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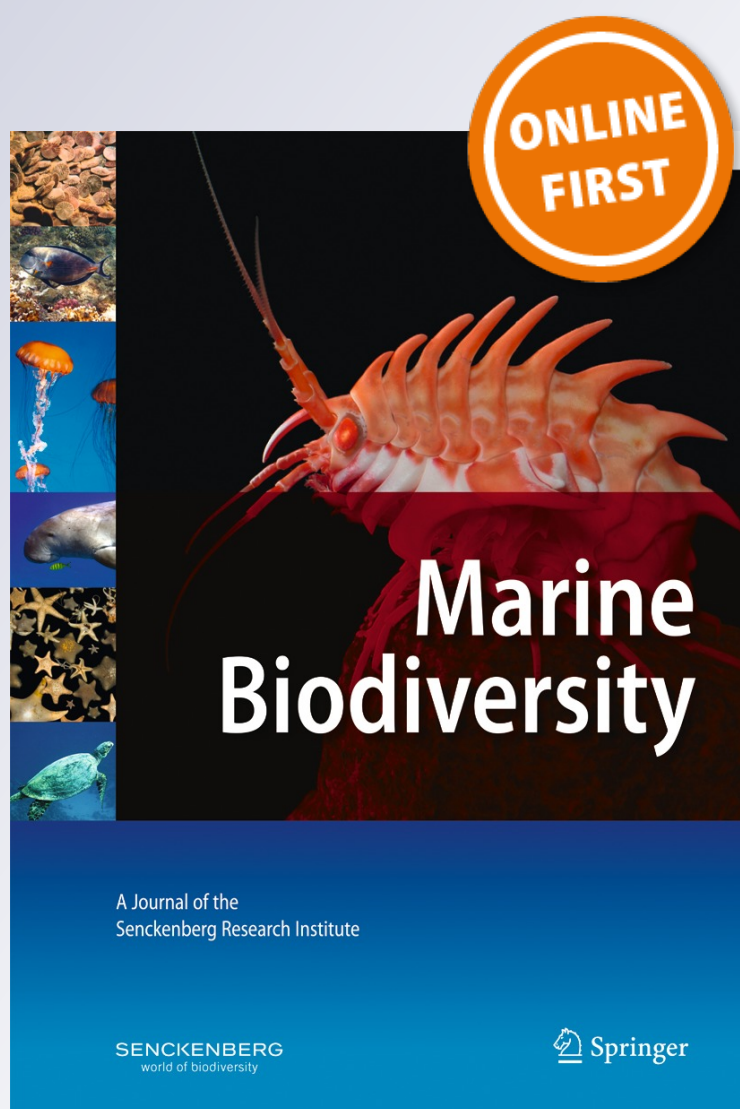
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Marine Biodiversity

ISSN 1867-1616

Mar Biodiv

DOI 10.1007/s12526-016-0478-1



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Taxonomic clarification and re-description of two deep-sea roughies of genus *Hoplostethus* from the Indian Ocean

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Received: 12 January 2016 / Revised: 23 February 2016 / Accepted: 11 March 2016
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Abstract Two deep-sea roughies, *Hoplostethus* (*Leiogaster*) *rubellopterus* Kotlyar, 1980 and *H. (L.) melanopus* (Weber, 1913), are re-described based on several specimens collected from the Arabian Sea, Bay of Bengal and Andaman Sea. Some notes on the taxonomic status of these two species are also included, and their distributional ranges are updated. *Hoplostethus* (*L.*) *rubellopterus* is a commonly occurring species in the deep-sea catches from the upper continental slope (160–800 m) of this region, which is often misidentified and reported as *H. mediterraneus* Cuvier, 1829. Previous reports of *H. mediterraneus* from Indian waters were found to be misidentifications, and should be referred to *H. (L.) rubellopterus*. *Hoplostethus* (*L.*) *melanopus* is found to be distributed in much deeper waters at bathyal depths (>900 m) of the Arabian Sea and Andaman Sea.

Keywords Re-description · Deep-sea roughies · Trachichthyidae · *Hoplostethus* (*Leiogaster*) *rubellopterus* · *Hoplostethus* (*Leiogaster*) *melanopus* · Indian Ocean

Introduction

The genus *Hoplostethus* Cuvier, 1829, commonly known as roughies or slime-heads, is distributed in the continental slope

regions across the globe. Roughies belong to the family Trachichthyidae under the order Beryciformes (Nelson 2006). Members of the genus are characterised by their deep body; large head with extensive mucous cavities separated by spinous ridges and covered with membranous skin; large oblique mouth; posteriorly directed spines on the post-temporal and preopercular bones; 3 to 7 dorsal fin spines; conspicuously large, vertically elongate, diamond-shaped lateral-line scales; and in most species, a well-defined keel of large abdominal scutes (Kotlyar 1986; Moore 1993).

The genus *Hoplostethus* currently comprises 30 valid species (Bailly 2015). Kotlyar (1986) summarised the systematics, distribution and phylogeny of the genus, and divided it into four sub-genera, based on body colour, belly scutes, pectoral fin elements, number of vertebrae, branching of pyloric caeca and striated zones in the belly. The sub-genera are *Hoplostethus* Cuvier, 1829, *Leiogaster* Weber, 1913, *Aulohoplostethus* Fowler, 1938 and *Macrohoplostethus* Kotlyar, 1986. Out of the 30 nominal species in the genus *Hoplostethus*, 12 were described by Kotlyar. While the studies of Kotlyar (1980, 1986) were authentic and comprehensive, all of them were published in Russian, which limited their wide circulation and readership. This proves a minor impediment for exact identification, comparisons and other systematic treatments. In the present paper, two species from various parts of the northern Indian Ocean are described. The identity of specimens from this region previously assigned to *H. mediterraneus* is examined and discussed.

Materials and methods

All specimens of *Hoplostethus* spp. under the present study were collected during the exploratory deep-sea fishery surveys in the continental margins of the Indian EEZ by the Fishery Oceanographic Research Vessel (FORV) Sagar Sampada of

Communicated by R. Thiel

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the Centre for Marine Living Resources and Ecology (CMLRE), Ministry of Earth Sciences (MoES), Govt. of India. The study materials were collected using either High Speed Demersal Trawl-Crustacean Version (HSDT-CV) or EXPO model fish trawl or high opening trawl (HOT) operated at a speed of 2.5 knots. Samples were preserved in 5 % buffered formaldehyde solution and deposited with CMLRE Referral Centre, Cochin, India. The materials were identified following their original description and keys given by Kotlyar (1986). Morphometric and meristic measurements (Table 1) were taken from the preserved specimens and compared with type materials following Moore and Dodd (2010).

Results and discussion

Systematics

Order: Beryciformes

Family: Trachichthyidae Bleeker, 1856

Genus: *Hoplostethus* Cuvier, 1829

Type: *Hoplostethus mediterraneus* Cuvier, 1829

Sub-genus: *Leiogaster* Weber, 1913

***Hoplostethus (Leiogaster) rubellopterus* Kotlyar, 1980**

Hoplostethus mediterraneus – Alcock 1899; Tholasilangam et al. 1964; Venu 2006, 2009, 2013; Sajeevan et al. 2009; Somvanshi et al. 2009; Hashim 2012.

Fig. 1

Materials examined

CMLRE No. 2790515, 25 Nos., 114–147 mm TL, Bay of Bengal, 11°04'N, 80°13'E, 540 m, 27/08/2010; CMLRE No. 2792310, 3 Nos., 138–145 mm TL, Bay of Bengal, 17°09'N, 83°25'E, 567 m, 02/09/2010; CMLRE No. 2792410, 10 Nos., 134–152 mm TL, Bay of Bengal, 17°03'N, 83°17'E, 560 m, 02/09/2010; CMLRE No. 2792510, 8 Nos., 144–162 mm TL, Bay of Bengal, 17°01'N, 83°15'E, 550 m, 02/09/2010; CMLRE No. 2910522, 5 Nos., 150–168 mm TL, Bay of Bengal, 18°49'N, 85°22'E, 614–643 m, 30/10/2011; CMLRE No. 2911013, 1 No., 160 mm TL, Bay of Bengal, 11°55'N, 80°08'E, 505–785 m, 05/11/2011; CMLRE No. 2911120, 21 Nos., 92–163 mm TL, Bay of Bengal, 11°54'N, 80°08'E, 505–785 m, 5/11/2011; CMLRE No. 2911706, 32 Nos., 70–172 mm TL, Bay of Bengal, 11°54'N, 80°08'E, 528–777 m, 09/11/2011; CMLRE No. 3050201, 10 Nos., 128–172 mm TL, Arabian Sea, 09°58'N, 75°53'E, 160 m, 21/08/2012; CMLRE No. 3310206, 5 Nos., 98–109 mm TL, Arabian Sea, 9°19'N, 75°39'E, 392 m, 02/11/2014; CMLRE No. 3343A2, 1 No., 170 mm TL, Andaman Sea, 9°33'N, 92°36'E, 625–633 m, 27/01/2015; CMLRE No. 3383904, 3 Nos., 85–92 mm TL, Arabian Sea, 10°58'N, 75°06'E, 351 m,

20/04/2015; CMLRE No. 3384704, 62 Nos., 80–110 mm TL, Arabian Sea, 13°00'N, 73°51'E, 328 m, 23/04/2015.

Diagnosis

D VI, 13–14; A III, 9; P 18; V I, 6; Gr 21 (7 + 1 + 13); LL 27–29; Belly scutes (BS) 9–12; Pre-dorsal scales rows (Pdr) 18–20

Body of fresh specimen appear light orange-red colour with a silver sheen; all fins are brick-red; on preservation, body colour changes to greyish silver with grey-black fins. Ventral keel scutes are markedly large.

Description

Body oval, medium sized, laterally compressed, maximum body width 46–50 % of standard length (SL). Head large, 42–45 % of SL, occupied by moderately deep muciferous cavities covered by a thin skin. Snout rounded with deep muciferous cavities, pre-dorsal length nearly equal to the head length (HL). A flat supra-clavicular spine, and a much stronger one at the angle of the preopercle. Eyes large, diameter 12–14 % of SL. Mouth wide, terminal and obliquely angled, supramaxilla present. Small villiform teeth bands on jaws and on palatines. First dorsal fin with 6 spines and 13–14 soft rays, base length 37–39 % of SL. Anal fin with 3 spines and 9 soft rays, base length 17–18 % of SL. Caudal fin forked with 6 procurent spines in upper and lower lobes. Pectoral fins reach near end of anal base, with 18 rays, its length 33–38 % of SL. Pelvic fins with 1 spine and 6 rays. Scales thin, ctenoid and deciduous, lateral line possess 27–29 large scales. 9–12 large keeled scales along midventral belly between pelvic and anal fins, forming row of well-developed scutes.

Colour Body of fresh specimen appear light orange-red colour with a silver sheen; muciferous cavities in the head with silver sheen; all fins are brick-red; on preservation, body colour changes to greyish silver with grey-black fins. Mouth cavity and visceral peritoneum black.

Remarks

Alcock (1899) reported the distribution of *H. mediterraneus* Cuvier, 1829 in the Indian waters based on specimens collected by HMS Investigator from the Bay of Bengal and Arabian Sea. Subsequent works (Tholasilangam et al. 1964; Venu 2006, 2013; Sajeevan et al. 2009) also reported the Indian species as *H. mediterraneus*. Examination of the literature reveals that *H. mediterraneus* has a wide distribution range, covering the east and west coast of the Atlantic, the western Pacific (southern coast of Australia and New Zealand) and in the tropical waters of the Indian Ocean. Morphological variations in *H. mediterraneus* populations, owing to its wide spread across the world's oceans, was noted by Kotlyar (1986). He recognised it as a polytypic

Table 1 Comparison of morphometric and meristic characters of *Hoplostethus (Leiogaster) rubellopterus* Kotlyar, 1980 and *H. (L.) melanopus* (Weber, 1913) with type specimens

Morphometric and meristic measurements	<i>Hoplostethus (Leiogaster) rubellopterus</i> Kotlyar, 1980 ^a	<i>H. (L.) rubellopterus</i> Kotlyar, 1980, present specimens	<i>H. (L.) melanopus</i> (Weber, 1913) ^a	<i>H. (L.) melanopus</i> (Weber, 1913), present specimens
Total length (mm)	–	70–172	–	230–312
Standard length (mm)	–	59–135	–	180–235
In% SL				
Head length	35.8–42.4	42.4–44.6	36.3–44.7	35.9–35.9
Snout length	7.7–11.6	5.5–9.3	8.9–9.9	8.1–9.8
Orbital horizontal	9.0–12.8	12.2–13.8	8.8–10.6	9.9–11.8
Post-orbital length	17.0–20.6	22.2–24.7	11.0–19.8	17.3–20.9
Inter-orbital width	8.9–14.3	11.7–12.8	13.2–14.4	11.4–13
Upper jaw length	25.3–29.1	27.0–29.4	26.4–30.1	26.1–28.4
Lower jaw length	26.1–30.3	21.5–25.2	25.3–31.5	17.8–22.1
Head depth	40.6–47.1	45.4–49.0	48.4–57	41.9–45.9
Max body depth	42.8–49.5	46.3–49.6	50.5–55.6	46.8–52.3
Min depth of caudal peduncle	7.1–12.1	10.6–12.2	8.8–10.3	9.2–9.6
Pre-dorsal length	45.3–52.5	39.1–43.3	50.0–55.8	41.0–47
Pre-pectoral length	36.8–44.7	38.4–41.2	37.2–48.4	38.4–41.3
Pre-ventral length	38.2–45.0	32.9–39.1	42.1–54.9	33.6–40.9
Pre-anal length	51.5–71.6	57.2–64.7	63.3–76.9	64.0–67.9
Pectoral to ventral	9.3–15.4	10.0–11.9	13.0–14.7	7.6–12.8
Ventral to anal	25.8–32.4	21.5–31.6	23.6–30.5	26.0–36.9
Dorsal fin base length	31.6–42.6	37.0–38.9	36.6–39.8	34.3–38.6
Anal fin base length	15.8–20.5	17.2–17.9	19.8–21.3	12.6–18.7
Pectoral fin length	28.3–41.8	32.9–37.9	27.9–35.2	32.8–37.7
Ventral fin length	13.4–27.3	17.7–26.5	16.5–18.5	17.0–20.7
Meristic counts				
Dorsal spines	4–6	6	4	4
Dorsal max	6	6	5	4
Dorsal rays min	12–14	13	13	15
Dorsal rays max	14	14	14	16
Anal spines	3	3	3	2
Anal spines max	3	3	3	3
Anal rays	9–10	9	9	10
Anal rays max	10	9	9	11
Pectoral rays	17–18	18	18	19
Pectoral rays max	18	18	20	20
Pelvic spines		1		1
Pelvic rays		6		6
Gill rakers	6–7 + 1 + 13–15	7 + 1 + 13		7 + 1 + 13
Pre-dorsal scales	24–28	18–20		16
Belly scutes	11–15	9–12		16–18
Lateral line scales	27–29			26–30

^a Morphometric and meristic data of type materials taken from Moore and Dodd (2010)

species, showing allopatric distribution. Four nominal sub-species were recognised within the species, viz. *H. (Hoplostethus) mediterraneus mediterraneus* Cuvier, 1829, *H. (H.) m. sonodae* Quero, 1979, *H. (H.) m. trunovi*, Kotlyar,

1986 and *H. (H.) m. intermedius* Hector, 1875, distributed in the northeast Atlantic, northwest Atlantic, south African and Australian regions, respectively. Moore and Dodd (2010) raised *H. (H.) intermedius* Hector, 1875 as another species, even though

Fig. 1 *Hoplostethus (Leiogaster) rubellopterus* Kotlyar, 1980 (CMLRE No. 3343A2, 170 mm TL, Andaman Sea)



genetic evidence supports its synonymy with *H. (H.) mediterraneus* Cuvier, 1829 (Smith and Roberts 2004). According to Kotlyar (1986), reports of *H. mediterraneus* (Alcock 1899; Tholasilangam et al. 1964) from Indian waters are suspicious, since their fin formula is obviously not identical to that of *H. (H.) mediterraneus* Cuvier, 1829.

Recent works also followed the identification of Alcock (1899), who mistakenly recorded several specimens as *H. (H.) mediterraneus* from the Arabian Sea, Bay of Bengal and Andaman Sea (Venu 2006, 2009, 2013; Somvanshi et al. 2009; Hashim 2012). It is to be noted that these specimens are described as having higher pectoral radial counts (18 instead of the 16 described for *H. mediterraneus*). It is evident however, and detailed in this paper that, based on the sub-generic distinction made by Kotlyar (1986), these specimens in fact represent the sub-genus *Hoplostethus (Leiogaster)* Weber, 1913, rather than *H. (Hoplostethus)* Cuvier, 1829. The main distinguishing feature between these two sub-genera is the retention of yellow or brown colour in *H. (Hoplostethus)* Cuvier, 1829 upon fixation or preservation, whereas in *H. (Leiogaster)* Weber, 1913, the original colour changes to black or grey (Kotlyar 1980). Examination of the literature and comparison with other species of the sub-genera confirms that the frequently captured roughy from the upper continental region of the Indian EEZ is found to be *Hoplostethus (Leiogaster) rubellopterus* Kotlyar, 1980. This species is only known from its type localities, from the eastern and western part of the Indian Ocean (Kotlyar 1980, 1986). The present report of *H. (L.) rubellopterus* (Kotlyar, 1980) from the south eastern Arabian Sea, Bay of Bengal and from Andaman Sea establishes its wider distribution in the Central Indian Ocean than previously acknowledged.

Meristic counts (Table 1) of Indian specimens match closely with the holotype and paratypes of *H. rubellopterus* Kotlyar, 1980. Morphometric variables in proportions to the standard length were also well within the range described. However, head length, post-orbital head length, lower jaw length and pre-dorsal length showed slight deviations. Otoliths are small (Figs. 2a–h), with two appendages along

the lateral margin on its external phase, as described for *H. rubellopterus* Kotlyar, 1980. However, these showed pronounced shape variations in their rostral and dorsal dome portions. Even though the lateral margins of otoliths possess two appendages in all specimens, their general shape and outline, especially in the dorsal dome portion, exhibit noticeable variations within specimens of the same size collected from the same locality, as well as in other regions.

Distribution

Northern Indian Ocean (Fig. 3): off Socotra Island in the Arabian Sea and off Mentawai Island in the eastern equatorial Indian Ocean. The present study fills the gap in the distribution range in the central Indian Ocean, along the southwest and east coast of India and Andaman Islands.

Hoplostethus (Leiogaster) melanopus Weber, 1913

Fig. 4

Materials examined

CMLRE No. 2810306, 15 Nos., 278–290 mm TL, Arabian Sea, 08°22'N, 76°09'E, 982 m, 12/10/2010; CMLRE No. 3212007, 75 Nos., 230–312 mm TL, Arabian Sea, 08°31'N, 75°59'E, 1047 m, 12/12/2013; CMLRE No. 3220905, 76 Nos., 240–308 mm TL, Arabian Sea, 08°05'N, 76°25'E, 1031 m, 12/01/2014; CMLRE No. 3221314, 12 Nos., 283–310 mm TL, Arabian Sea, 08°28'N, 78°32'E, 1057 m, 15/01/2014; CMLRE No. 3310210, 4 Nos., 280–292 mm TL, Arabian Sea, 08°32'N, 75°59'E, 1024 m, 04/11/2014.

Diagnosis

D IV, 15–16; A II–III, 10–11; P 19–20; V I, 6; Gr 21 (7+1+13); LL 27; BS 16; Pdr 26–30

Body of fresh specimen appear greyish with a silver tint; muciferous portions of the head with an orange sheen; pectoral, pelvic, dorsal, anal and caudal fins are black; on

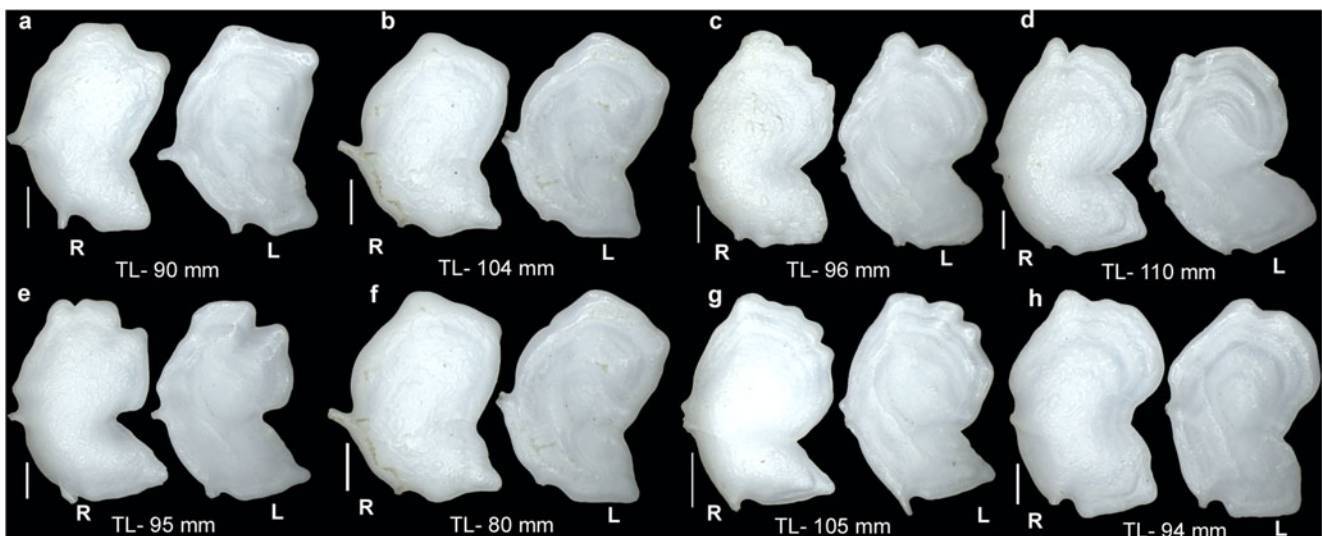


Fig. 2 a–h Shape variations in the otoliths of *Hoplostethus (Leiogaster) rubellopterus* Kotlyar, 1980. R right otolith dorsal view, L left otolith ventral view. Scale bar: 1 mm

preservation, body colour changes to greyish-black. Belly scutes are small.

Description

Body more plump than ovate, large sized, laterally compressed, maximum body depth 47–52 % of SL. Head large, length about 36–37 % of SL, occupied by deep muciferous cavities covered by a thin skin. Snout rounded with deep muciferous cavities, pre-dorsal length slightly greater than HL. A flat supra-clavicular spine, and a much stronger one at the angle of the preopercle. Eyes large, diameter 27–33 % of HL. Mouth wide, terminal and obliquely angled, supramaxilla present. Small villiform teeth bands on jaws and on palatines. First dorsal fin with 4 striated spines and 15–16 soft rays, base length 34–39 % of SL. Anal fin with 2–3 spines and 10–11 soft rays, base length 13–19 % of SL. Caudal fin forked with 6 procurent spines in upper and lower lobes. Pectoral fins reach near end of anal base, with 19–20 rays, its length 33–38 % of SL. Pelvic fins with 1 spine and 6 rays. Body scales thin,

ctenoid and deciduous, lateral line scales 26–30. 16–18 small keeled scales along midventral belly between pelvic and anal fins, forming row of un-developed scutes.

Colour Body of fresh specimen appear greyish with a silver tint; muciferous portions of the head with an orange sheen; pectoral, pelvic, dorsal, anal and caudal fins are black; on preservation, colour changes to greyish-black.

Remarks

Based on specimens collected during the John Murray Expedition, Norman (1939) reported another deep-sea roughy, *Hoplostethus melanopus* (Weber, 1913) from the Western and Central Arabian Sea. Weber (1913) originally described this species under a new genus *Leiogaster* under the family Trachichthyidae. While introducing the new genus, he pointed out that the main diagnostic feature that separated it from other trachichthyids (*Hoplostethus* and *Trachelychthys*) was the lack of strong abdominal scutes, presence of vomerine teeth

Fig. 3 Geographical distribution of *Hoplostethus (Leiogaster) rubellopterus* Kotlyar, 1980 (red circles) and *Hoplostethus (Leiogaster) melanopus* Weber, 1913 (blue squares). The closed symbols represent present reports

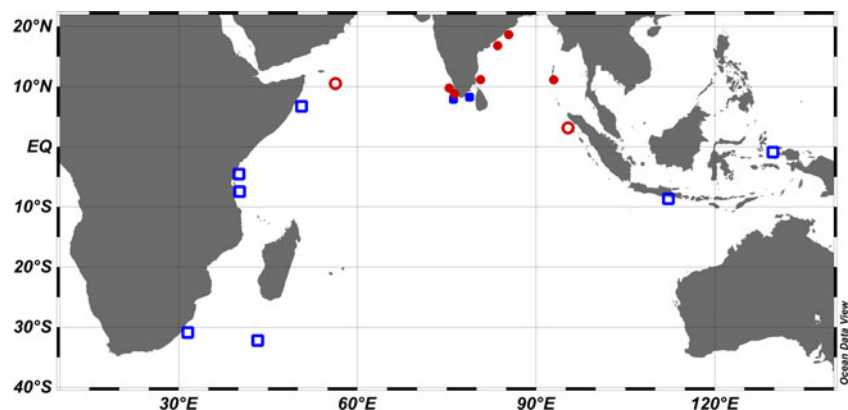
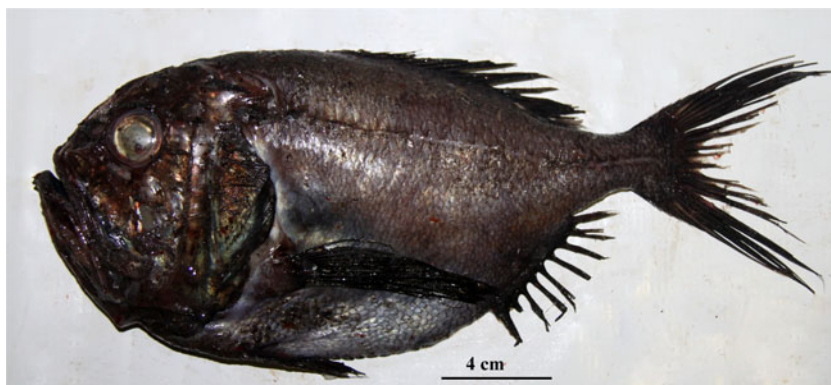


Fig. 4 *Hoplostethus (Leiogaster) melanopus* Weber, 1913 (CMLRE No. 2810306, 282 mm TL, Arabian sea)



and rough ctenoid scales. The holotype of *H. melanopus* was collected from the Halmahera Sea, Indonesia at a depth of 798 m during the Siboga Expedition. Later, Norman (1939) relegated the genus *Leiogaster* as a sub-genus under *Hoplostethus*. He noted the presence of small-sized belly scutes in adult specimens of *H. (Leiogaster) melanopus*, which justified his revision. Kotlyar (1986) recognised *H. melanopus* as a member of the sub-genus *Leiogaster* and retained the sub-generic status of the latter by proposing new diagnostics, based on colour retention, as mentioned in the case of *H. (L.) rubellopterus*.

Meristic counts match with the type specimens, while some morphometric measurements (Table 1) showed slight deviation from type materials. The present specimens possess a relatively lower head depth, pre-dorsal length, lower jaw length and pectoral to ventral space than type materials. Otoliths are large (Fig. 5a–h), showing major variations within species, even for specimens having comparable lengths and

collected in the same haul. This may be because these specimens belong to different age classes, despite having roughly the same length, and since these fishes are known to have slower growth rates and longer life spans (Fenton et al. 1991). However, it was also noted that the otolith shape of some of the present specimens matches with the illustrations of Kotlyar (1986).

Distribution

Indo-West Pacific (Fig. 3): over the continental slope of South Africa in the south western Indian Ocean, off Zanzibar in the western Arabian Sea, off Maldives in the eastern Arabian Sea and in the Halmahera Sea in the Western Pacific. Present observations from the south west coast of India and off Andaman reveal a much wider distribution in the species throughout the northern Indian Ocean.

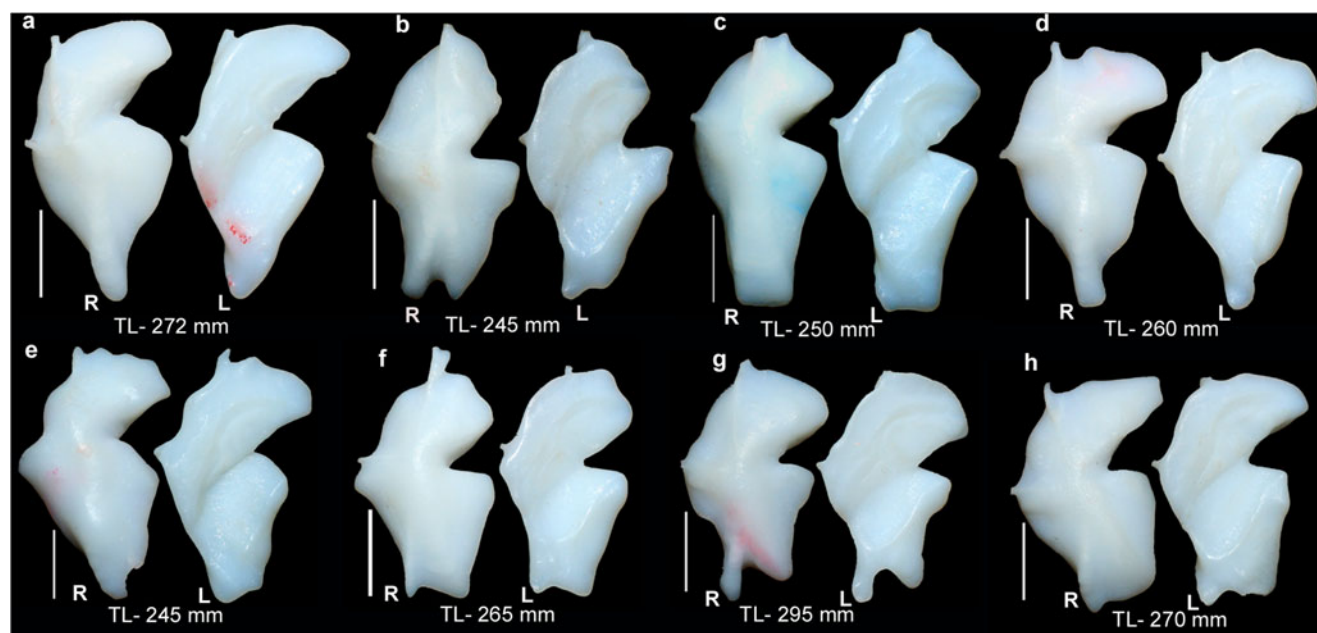


Fig. 5 a–h Shape variations in the otoliths of *Hoplostethus (Leiogaster) melanopus* Weber, 1913. R right otolith dorsal view, L left otolith ventral view. Scale bar: 1 cm

Acknowledgements We thank Kotlyar AN for his advice and suggestions for proper identification of the *Hoplostethus* species. We thank all the scientific cruise participants of FORV Sagar Sampada Cruises (Cr. 279, 281, 291, 305, 321, 322, 331, 334 and 338) for collecting samples for analysis. We sincerely thank Usha V Parameswaran for the critical reading and valuable corrections in the text. We are extremely grateful to Aneesh Kumar, Deepa KP for providing otolith samples. We thank all our colleagues and friends at the CMLRE for the constant support and encouragement. The suggestions and comments of the anonymous reviewers, which improved the manuscript are gratefully acknowledged.

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