



New Record of *Ariomma brevipanum* (Klunzinger, 1884) (Perciformes: Ariommatidae) from Indian Waters

Subal Kumar Roul¹ · Rajan Kumar¹ · Shikha Rahangdale¹ · Suraj Kumar Pradhan² · Sandhya Sukumaran¹ · Prathibha Rohit¹

Received: 3 February 2019 / Revised: 21 May 2019 /
© Springer Nature Switzerland AG 2019

Abstract

Nine specimens (584–670 mm standard length) of *Ariomma brevipanum* (Klunzinger 1884) were collected from the Cochin Fishing Harbour (south-eastern Arabian Sea) in 2016. Morphometric and meristic parameters, along with the DNA barcoding confirmed the identity of the specimens. The majority of the proportional morphometric measurement and meristic counts were concurrent with the previous description of *A. brevipanum*: body elongated (depth at first dorsal and second dorsal fin origin was about 22.8–25.2% and 22.0–22.7% of the standard length respectively); first dorsal fin with XI spine and second dorsal fin with I spine and 15 rays; anal fin with II spine and 15 rays; pectoral fin with 22–24 rays; scales large, cycloid, thin and deciduous; lateral line with 52–55 pored scales; pre-dorsal scale patch extending to about the hind margin of the eye; pre-opercular margin angular; horizontal eye diameter 18–22% of head length; gill rakers, 30–32 on first gill arch. In the present study, the partial sequences of the mitochondrial COI gene of *A. brevipanum* were generated. The analysis using the sequences of the COI gene produced a phylogenetic tree considering the maximum likelihood tree showed distinct clustering among species of *Ariomma* and revealed an identical phylogenetic relationship. The present study represents the first record for Indian waters, as well as the south-eastern Arabian Sea record of this species.

Keywords *Ariomma brevipanum* · Ariommatidae · Indian waters · DNA barcoding

Introduction

The family Ariommatidae has only one genus *Ariomma* Jordan & Snyder, 1904 and 7 valid species (Froese and Pauly 2018) which is grouped into two types based on the body shape such as deep and elongated species (Ajiad and Mahasneh 1986). Ariommatids are characterized by the presence of 2 low lateral keels on each side near caudal-fin base; large eyes and located centrally; small and terminal mouth, not protractile, maxilla barely reaching border of eye; teeth absent from palatines and vomer; two distinct dorsal fins, almost connected; lateral line on upper half of body, often indistinct, following dorsal profile but not extending onto caudal peduncle; large, cycloid, thin, very deciduous scales; and six

branchiostegal rays (Last 2001). Most of the species in this group having the elongated type of body are found in large schools on the continental shelf and continental slope with a depth range of 750 m in tropical and subtropical Atlantic, Pacific, and Indian Oceans. They usually feed on small pelagics and are considered as one of the important food fishes which are mostly captured by trawls (Last 2001). Ariommas are benthopelagic and oceanodromous in nature and moves in a large shoal. Some species form minor to moderate fisheries along different parts of the world. The species have good flesh and go for fresh consumption. The information regarding the ecological role of the group is least known and a dedicated study is required in this domain. Out of seven species of *Ariomma* so far described, only one species, the Indian driftfish *Ariomma indicum* (Day, 1871) was reported from Indian waters (Kapoor et al. 2002; Froese and Pauly 352,018). During the routine fishery survey (thrice in a week) at Cochin Fisheries Harbour, Kerala, a second species of *Ariomma* was recorded from Indian waters. The fishes were identified as *Ariomma brevipanum* (Klunzinger 1884) which was earlier reported from the Red Sea, Indonesia to Japan and Hawaii (Froese and Pauly 2018). In spite of its distribution in

✉ Subal Kumar Roul
subalroul@gmail.com

¹ ICAR-Central Marine Fisheries Research Institute, P. B. No. 1603, Ernakulam North P. O., Cochin, Kerala 682 018, India

² ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra 400 061, India

the Indo-Pacific region, their occurrence in Indian waters was not reported as yet. The present study confirms their occurrence from Indian waters based on morphological and molecular analyses.

Materials and Methods

Sampling

In the present study, a total of nine specimens of *Ariomma brevimanum* (Fig. 1a) were observed at Cochin Fisheries Harbour (09°56'327"N, 76°15'764"E) on 30 September 2016 (Fig. 2). These fishes were caught off Cochin (near to Lakshadweep Islands) as bycatch in multiday hook and line fishery. The specimens were brought to the laboratory of ICAR-Central Marine Fisheries Research Institute, Cochin in iced condition for detailed taxonomic investigation. The

specimens were identified based on the key given by Last (2001). The morphometric and meristic characters were recorded following a standard method (Hubbs and Lagler 2004) and compared with the information available about the species in reports published from other parts of the world (Klunzinger 1884; Ajiad and Mahasneh 1986; Ho et al. 2013; Bos and Gumanao 2013). The morphometric characters were measured for each specimen with a digital caliper to the nearest 0.01 mm, and total body weight (TW) was recorded to the nearest 0.1 g using an electronic weighing balance. Freshly collected specimens were used to record the natural color patterns and tones which are fully or partially lost in preservative. One specimen was fixed in 10% formalin and deposited in the Marine Biodiversity Referral Museum of ICAR-Central Marine Fisheries Research Institute (CMFRI), Cochin, Kerala, India under the Accession Number GB 31.10.2.2 for future reference.

Fig. 1 *Ariomma brevimanum* (Klunzinger 1884) (605.0 mm SL, fresh, Cochin Fisheries Harbour, Kerala, India): (a) the whole specimen; (b) pre-dorsal scale patch extending forward to hind margin of eye; (c) angular pre-opercular margin; (d) *Ariomma indicum* (Day, 1870) (90.0 mm SL, fresh, Versova Fish Landing Centre, Maharashtra, India)

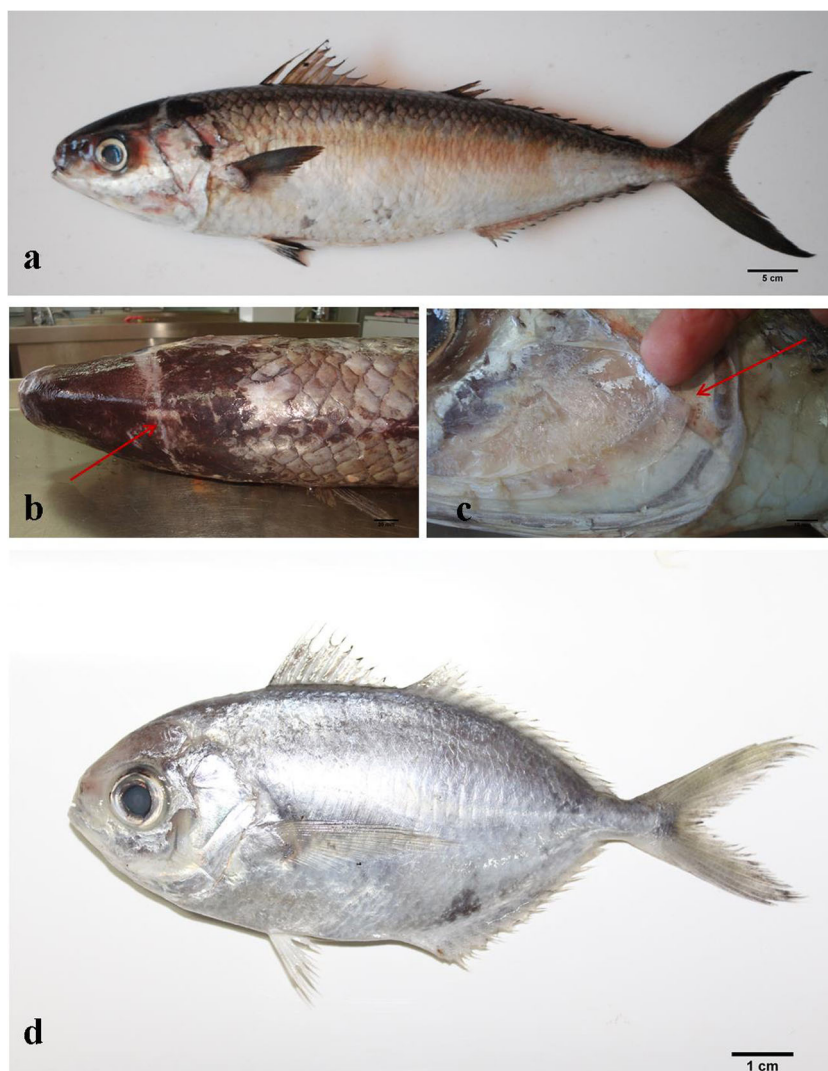
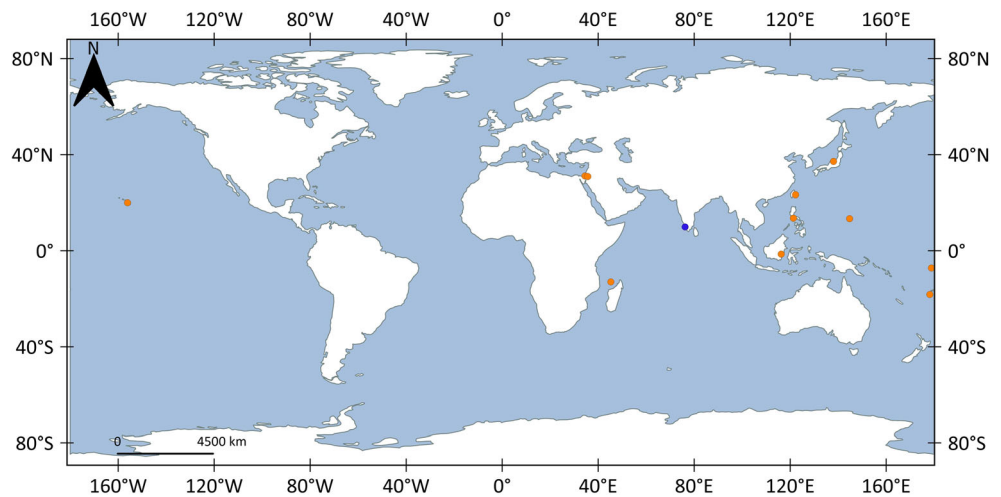


Fig. 2 Distribution of *Ariomma brevipanum* (Klunzinger 1884) in the World Ocean. The blue circle indicates present record and orange circles indicate previous records



DNA Barcoding

Genomic DNA was extracted from the muscle tissue samples preserved in 95% ethanol following a standard phenol/chloroform extraction protocol (Sambrook and Russell 2001). A partial region of the Cytochrome C oxidase I (COI) gene was amplified using the universal primer (LCO1490:5'-GGTCAACAAATCATAAAGATATTGG-3'HC02198:5'-TAAACTTCAGGGTGACCAAAAAATCA-3') (Folmer et al. 1994; Samonte et al. 2000), sequenced using ABI 3730 automated sequencer at Agrigenome Labs Pvt. Ltd. and the sequence deposited in NCBI, GenBank under the Accession Number KY398838. Sequence generated in the present study was searched for similarity using Basic Local Alignment Search Tool (BLAST) (Altschul et al. 1990) through web searches of National Center for Biotechnology Information (USA) website (<http://www.ncbi.nih.gov/BLAST/>). The sequence of *A. brevipanum* generated in the present study was aligned with sequences of other species of *Ariomma*; *A. indicum* from Indian (KP244488-KP244491; EU148514-EU148518) and Japanese waters (AB205433), *A. bondi* from USA (KT883659), *A. luridum* from Japanese waters (AB205431) and South China Sea (KP266811) and *Ariomma* sp. from South China Sea (JQ681386, JQ681426) using ClustalW (Thompson et al. 1997) in MEGA 6 (Tamura et al. 2013) and a maximum likelihood tree was constructed using Kimura 2 parameter (K2P) model (Kimura 1980) in MEGA 6 (Tamura et al. 2013). The tree was rooted using the sequence of *Trachinotus blochii* (KX018988).

Materials Examined

Ariomma brevipanum (Klunzinger 1884): GB 31.10.2.2 (9 ex: 5 male and 4 female, 584–670 mm SL, 3.1–4.6 kg TW), collected from Cochin Fisheries Harbour, captured off Cochin, southwest coast, Kerala, India, 200–300 m depth, collector S. K. Roul, 30 September, 2016.

Ariomma indicum (Day, 1870): 14 ex., 101.0–117.0 mm SL, Versova Fish Landing Centre (19°80'N, 72°50'E), Mumbai, Maharashtra, India, collector Suraj Kumar Pradhan, 9 July 2017; 5 ex., 122–142 mm SL, Cochin Fisheries Harbour (09°56'327"N, 76°15'764"E), Cochin, Kerala, India, collector Subal Kumar Roul, 15 September 2017.

Results

Ariomma brevipanum (Klunzinger 1884).

Smalleye ariomma.

Morphological Features

Morphometric Characteristics

Medium sized fish (584.0–670.0 mm SL) with rounded and elongated type body (Fig. 1a); depth at first dorsal and second dorsal fin origin was about 22.8–25.2% and 22.0–22.7% of the SL respectively; two distinctly separated dorsal fin with interdorsal space 4.7–6.3% of SL; first dorsal fin originated behind the origin of pectoral fin with XI slender and brittle spine, folding into a deep groove whereas second dorsal fin with I spine and 15 soft rays; anal fin with II spine and 15 soft rays; second dorsal and anal fin rays widely spaced posteriorly and finlet like appearance; pectoral fin short with 22–24 soft rays and ventral fin with I long spine and 5 soft rays, folded into the groove which runs up to the anus; caudal fin deeply forked; caudal peduncle short and cylindrical with pair of fleshy keels on both sides near caudal fin base; lateral line well above and towards the dorsal profile of body originating from the operculum and ending at the beginning of the caudal peduncle with 52–55 pored scales; scales large, cycloid, thin and deciduous; pre-dorsal scale patch extending to about the hind margin of the eye (Fig. 1b, 4a); opercle and pre-opercle thin

Table 1 Morphometric and meristic data for *Ariomma brevimanum* and *A. indicum*. Standard length is represented in millimeter

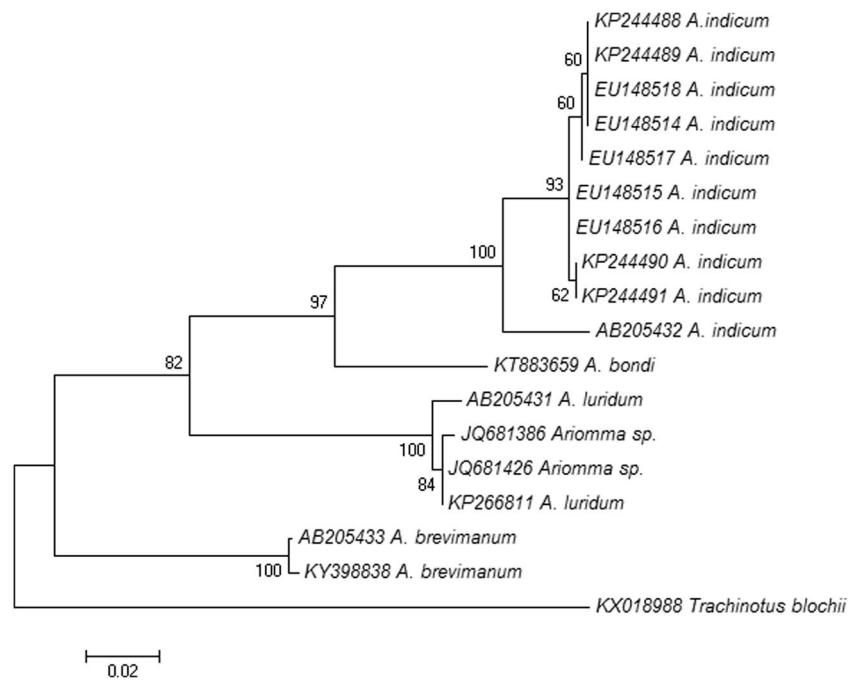
Characters	<i>Ariomma brevimanum</i>			<i>Ariomma indicum</i>
	Present study (n = 9)	Ajiad and Mahasneh (1986) (n = 2)	Bos and Gumanao (2013) (n = 37)	Present study (n = 19)
Standard Length (SL mm)	584.0–670.0	375.0–680.0	115.0–475.0	101.0–142.0
In % of SL			–	
Head Length	26.1–28.0	25.6–25.7	–	33.4–36.9
Pre-first dorsal length	31.7–32.9	32.0–32.4	–	30.7–39.1
Pre-second dorsal length	59.1–61.2	–	–	54.1–59.9
Pre-pectoral length	27.4–29.1	–	–	33.5–36.5
Pre-pelvic length	29.8–32.4	–	–	32.7–40.0
Pre-anal length	61.6–65.7	62.7–64.0	–	57.2–63.7
Interdorsal space	4.7–6.3	6.7–6.8	–	–
Pectoral length	14.8–15.6	11.7–12.7	–	31.4–36.7
Pelvic length	8.4–9.5	7.6–8.8	–	13.7–16.2
First dorsal height	9.1–12.4	–	–	16.1–23.3
Second dorsal height	6.5–7.5	–	–	9.4–39.2
Anal height	6.5–6.8	–	–	10.7–14.5
Caudal fin length	22.0–25.3	–	–	31.5–37.5
Caudal peduncle length	7.9–8.6	–	–	5.6–7.9
Caudal peduncle depth	5.4–5.8	–	–	6.1–7.6
Inter-dorsal space	4.7–6.3	6.7–6.8	–	–
Depth at first dorsal fin origin	22.8–25.2	24.9–25.7	–	40.8–45.9
Depth at second dorsal fin origin	22–22.7	–	–	40.2–46.0
Head Length (HL mm)	152–187	96–175	–	36–50
In % of HL				
Head depth	79.7–88.9	–	–	111.5–126.6
Snout length	39.5–40.6	34.3–34.4	–	35.5–41.9
Pre-orbital length	30.8–31.8	–	–	23.6–48.6
Post-orbital	47–50.1	44.8–46.9	–	26.5–52.3
Eye diameter (horizontal)	18.1–22.5	18.9–20.8	–	25.5–33.2
Inter-orbital width	36.0–38.8	–	–	26.8–34.4
Upper jaw length	21.9–24.2	–	–	23.7–28.2
Meristic counts				
Dorsal fin	XI + I, 15	X + I, 13	XI–XII, 15	X–XI + I, 15–16
Anal fin	II + 15	II + 15	II + 14–15	III + 15
Pectoral fin	22–24	24	23	23–24
Pelvic fin	I + 5	I + 5	I + 5	I + 5
Gill rakers	(12–13) + (18–19)	10 + 1 + 19	–	(6–8) + (14–16)
Lateral line scale	52–55	45	52–53	–
Branchiostegals	6	6	–	6

covered with scales, and pre-opercular margin angular (Fig. 1c, 4a); eyes located centrally with well-developed adipose tissue; mouth small, terminal and not protractile; snout obtuse, maxilla not reaching to under the eye; teeth on jaws minute, uniserial and pointed whereas absent on palate and vomer; gill rakers slender and numerous about 30–32 on first gill arch (Table 1).

Coloration

Freshly collected specimens were dark brown dorsally, and a silvery appearance on the ventral surface and sides of the body. Anterior first dorsal fin spines, membrane and second dorsal fin margin were black in color. The caudal fin was generally grey with a black margin and

Fig. 3 Maximum likelihood phylogenetic tree of *Ariomma* spp. based on DNA sequences of the mitochondrial COI gene (AB205433, *A. brevipanum* for the present study)



the tips of both the lobes were black. The anal fin was white with a black margin. Pectoral fins were black in color while white towards their ventral sites. Pelvic fin was black, and white at the base and anterior margin. The caudal and dorsal fins had a light yellow shine in almost all the specimens. Most of the specimens had a dark edge at the dorsal posterior end of the operculum. Black marking was at the posterior dorsal edge of the eye, while the mouth and gill cavity were dark.

DNA Barcoding Results

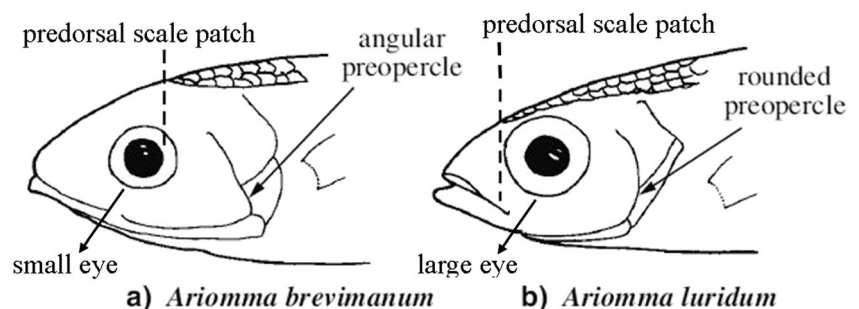
The partial sequence of the mitochondrial Cytochrome C oxidase I (COI) gene resulted in a mean value of 636 nucleotide base pairs. NCBI, Blast analysis revealed that the sequence generated in the present study is 99.65% identical with *A. brevipanum* from Japanese waters (AB205433.1) with E value being 0. Maximum likelihood tree constructed using Kimura 2 parameter (K2P) distance values showed distinct clustering among *Ariomma* species with significant bootstrap

values (Fig. 3). *Ariomma indicum*, *A. luridum* and *A. bondi* clustered separately from *A. brevipanum* indicating that they are diverged significantly. Two sequences of *Ariomma* sp. collected from South China Sea (JQ681386 and JQ681426) also clustered together with *A. luridum* indicating that they belong to the species *A. luridum*.

Discussion

The literature on Indian Ariommatids is restricted to *Ariomma indicum* (Day, 1871). This species has been recorded almost all along the Indian coast (Barman et al. 2000; Barman et al. 2004; Barman et al. 2007; Barman et al. 2011; Barman et al. 2012; Rajan et al. 2013; Barman et al. 2013; Bijukumar and Raghavan 2015; Yennawar et al. 2017). The present study reported the first record of the species small eye ariomma, *Ariomma brevipanum*, from Indian waters. Distribution of this species is restricted to the Indo-Pacific region where it has been reported from the Red Sea, Mayotte, Indonesia,

Fig. 4 Pre-dorsal scale patch, pre-opercular margin shape and eye size of two species of *Ariomma*. (a) *A. brevipanum*; (b) *A. luridum*. (Source: Last 2001)



Philippines, Guam, Japan, Fiji, Hawaii, Tuvalu and Ryukyu Islands, Taiwan (Ajiad and Mahasneh 1986; Ho et al. 2013; Bos and Gumanao 2013; Froese and Pauly 2018) and India (present study). The fish was first described as *Cubiceps brevimanus* by Klunzinger (1884) from the Red Sea based on a single specimen of 800.0 mm long, having XI dorsal spine and 15 soft rays, II anal spine and 15 soft rays, and 24 pectoral soft rays. Subsequently, it was re-described by Ajiad and Mahasneh (1986) from the Gulf of Aqaba (Red Sea) and after that several new records from various parts in the Indo-Pacific region (Ho et al. 2013; Bos and Gumanao 2013; Froese and Pauly 2018) were documented. Most of the proportional morphometric measurement and meristic counts of *A. brevimanus* based on the present specimens are concurrent with the ranges given by the earlier authors (Table 1). Among the two species of Ariommatids available along the Indian coast, *A. indicum* can be easily identified based on the smaller size and deeper body (body depth 40.0 to 46.0% of SL) whereas *A. brevimanus* grows to a bigger size and have an elongated body (body depth less than 26.0% of SL). A similar range with some variations was provided by Last (2001) in the Western Central Pacific: body depth 42.0 to 50.0% of SL in *A. indicum* and body depth less than 32.0% of SL in *A. brevimanus* which may be attributed to the different geographical area. *Ariomma brevimanus* morphologically resembles with its congener, *A. luridum*, but both the species can be distinguished based on pre-dorsal scale patch (extending forward to about hind margin of eye in *A. brevimanus* versus extending forward to front margin of eye in *A. luridum*) (Fig. 1b, 4); pre-opercular margin shape (angular in *A. brevimanus* versus rounded in *A. luridum*) (Fig. 1c, 4); and eye size (small, less than 26.0% of HL in *A. brevimanus* versus larger, more than 26.0% of HL in *A. luridum*) (Last 2001). In the present study, a similar pre-dorsal scale patch and pre-opercular margin shape were observed with minor variation in eye size (18.0–23.0% of HL) (Fig. 1b, c). The analyses of mitochondrial gene COI sequences confirmed the identity of the specimen as *A. brevimanus*.

The smalleye ariomma *Ariomma brevimanus* is listed as Not Evaluated by the IUCN Red List of Threatened Species (IUCN 2018). The species is generally considered as a rare one, and has occasionally been caught in large quantities in Japan (Last 2001) and frequently available in the markets in Philippines (Bos and Gumanao 2013). In the Indian Ocean, *A. brevimanus* was previously reported only from the Red Sea (Baranes and Golani 1993; Khalaf 2004), Mayotte Island (south-western Indian Ocean) (Wickel et al. 2014) and western Indonesia (Gloerfelt-Tarp and Kailola 1984). The present study presented the first record of this deep-sea fish species from Indian waters (south-eastern Arabian Sea) which provide the insight into their specific distributions and possible range extension in the Indian Ocean. This information is highly essential from a biodiversity point of view which adds another species to the ichthyofaunal diversity to Indian

waters. The marine biodiversity of Indian waters is increasing day by day with several newly described fish species and records. The species was caught in hook and line off Cochin, near Lakshadweep waters at a depth of 200–300 m from the water surface. A detailed study can further explore the stock status, abundance, and biological information of the species. The maximum length (L_{\max}) known for this species was 800.0 mm TL (Masuda et al. 1984) whereas, in the present study, L_{\max} was observed as 888.0 mm TL. Based on the present investigations, a field identification key for the two species of Ariommatids available along India waters is provided to aid in the correct identification of the species.

Key to the three species of Ariommatidae, adapted from Last (2001).

- 1a.** Body depth 40.0 to 46.0% of standard length (Fig. 1d).....*Ariomma indicum*
1b. Body depth of less than 32.0% of standard length.....**2**
2a. Pre-dorsal scale patch extending forward to about hind margin of the eye (Fig. 1b, 4a); pre-opercular margin somewhat angular (Fig. 1c, 4a); eye small, 18.0–23.0% of head length (Fig. 1a, 4a).....*Ariomma brevimanus*
2b. Pre-dorsal scale patch extending forward to front margin of eye; pre-opercular margin rounded; eye large, more than 26.0% of head length (Fig. 4b)..... *Ariomma luridum*

Acknowledgments The authors are highly grateful to Dr. A Gopalakrishnan, Director, ICAR-CMFRI, Cochin for providing all necessary facilities and constant support during the entire study period.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any experimental studies with animals performed by any of the authors.

References

- Ajiad AM, Mahasneh DM (1986) Redescription of *Ariomma brevimanus* (Klunzinger, 1884), a rare stromateoid from the Gulf of Aqaba (Red Sea). *Cybio* 10(2):135–142
- Altschul SF, Gish W, Miller W, Myers EW, Lipman DJ (1990) Basic local alignment search tool. *J Mol Biol* 215:403–410. [https://doi.org/10.1016/S0022-2836\(05\)80360-2](https://doi.org/10.1016/S0022-2836(05)80360-2)
- Baranes A, Golani D (1993) An annotated list of deep-sea fishes collected in the northern Red Sea, Gulf of Aqaba. *Israel J Zool* 39(4):299–336. <https://doi.org/10.1080/00212210.1993.10688725>
- Barman RP, Mukherjee P, Kar S (2000) Marine and estuarine fish. In *Fauna of Gujarat, State Fauna Series. Zool Surv India* 8(1):311–411

- Barman RP, Kar S, Mukherjee P (2004) Marine and estuarine fish. In Fauna of Andhra Pradesh, State Fauna Series. Zool Surv India 5(2): 97–311
- Barman RP, Mishra SS, Kar S, Mukherjee P, Saren SC (2007) Marine and estuarine fish fauna of Orissa. Rec Zool Surv India 260:1–186
- Barman RP, Mishra SS, Kar S, Mukherjee P, Saren SC (2011) Marine and estuarine fish. In Fauna of Tamil Nadu, State Fauna Series. Zool Surv India 17(2):293–418
- Barman RP, Mishra SS, Kar S, Mukherjee P, Saren SC (2012) Marine and estuarine fish. In Fauna of Maharashtra, State Fauna Series. Zool Surv India 20(1):369–480
- Barman RP, Mishra SS, Kar S, Saren SC (2013) Marine and estuarine fish. In Fauna of Karnataka, State Fauna Series. Zool Surv India 21: 277–387
- Bijukumar A, Raghavan R (2015) A checklist of fishes of Kerala, India. J Threat Taxa 7(13):8036–8080. <https://doi.org/10.11609/jott.2004.7.13.8036-8080>
- Bos AR, Gumanao GS (2013) Seven new records of fish (Teleostei: Perciformes) from coral reefs and pelagic habitats in southern Mindanao, the Philippines. Mar Biodivers Rec 6:1–6. <https://doi.org/10.1017/S1755267213000614>
- Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome oxidase subunit I from diverse metazoan invertebrates. Mol Mar Biol Biotechnol 3: 294–299
- Froese R, Pauly D (eds) (2018) FishBase 2018, version (October, 2018). World Wide Web electronic publication Retrieved from <http://www.fishbase.org>
- Gloerfelt-Tarp T, Kailola PJ (1984) Trawled fishes of southern Indonesia and northwestern Australia. Australian development assistance bureau, Australia, directorate general of fishes, Indonesia, and German Agency for Technical Cooperation, Federal Republic of Germany, 407 p
- Ho HC, Lin CJ, Yang CR (2013) New records of five fish species from the Green Island, Orchid Island and Kenting, Taiwan. Platax, 19: 73–80. <https://doi.org/10.29926/PLATAX>
- Hubbs CL, Lagler KF (2004) Fishes of the Great Lakes region. Revised ed. Smith GR, rev. University of Michigan Press, 199 pp. <https://doi.org/10.3998/mpub.17658>
- IUCN (2018) IUCN red list of threatened species. Version 2018–2. Downloaded on 19 November 2018
- Kapoor D, Dayal R, Ponniah AG (2002) Fish biodiversity of India. National Bureau of fish genetic resources, Lucknow, India, 775 pp.
- Khalaf MA (2004) Fish fauna of the Jordanian coast, Gulf of Aqaba, Red Sea. Journal of King Abdulaziz University, Marine Sciences 15(1): 23–50
- Kimura MA (1980) Simple method for estimating rate of base substitutions through comparative studies of nucleotide sequences. J Mol Evol 16:111–120. <https://doi.org/10.1007/BF01731581>
- Klunzinger CB (1884) Die Fische des Rothen Meeres. Eine kritische Revision mit Bestimmungen - Tabellen. Acanthopteri. Stuttgart, 133 pp., 13 Pls
- Last PR (2001) Ariommatidae. Ariommas. In: Carpenter KE, Niem V (eds) FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 6. Bony fishes part 4 (Labridae to Latimeriidae), estuarine crocodiles, sea turtles, sea snakes and marine mammals. FAO, Rome, pp 3780–3783
- Masuda H, Amaoka K, Araga C, Uyeno T, Yoshino T (1984) The fishes of the Japanese archipelago, vol 1. Tokai University Press, Tokyo, p 437
- Rajan PT, Sreeraj CR, Immanuel T (2013) Fishes of Andaman and Nicobar Islands: a checklist. J Andaman Sci Assoc 18(1):47–87
- Sambrook J, Russell DW (2001) Molecular cloning: a laboratory manual. Cold Spring Harbor laboratory press, Cold Spring Harbor, New York, 2028 pp.
- Samonte IE, Pagulayan RC, Mayer WE (2000) Molecular phylogeny of Philippine freshwater sardines based on mitochondrial DNA analysis. J Hered 91(3):247–253. <https://doi.org/10.1093/jhered/91.3.247>
- Tamura K, Stecher G, Peterson D, Filipski A, Kumar S (2013) MEGA 6: molecular evolutionary genetics analysis version 6.0. Mol Biol Evol 30:2725–2729. <https://doi.org/10.1093/molbev/mst197>
- Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG (1997) The Clustal X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucleic Acids Res 24:4876–4882. <https://doi.org/10.1093/nar/25.24.4876>
- Wickel J, Jamon A, Pinault M, Durville P, Chabanet P (2014) Composition et structure des peuplements ichtyologiques marins de l'île de Mayotte (sud-ouest de l'océan Indien). Cybium 38(3): 179–203. <https://doi.org/10.13140/RG.2.1.4098.4084>
- Yennawar P, Mohapatra A, Tudu PC (2017) An account of Ichthyofauna of Digha coast, West Bengal. Rec Zool Surv India 117(1):4–21. <https://doi.org/10.26515/rzsi/v117/i1/2017/117289>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.