



## New distributional records of deep-sea sharks from Indian waters

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### Abstract

This paper reports the first documented record of three deepwater sharks from Indian waters *i.e.*, *Hexanchus griseus* (Hexanchidae), *Deania profundorum* (Centrophoridae), pygmy false catshark (undescribed) (Pseudotriakidae) and presents a taxonomic account of smooth lanternshark, *Etmopterus pusillus* (Etmopteridae) and leafscale gulper shark, *Centrophorus squamosus* (Centrophoridae), caught by hooks & line units operated in the Arabian Sea, west coast of India and landed at Cochin Fisheries Harbour (Kerala), southwest coast of India.

**Keywords:** Deep-sea sharks, new reports, Arabian Sea, Indian EEZ

### Introduction

The Arabian Sea with its unique ecological features such as position between two land masses, presence of islands, features like oxygen minimum zone (OMZ), circulation pattern, currents, influence of monsoon and high saline water intrusion from Persian Gulf and Red Sea etc. supports a very diverse ichthyofauna. Reports on the diversity of deep-sea fish fauna especially that on deep-sea chondrichthyans from Indian waters are very few. Raje *et al.* (2007) listed 47 species of sharks in commercial landings along the Indian coast mainly from catches made within 100 m depths. However elasmobranchs are also known from deeper waters and probably many species, which are not yet recorded, occur in the unexploited/underexploited deep waters of the Indian EEZ.

The targeted deep-sea shark fishery in Indian waters, especially along the southwest and southeast coasts of India started lately after 2002 by the multiday shark fishermen of Thoothoor (Tamilnadu). The fishery targets gulper sharks (Centrophoridae) but many other deep-sea chondrichthyans occur as by catch, which were dominated by bramble shark, *Echinorhinus brucus* and chimaera, *Neoharriotta pinnata* besides several small sized deep-sea sharks, skates and rays which are often discarded. Cochin

Fisheries Harbour (Kerala), is a major fishing base where chondrichthyans which are caught along the entire west coast of India by multiday deep-sea trawlers, longlines and hooks & line units are landed throughout the year. The species described in this communication were captured by hooks & line units specifically targeting for deep-sea sharks operated off southwest coast of India at depths beyond 250 m. Deep-sea sharks, *Hexanchus griseus* (Hexanchidae), *Deania profundorum* (Centrophoridae) and pygmy false catshark (undescribed) (Pseudotriakidae) represent new species records from the Indian EEZ. In this paper these species are described and the occurrence of *Etmopterus pusillus* and *Centrophorus squamosus* off southwest coast of India is confirmed.

### Material and Methods

During weekly observations of fish landings at Cochin Fisheries Harbour (CFH), Cochin, southwest coast of India, specimens of *Hexanchus griseus*, *Centrophorus squamosus*, *Deania profundorum*, *Etmopterus pusillus* and pygmy false catshark (undescribed) were collected from the deep-sea hooks & line landings operated in the Arabian Sea during April 2008. Species identification was based on Compagno (1984), Smith and Heemstra (1986), Shirai and Tachikawa (1993) and Compagno *et al.*

(2005). Morphometric measurements (direct) of formalin (5%) preserved specimens were taken following Compagno (1984) for all the specimens except those of *Etmopterus pusillus* which was followed by Compagno (2001). Unless otherwise stated all proportional measurements are expressed as percentage of total length (TL).

## Results and Discussion

### Order: Hexanchiformes

### Family: Hexanchidae

#### *Hexanchus griseus* (Bonnaterre, 1788) (Fig. 1)

Materials examined: immature (female), 870 mm TL.

**Diagnosis:** A heavily bodied, broad headed six gill shark with very long gill slits. Snout very short and blunt, mouth with 6 rows of lower, bladelike, comb shaped teeth on each side. Anal fin smaller than dorsal fin. Single dorsal fin placed well posterior of body. Dorsal fin base separated from upper caudal fin origin by a distance equal to, or slightly greater than its length. Brown above, paler below and fins white edged.



Fig. 1. *Hexanchus griseus*, 870 mm TL

**Morphometry:** Fork length 76.4; predorsal length 67; dorsal base 6.7; dorsal caudal space 7.9; anal caudal space 4.9; anal base 5.3; head length 21.6; pre gill length 17.1; intergill length 4.7; pre orbital length (not direct) 5.2; pre oral length 5.3; first gill slit height 9.2; sixth gill slit height 5.7; mouth width 14.9; inter narial length 5.2; inter orbital length 9.8; head width at 1<sup>st</sup> gill slit 17.6.

**Remarks:** Bluntnose sixgill shark, *H. griseus* has a circumglobal distribution in marine tropical and temperate waters, continental and insular shelves and slopes of Atlantic, Indian and Pacific Oceans (Nelson, 2006). Within Indian Ocean *H. griseus* has been reported from Madagascar, Mozambique, South

Africa and Maldives. Depth of occurrence ranges from surface and 2500 m (Carey and Clark, 1995). Size at birth for this species is 650-740 mm TL and the maximum reported size is at least 482 cm TL (Compagno *et al.*, 2005). IUCN Red List status: Near Threatened (IUCN, 2009).

### Order: Squaliformes

### Family: Centrophoridae

#### *Centrophorus* Müller & Henle, 1837

Seven *Centrophorus* species are reported/listed to be occurring in Indian waters: *Centrophorus moluccensis* Bleeker, 1860; *C. uyato* Rafinesque, 1810; *C. granulosus* (Bloch and Schneider, 1801); *C. lusitanicus* Bocage and Capello, 1864; *C. acus* Garman, 1906; *C. squamosus* (Bonnaterre, 1788) and *C. atromarginatus* Garman 1913 (Nair and Mohan, 1970; Appukuttan and Nair, 1988; Raje *et al.*, 2002; Venu and Kurup, 2002; Soundararajan and Roy, 2004; Titto D'Cruz, 2004; Jayaprakash *et al.*, 2006; Raje *et al.*, 2007; CMFRI, 2007; Joshi *et al.*, 2008; Vivekanandan and Sivaraj, 2008). This is a taxonomically problematic genus due to poor species descriptions, absence of type material for several nominal species and ontogenetic changes in some important morphological characters such as denticle morphology. Consequently the occurrence of several species in Indian waters requires confirmation.

#### *Centrophorus squamosus* (Bonnaterre, 1788) (Fig. 2)

Materials examined: Several specimens in commercial fishery landings, total length 580-1070 mm TL.

**Diagnosis:** *Centrophorus squamosus* is easily identified by its denticle pattern (leaf like flattened crowns on elevated pedicels extending above the denticle bases (Fig. 3)), shape of the pectoral fins (broadly angular without extended rear tips) and tooth morphology (Fig.4).



Fig. 2. *Centrophorus squamosus*, female (mature), 720 mm TL

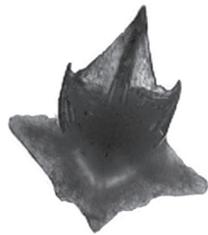


Fig. 3. Lateral dermal denticle of *Centrophorus squamosus*

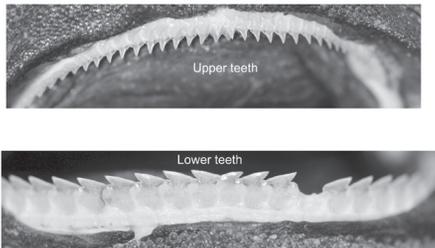


Fig. 4. Teeth of *Centrophorus squamosus*

**Remarks:** Titto D'Cruz's (2004) report of *C. squamosus* from Indian waters is confirmed here. Furthermore, we observed bulk landings of this species at Cochin Fisheries Harbour during 2008. This species is reported to live at depths between 229 and 2,359 m (Compagno, 1984) and has a very wide but patchy reported distribution in the world's oceans. In the Indian Ocean it has been previously reported from South Africa, Aldabra Islands and Maldives (Compagno, 1984; Adam *et al.*, 1998).

**Order: Squaliformes**

**Family: Centrophoridae**

***Deania* Jordan & Snyder, 1902**

***Deania profundorum* (Smith & Radcliffe, 1912) (Fig. 5)**

Materials examined: Three females, total length 580-602 mm.

**Diagnosis:** First dorsal fin long, low and keel shaped. Second dorsal fin spine much larger than first. Pectoral fin free, rear tip not elongated. Snout greatly elongated and its length greater than distance from centre of mouth to pectoral fin origins. This species can be easily identified by the presence of a keel on the underside of the caudal peduncle (Compagno, 1984). Teeth of lower jaw broader than that in upper jaw. Dermal denticles on sides of body

have stellate bases, high pedicels, tricuspidate and triridged erect crowns. Brownish grey or dark grey in color.



Fig. 5. *Deania profundorum*, female, 63 cm TL.

**Morphometry:** Pre-caudal length 81.6-82.2; pre-dorsal length 6.4-6.8; head length 26-26.2; pre-branchial length 21-22; pre-spiracular length 15.6-15.7; pre-orbital length 9.8-10; pre-pectoral length 24.7-24.9; pre-pelvic length 6-6.4; dorsal caudal space 3.3-3.9; interdorsal space 14.9-16.4; pre-narial length 4.8-4.9; preoral length 12.7-13.1; inter gill length 5.4-5.6; pectoral fin-anterior margin 10.4-11.2, pectoral base 5-5.1; pectoral fin-inner margin 8.6-9.2; pectoral-posterior margin 7.5-8.2; dorsal caudal margin 18.7-19.5; preventral caudal margin 10-11.8; terminal caudal margin 6-6.6; first dorsal fin length 23.4-24.1; first dorsal anterior margin 11.2-11.9; first dorsal base 17.3-17.4; first dorsal height 4.9-5; first dorsal inner margin 6.3-7.2; 2<sup>nd</sup> dorsal base 12.5-13.5; 2<sup>nd</sup> dorsal height 6.4-6.5; 2<sup>nd</sup> dorsal length 16.6-16.9; 2<sup>nd</sup> inner margin 3.9-4.4; pelvic length 10.6-10.8; pelvic anterior margin 6.7-7.1; pelvic base 4.9-5.2; pelvic inner margin 5.8; caudal peduncle height 3.3; mouth width 7-7.2; nostril width 2-2.3; inter narial 3.8-3.9; inter orbital 6.4-6.7; head width 12.3-13.3.

**Remarks:** Arrowhead dogfish, *D. profundorum* is a little known deepwater shark species that lives at depths between 275 and 1785 m and has a very disjunct distribution in the world oceans. It's distributed on both sides of the Atlantic Ocean and Pacific Ocean (Compagno, 1984). Indian Ocean reports are only from South Africa (Compagno, 1998) and Gulf of Aden (Bonfil and Abdallah, 2004). Sousa *et al.* (2008) carried out pioneer work on the biology of the species.

**Order: Squaliformes**

**Family: Etmopteridae**

Three *Etmopterus* species are listed from the Indian EEZ: *E. granulosus* (Günther, 1880); *E. pusillus* (Lowe, 1839); and *E. lucifer* Jordan &

Snyder, 1902 (Jayaprakash *et al.*, 2006; Sreedhar *et al.*, 2007; CMFRI, 2007; Vivekanandan and Sivaraj, 2008). As detailed description of species found in Indian waters is not available, a note is presented here to confirm its presence in Indian waters following the listing by Sreedhar *et al.* (2007).

***Etmopterus pusillus* (Lowe, 1839)** (Fig. 6)

Materials examined: three females, 305 - 465 mm TL.

**Diagnosis:** Small shark with cylindrical or slightly compressed body, first dorsal fin usually smaller than second dorsal fin, second dorsal spine larger than first; colour blackish-brown above, with a broad black mark running above pelvic fins and ending just behind second dorsal and with truncated denticle.

**Morphometry:** Fork length 87.87-89.03; pre caudal-fin length 80.66-81.72; head length 23.01-25.77; pre-orbital length 5.46-5.48; pre-oral length 8.7- 10.7; eye length 3.3-3.7; inter-gill length 5.38-6.76; dorsal caudal-fin margin 16.73-20.65; pre-ventral caudal-fin margin 10.58-10.67; caudal-fin fork length 10.23-10.72; first dorsal-fin anterior margin 5.02-5.44; 2<sup>nd</sup> dorsal-fin anterior margin 7.48-9.36; inter-dorsal space 22.74-26.65; pectoral-fin anterior margin 8.66-9.77; pelvic-fin anterior margin 5.10-5.80; head height 8.24-8.89; trunk height 9.08-10.10; tail height 5.53-5.81; caudal-fin peduncle height 2.20-2.30; head width 10.59-10.65; trunk width 9.15-10.77; tail width 4.13-5.55; caudal-fin peduncle width 1.63-1.81 and intestinal spiral valve turns 12-13.

**Remarks:** There are two species, *E. pusillus* and *E. bigelowi*, in the “*pusillus*” complex (Shirai and Tachikawa, 1993). They are separated from other *Etmopterus* species by their truncated dermal denticles. The characters distinguishing these two species are described by Shirai and Tachikawa (1993) and Last *et al.* (2002). There can be variations in some morphological characters due to growth and sexual dimorphism but certain characters are consistent and one of these is the number of spiral valve turns. *E. pusillus* has a spiral valve count of 10-14 and *E. bigelowi* 16. Another distinguishing character is the distance from snout tip to first gill

slit which is shorter than distance from first gill slit to first dorsal fin origin (Shirai and Tachikawa, 1993; Last *et al.*, 2002; Gianeti and Vooren, 2008).

The smooth lanternshark, *E. pusillus* is a small circumglobally distributed shark found on or near the bottom over continental and insular slopes at depths from 274 to 1000 m, and possibly to 2000 m (Compagno *et al.*, 2005). In the western Indian Ocean this species has been reported from South Africa (Compagno, 1984).



Fig. 6. *Etmopterus pusillus*, female, 305 mm TL.

**Order: Carcharhiniformes**

**Family: Pseudotriakidae**

**Pygmy False catshark** Genus and species nov. (Compagno, Stehmann & Anderson), (Fig. 7)

Material examined: female, 630 mm TL.

**Diagnosis:** Second dorsal fin larger than the first with its origin over the pelvic inner margin. Last two gill slits over pectoral fin. 5<sup>th</sup> gill slit smallest.

**Morphometry:** Precaudal length 81.5; pre-first dorsal length 35.6; pre-second dorsal length 6.3; head length 24.3; prebranchial length 20.8; pre spiracular length 13.7; spiracle length 1.3; spiracle width 0.7; preorbital length 7.8; pre pectoral length 23.3; pre pelvic length 5.3; dorsal caudal space 4.8; snout vent length 5.7; inter dorsal space 13.7; pre narial length 6.2; pre oral length 7.1; inter gill length 4.6; first gill slit height 2.9; fifth gill slit height 1.8; pectoral anterior margin 10.4; pectoral base 4.6; pectoral inner margin 5.0; pectoral posterior margin 9.7; dorsal caudal margin 21.1; pre-ventral caudal margin 9.1; terminal caudal margin 5.1; first dorsal length 16.1; dorsal anterior margin 9.7; first dorsal base 13.6; first dorsal height 5.9; first dorsal inner margin 2.6; 2<sup>nd</sup> dorsal base 13.5; 2<sup>nd</sup> dorsal height 6.6; 2<sup>nd</sup> dorsal length 16.0; 2<sup>nd</sup> inner margin 2.4; pelvic length 11.0; pelvic anterior margin 8.4; pelvic base 7.4; pelvic inner margin 3.9; caudal peduncle height 2.7; mouth width 13.4; nostril width 2.6; inter narial 4.0; inter orbital 7.2; inter spiracle 10.2 and head width 17.4.

**Remarks:** This species has previously been reported only from two localities in the northwest Indian Ocean: off Socotra Island in the Arabian Sea, and from the Maldives Islands. It is believed to occur upto depths of 1120 m (Compagno *et al.*, 2005).

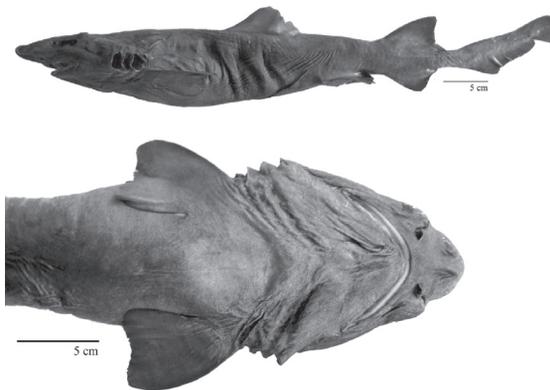


Fig. 7. Pygmy false catshark (genus and species nov.), female, 630 mm TL.

The diversity of deep-sea fauna of Indian EEZ still remains largely unknown/undescribed. Recent increase of distant water multiday fishing is resulting in landings of rare deep-sea species, which were not reported earlier from Indian waters. Deep-sea resources, especially chondrichthyans, are highly vulnerable to fishing pressure (Kyne and Simpfendorfer, 2007) and a knowledge base on their occurrence, distribution and abundance is a critical factor in formulating conservation and fisheries management strategies. The recent exploratory surveys for chondrichthyan resources in Indonesia and Australia have come up with fascinating results and emphasize the need to conduct similar exercise in Indian waters also.

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### References

- Adam, M. S., N. R. Merrett and R. C. Anderson. 1998. An annotated checklist of the deep demersal fishes of the Maldivian Islands. J. L. B. Smith Institute of Ichthyology, *Ichthyological Bulletin*, 67: 1 - 32.
- Appukkuttan, K. K. and K. P. Nair. 1988. Shark resources of India, with notes on biology of a few species. In: M. Mohan Joseph (Ed.) *The First Indian Fisheries Forum, Proceedings of Asian Fisheries Society*, p. 173 - 183.
- Bonfil, R. and M. Abdallah. 2004. *Field Identification Guide to the Sharks and Rays of the Red Sea and Gulf of Aden*. FAO Species Identification Guide for Fisheries Purposes. Rome. FAO. 71 pp.
- Carey, F. G. and E. Clark. 1995. Depth telemetry from the sixgill shark, *Hexanchus griseus*, at Bermuda. *Environ. Biol. Fish.*, 42(1): 7 - 14.
- CMFRI. 2007. Diversity of deep-sea resources in the shelf break area of Indian EEZ. *CMFRI Newsletter*. 113: 24 pp.
- Compagno, L. J. V. 1984. FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species of world known to date. Part 1 - Hexanchiformes to Lamniformes. *FAO Fish Synop.*, 125. Vol. 4, Pt. 1, 249 pp.
- Compagno, L. J. V. 2001. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes). *FAO Species Catalogue for Fishery Purposes*. No. 1, Vol. 2., Rome, FAO. 269 pp.
- Compagno, L. J. V. and V. H. Niem. 1998. Hexanchidae. Cow sharks, six gill, and seven gill sharks. In: K. E. Carpenter and V. H. Niem (Eds.) *FAO Species Identification Guide for Fishery Purposes. The Living Marine Resources of the Western Central Pacific. Cephalopods, Crustaceans, Holothurians and Sharks*. Vol. 2. FAO, Rome, p 687 - 1396.
- Compagno, L. J. V., M. Dando and S. Fowler. 2005. *A Field Guide to the Sharks of the World*. Harper Collins Publishing Ltd., London, 368 pp.
- Gianeti, M. D. and C. M. Vooren. 2008. Identification of the sharks of the genus *Etmopterus* Rafinesque, 1810 (Elasmobranchii: Etmopteridae) from the upper slope of southern Brazil, with comparison between the species *E. bigelowi* Shirai & Tachikawa, 1993 and *E. pusillus* Lowe, 1839. *Braz. J. Oceanogr.*, 56(2): 139 - 143.
- IUCN. 2009. IUCN Red List of Threatened Species. [www.iucnredlist.org](http://www.iucnredlist.org), version (08/2009).

- Jayaprakash, A. A., B. M. Kurup, U. Sreedhar, S. Venu, T. Divya, M. Hashim, V. P. Anish, T. Paul and S. Siva. 2006. Distribution, diversity, length-weight relationship and recruitment pattern of deep-sea fin fishes and shellfishes in the shelf break area of the southwest Indian EEZ. *J. Mar. Biol. Ass. India*, 48(1): 56 - 67.
- Joshi, K. K., K. Balachandran and S. G. Raje. 2008. Changes in the shark fishery at Cochin. *J. Mar. Biol. Ass. India*, 50(1): 103 - 105.
- Kyne, P.M. and C. A. Simpfendorfer. 2007. A collation and summarization of available data on deepwater chondrichthyans: biodiversity, life history and fisheries. A report prepared by the IUCN SSC Shark Specialist Group for the Marine Conservation Biology Institute, 137 pp.
- Last, P. R., G. H. Burgess and B. Séret. 2002. Description of six new species of lantern-sharks of the genus *Etmopterus* (Squaloidea: Etmopteridae) from the Australasian region. *Cybium*, 26(3): 203 - 223.
- Nair, R.V. and S.L. Mohan. 1970. The deep-sea spined dogfish *Centrophorus armatus* (Gilchrist) (Selachii: Squalidae) from the east coast of India, with a note on its taxonomy. *J. Bom. Nat. Hist. Soc.* 69(1) 193-199.
- Nelson, J. S. 2006. *Fishes of the World*, 4th Edition. John Wiley & Sons, Inc., 624 pp.
- Raje, S. G., Grace Mathew, K. K. Joshi, J. Rekha Nair, G. Mohan Raj, M. Srinath, S. Gomathy and N. Rudramurthy. 2002. Elasmobranch fisheries of India - An Appraisal. *CMFRI. Sp. Publ.*, 71: 76 pp.
- Raje, S. G., S. Sivakami, G. Mohan Raj, P. P. Manoj Kumar, A. Raju and K. K. Joshi. 2007. An Atlas on the Elasmobranch fishery resources of India. *CMFRI. Sp. Publ.*, 95: 253 pp.
- Sousa, R., S. Ferreira, T. Chada, J. Delgado and D. Carvalho. 2008. First approach to the biology of the deepwater shark *Deania profundorum* (Chondrichthyes: Centrophoridae). *J.M.B.A. Biodiversity Records*. 6137.
- Shirai, S. and H. Tachikawa. 1993. Taxonomic resolution of the *Etmopterus pusillus* species group (Elasmobranchii, Etmopteridae), with description of *Etmopterus bigelowi*, new species. *Copeia*, 2: 483 - 494.
- Smith, M. M. and P. C. Heemstra (Eds.). 1986. *Smith's Sea Fishes*. New York: Springer-Verlag. 1047 pp.
- Soundararajan, R. and S. D. Roy. 2004. Distributional record and biological notes on two deep-sea sharks, *Centrophorus acus* Garman and *Squalus megalops* (Macleay), from Andaman waters. *J. Mar. Biol. Ass. India*, 46(2): 178 - 184.
- Sreedhar, U., G. V. S. Sudhakar and B. Meenakumari. 2007. Deep-sea fish catch from 16 stations off southeast coast of India. *J. Mar. Biol. Ass. India*, 49(2): 183 - 187.
- Titto D'Cruz, S. 2004. Artisanal Deep-Sea Fishing in Kerala: Prospects and problems. Discussion Paper No. 74. Kerala Research Programme on Local Level Development, Centre for Development Studies, 81 pp.
- Venu, S and B. M. Kurup. 2002. Distribution and abundance of deep-sea fishes along the west coast of India. *Fishery Technology*. 39(1): 20 - 26.
- Vivekanandan, E. and P. Sivaraj. 2008. Status of shark fisheries in the Indian Exclusive Economic Zone. *BOBP-IGO/RC-SF/3*, 16 pp.

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