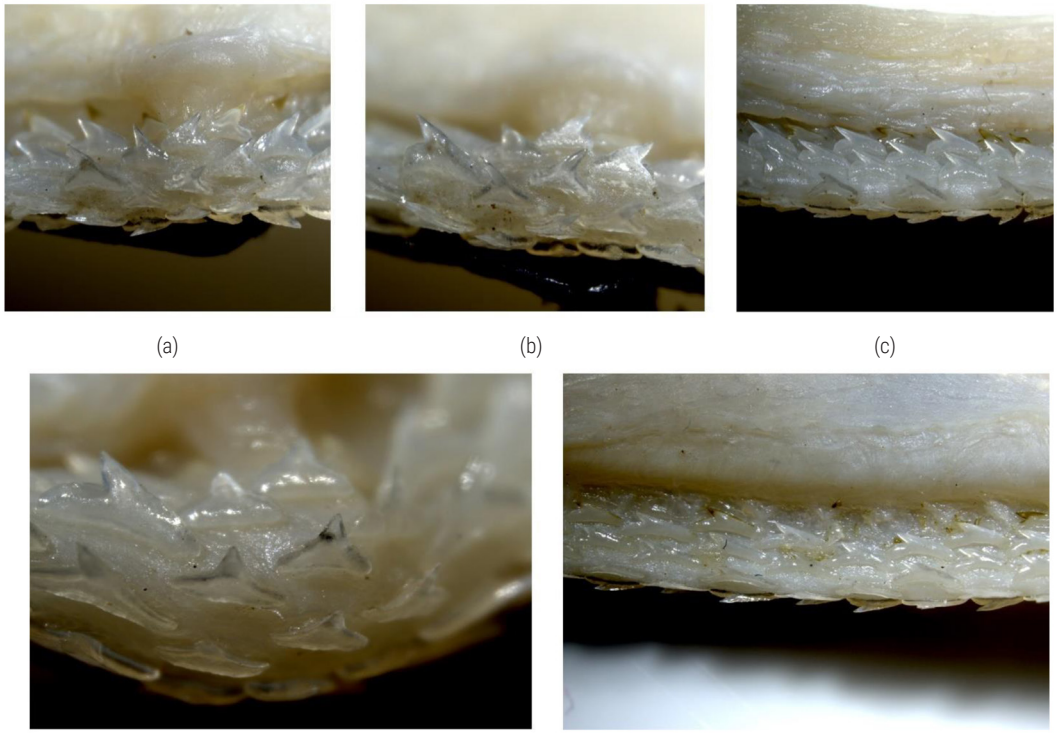


Fig. 4. Teeth of *Iago gopalakrishnani* sp. nov. Paratype 1, 450 mm TL, adult male. (a) Upper jaw symphyseal teeth; Paratype 2, 884 mm TL, adult female; (b) Upper jaw symphyseal teeth; (c) Right upper jaw lateral teeth; (d) Lower jaw symphyseal teeth; (e) Right lower jaw lateral teeth

side; lower jaw symphysials upper series cusps straight and pointed, lower series cusps curved posteriorly. Upper jaw lateral teeth inclined laterally towards posterior side with serrations and transverse ridges (Fig. 4).

Dermal denticles

Head and caudal dorsal margin denticles closely-set, weakly imbricate and leaf shaped; median ridge very narrow and pointed at the anterior margin; cusps broad at crown. Lateral flank denticles below first dorsal fin unicuspid, small and lapping; apices long and pointed narrowly; median ridge slender with thin lateral ridges, slightly curved (Fig. 5).

Colouration

Prominent colour variation is present between the sexes. Females, when freshly caught, exhibit a dorsal and lateral colour pattern ranging from dark chocolate brown to blackish brown, gradually transitioning to a pale to dusky-greyish ventrally. Dorsal, pectoral, pelvic, anal and caudal fins are uniformly dark brown to blackish, lacking any white markings or blotches. Freshly caught males, have a dorsal and lateral colouration blackish to dark brown to pale greyish, with a pale grey or dusky ventral colouration. Caudal fin and anal fin generally blackish brown to dusky. Pectoral fins are predominantly dusky anteriorly, transitioning to a dusky or pale greyish hue ventrally, with narrow dark edges along the anterior margins. Pelvic fins uniformly dusky.

Vertebral counts

Monospondylous vertebrae 18 for holotype (18 for paratypes); 86 (86-87) precaudal vertebrae; 31 (31-36) caudal vertebrae; 117 (117-123) total vertebrae (Fig. 6).

Etymology

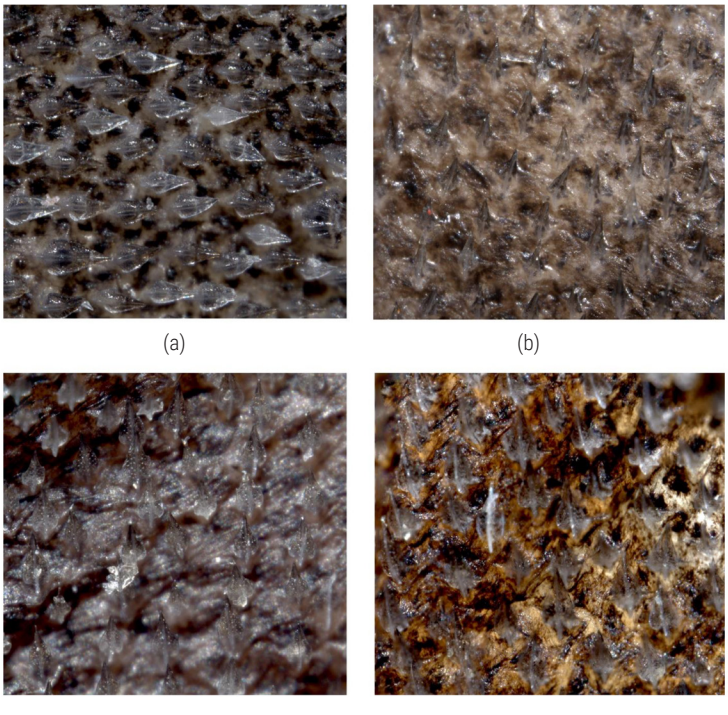
Named in honour of Dr. A. Gopalakrishnan, eminent marine fish geneticist and former Director of ICAR-Central Marine Fisheries Research Institute (2013-2024), Kochi and former Head, PMFGR of ICAR-National Bureau of Fish Genetic Resources, Kochi for his valuable contributions to fish conservation, sustainable management of Indian fisheries and his support to elasmobranch genetic research in India to BKK and AKV, which unveiled hidden genetic diversity of several elasmobranch species in India

Distribution

Known from the Arabian Sea, from deep-waters off south-west coast of India in the northern Indian Ocean at a depth of 300-400 m. This species is abundant in the fishery bycatch in the south-west coast of India and forms a minor fishery. A similar species occurs in the Bay of Bengal and Andaman Sea which needs confirmation.

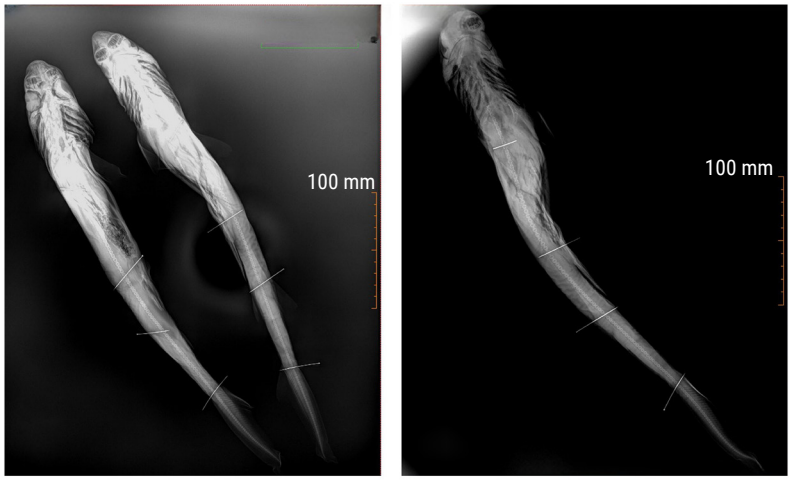
Remarks

The genus *Iago* Compagno and Springer, 1971, was erected for *Eugaleus omanensis* Norman 1939, which was described based on a female specimen measuring 280 mm from the Gulf of Oman at



(a) (b) (c) (d)

Fig. 5. Dermal denticles of *Iago gopalakrishnani* sp. nov. Paratype 2, 884 mm TL, adult female. (a) Caudal fin dorsal margin; (b) Below first dorsal fin base (flank denticles); (c) Head, above gill slits. Non-type, female; (d) Denticles from head



(a) (b)

Fig. 6. Radiograph image of *Iago gopalakrishnani* sp. nov. (a) and (b) Paratypes

210 m depth. The original description of Norman (1939) suggested that it is different from other genera and warrants further study. Compagno and Springer (1971) erected the genus *Iago* with a statement as "troublemaker for systematists and hence a kind of villain". Later, *Iago garricki* Fourmanoir and Rivaton 1979 was reported and described based on 5 specimens from the Vanuatu, south-western Pacific Ocean.

Mustelus mangalorensis Cubelio, Remya and Kurup 2011 was described from a single female (732 mm TL) material fished off Mangalore (India) in the eastern Arabian Sea and landed at Cochin, Kerala (India). Due to its limited original description of the morphological and diagnostic characteristics, *Iago mangalorensis* remains a doubtful, undifferentiable species and has become a challenge to clarify its taxonomic validity. Despite multiple visits to the Cochin University of Science and Technology (CUSAT), the holotype deposited in the Fish Museum of the School of Industrial Fisheries, CUSAT/SHK–1/1), could not be tracked and reported lost (Harikrishnan pers. Comm., 2012). In a subsequent publication, Akhilesh *et al.* (2014) placed the species in *Mustelus* as originally described and mentioned as "Holotype possibly lost". Weigmann (2016) tentatively placed the species in *Iago*, following Ebert *et al.* (2013) usage of *Iago mangalorensis* (possibly name only). However, the description and figure [Page 180; Fig. 1 81(2)] used in Ebert *et al*. (2013) appear to be similar to that of a dwarf, low-finned *Iago* sp. of Compagno (1984) and Compagno *et al.* (2005) known from the Arabian Sea (Compagno, 1988). Similarly, the available literature indicates the presence of multiple forms in the Indian Ocean that may be distinct in particular regions (Compagno, 1988; Ebert *et al.,* 2013) warranting detailed global study. Ebert *et al.* (2021) commented that *Iago mangalorensis* may be a conspecific *Iago omanensis*; however, it is known that *Iago* spp. shows considerable sexual dimorphism and ontogenic changes with growth with the available species description from a single specimen (Cubelio *et al.,* 2011), it was unconfirmed for either as a new species or previously described species (see Fernando *et al.,* 2019). Hence, we recommend considering *Iago mangalorensis* (Cubelio, Remya and Kurup 2011) with an "uncertain status" species warranting further detailed study as suggested by Ng *et al.* (2022) for nomenclature consistency and to avoid further uncertainty. However, its validity can be ascertained only by detailed investigations based on large number of materials.

Iago gopalakrishnani sp. nov. can be separated from *I. omanensis* based on the following characteristics, in addition to its basic black to dark chocolate colouration and weak body: pre-second dorsal length, 52-59.3% TL (*vs* 56.8-59.9% TL in *I. omanensis*); pre-oral length, 4.7-6% TL (*vs* 7.4-7.8% TL), 24.2-25% head length (*vs* 30.2-32.2%); mouth width, 31.2-34.7% head length (*vs* 27.8-30.5%); pre-pectoral length, 20.03-20.43% TL (*vs* 21.2-25.9% TL); pre-anal length, 53.3-60.4% TL (*vs* 58.3-57.5% TL); first dorsal base length, 6.7-9.8% (*vs*. 8.3-11.6% TL); pelvic anal space 0.5-0.6% pectoral pelvic space (*vs* 0.7-0.8 %); second dorsal base length, 1.2-1.3% fin height (*vs* 1.5-1.6%).

Iago gopalakrishnani sp. nov. can be differentiated from *Iago garricki* in having a pre-first dorsal fin length 23.4=27% of TL (*vs* 24.2=28% of TL in *Iago garricki*), pre-spiracular length 11=11.8% TL (*vs* 12.1=14.3%TL), pre-orbital length 5.6=7% TL (*vs* 12.1-14.3% of TL), preoral length 4.7-4.9% TL (*vs* 7.4-8.3% of TL), 0.7-0.8 times of mouth width (*vs* 1-1.3 times), interdorsal space 18.8-23.5% TL (*vs* 23.6-26.8% TL) and caudal pre-ventral margin 74.8-81.8% of dorsal caudal margin (*vs*. 72.2-74.5%). Geographically, the distribution of *I. garricki* does not match with that of *I. omanensis* or *Iago gopalakrishnani* sp. nov.The former is restricted to the western Pacific and the south-eastern Indian Ocean, while the latter occurs in the northern Indian Ocean, including the Red Sea. The distribution of *I. omanensis* remains unconfirmed however reported up to the south-west coast of India (Compagno, 1988)

Iago gopalakrishnani sp. nov. can be differentiated from *I. mangalorensis* in its colouration and morphology provided; dark brown to blackish body and dusky ventral in *I. gopalakrishnani* (*vs.* iridescent bronzy brown above, greyish white below in *I. mangalorensis*), pectoral anterior margin 11.7-13.5% TL (*vs.* 14.7% TL), pelvic anterior margin 3.8-4.8% TL (*vs*. 5% TL), anal fin height 3.2-3.5% TL (*vs.* 5.6% TL), inter-dorsal space 18.8-23.5% TL (*vs.* 26.9% TL).

The genus *Iago* possibly has multiple look-alike species and an undescribed diversity of small deepwater sharks in the Indian Ocean and Western Pacific, as several potential genetic clades have been reported from different regions. In addition, differences in morphometrics, ontogenetic changes, sexual dimorphism and counts have been reported among species. Given this, a global revision of hound sharks will clarify the major issues in its taxonomy, zoogeography and phylogeny.

Molecular analysis

The sequences of *Iago gopalakrishnani* sp. nov. were deposited in NCBI GenBank with Accession Nos. KF899737, KF899740, KF899738, KF899739, KF899742 and KF899741. A BLAST search against NCBI databases revealed species closely related to the genus Iago, showing 90-98% similarity. Phylogenetic analysis was performed using the COI sequences generated from *Iago* specimens collected in this study, along with publicly available sequences from NCBI, using *Triakis* as an outgroup.

One sequence, identified as *Iago mangalorensis* (OR391911) from Thailand, exhibited high similarity (98-99.6%) to *I. gopalakrishnani* sp. nov. However, sequences from the original *Iago mangalorensis* from its type locality are unavailable in NCBI for direct comparison. COI sequences of *Iago* sp. A (MK492928.1) and *Iago* sp. (MK422117.1, MK422118.1) from the Andaman Islands also showed high similarity (99.1-99.3%) with *I. gopalakrishnani* sp. nov. We recommend further morphological comparisons and analysis using advanced genetic markers such as NADH2 to confirm the species' distribution and status.

Sequences of *Iago garricki* from the Philippines (KERRI487-08) and Australia (FOAF643-07) formed a distinct clade from all other *Iago* species in the BOLD search. The COI sequences of *I. gopalakrishnani* sp. nov. formed a distinct clade with high posterior probability values (Fig. 7). The species was found to be closely related to Iago omanensis, with a K2P genetic distance of 4.5-5.2. These findings are consistent with morphological characteristics and support the recognition of *Iago gopalakrishnani* sp. nov. as a distinct species.

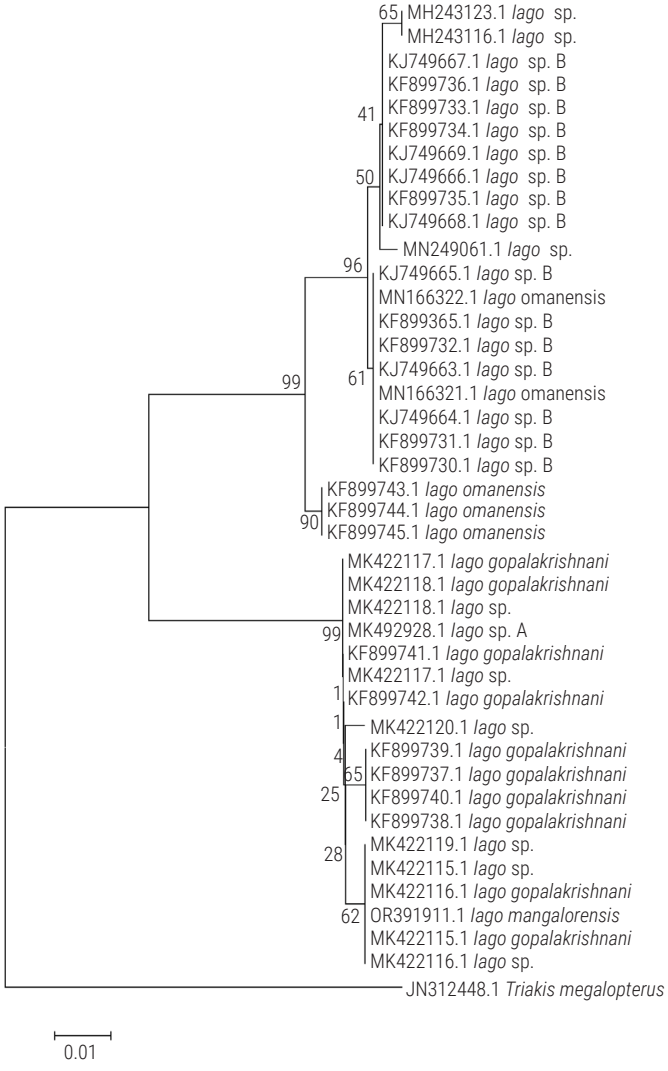


Fig 7. Neighbor-joining phylogenetic tree from the partial mitochondrial sequences of the genus *Iago*

Key to Indian Ocean species of *Iago* (modified from Compagno, 1984)

1. Snoutshort, pre-oral length 4.7-6% TL, 0.6-0.8 times the mouth width. Eye length 6.3-7 times pre-dorsal, first dorsal height 5.8-7% TL. Internarial width 2-3 times nostril width. Head length 18.9-24.6% TL. Colour distinct black chocolate to dark brown body above and dusky to pale ventrally. ..... *I. gopalakrishnani* sp. nov (Arabian Sea, west coast of India).

2. Snout medium length, with pre-oral length of 5.7-7.6% TL, 0.7-1.1 times the mouth width. First dorsal height 6-8.8 % TL, Internarial width 1.4-2 times nostril width, head length 23.0-27.5% TL. Colour brownish or greyish brown above and lighter below ..... *I. omanensis* (Oman to South India).

3. Snout slightly longer, with a preoral length 7.2-8.3% TL, shorter head 20.2-22.2% TL. Colour grey to brownish grey dorsally, gradually becoming paler ventrally ..... *I. garricki* (South China Sea to Australia).

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