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ORIGINAL ARTICLE

A new record of a spot-fin porcupine fish, *Diodon Hystrix* Linnaeus, 1785 in the Hooghly-Matlah estuary of West Bengal, India

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Abstract
The present communication is based on the report of a single specimen of spot-fin porcupine fish, *Diodon hystrix* Linnaeus, 1785 from the Hooghly-Matlah estuarine system which is a new record to the systems. The specimen was collected from a bag net catch during February 2021 at Fraserganj fishing areas of the lower stretch of Hooghly-Matlah estuarine systems, India. The size of the specimen was recorded as 280.13 mm in length, 235 g in weight, and big eyes with 18.23 mm in diameter. The fish specimen was also sequenced (barcoded) for a 655 bp region of the mitochondrial cytochrome oxidase subunit 1 (cox1) gene and submitted to the GenBank with accession number MZ665467. Being a marine species, previously this species was reported from the trawl net catch of Bay of Bengal, West Bengal, India, but not from any estuarine environments including Hooghly-Matlah estuarine systems. Average salinity of 26.3 ± 0.87 ppt was recorded at the site of collection. This first confirmed record of *D. hystrix* from the Hooghly-Matlah estuary of West Bengal, India is based on both standards' taxonomic keys-based identification as well as molecular characterization.

Keywords A new record · *Diodon hystrix* · Diodontidae · Hooghly-Matlah estuary · India

Introduction

Spot-fin porcupine fish, *Diodon hystrix* Linnaeus 1758 comes under the family Diodontidae of order Tetraodontiformes comprises seven genera, and seventeen species (Fricke et al. 2021). The family Diodontidae is characterized by several well-developed spines on the body and head, but not the fins and the pelagic young ones, but benthic adults (Leis 1991). This family is broadly distributed in the tropical and temperate marine areas of the Indo-Pacific and Atlantic Oceans (Leis, 2006; Nelson, 2006; Froese and Pauly, 2021). Globally genus *Diodon* comprises 5 species, namely *Diodon hystrix* Linnaeus, 1758; *Diodon eydouxii* Brisout de Barneville, 1846; *Diodon holocanthus* Linnaeus, 1758; *Diodon liturosus* Shaw, 1804; and *Diodon nicthemerus* Cuvier, 1818 (Fricke et al., 2021). Spot-fin porcupine fish is a circumtropical species, widely distributed in the Atlantic, Indian, and Pacific Oceans, and recently confirmed from the Mediterranean Sea.

The spot-fin porcupine fish is a broadly distributed species, mainly inhabited circumtropically and very often also in temperate marine environments (Bandyopadhyay 2014). It is well distributed in the Eastern Pacific: San Diego, California (USA) to Chile, including the Galapagos Islands; Western Atlantic: Bermuda, Massachusetts (USA), and northern Gulf of Mexico to Brazil; Eastern Atlantic: 30°N to 23°S; Western Indian Ocean: The Red Sea to Madagascar, Reunion, and Mauritius, in Bermuda, and Arabian Gulf region (Agüero et al. 1997; Robins and Ray 1986; Duron and Quero 1990; Fricke 1999; Jawad et al. 2019).

The Hooghly-Matlah estuarine system on the east coast of India is the largest and most productive estuary in the country (Jhingran and Ghosh 1978; Bhakta et al. 2021), covering a length of about 295 km from the sea face and accounting for 8029 km^2 area. The Hooghly-Matlah is a positive estuary in the mixo-haline range (Pantulu 1966; Bhakta et al. 2020), where salinity ranges from 0.1 to more than 30 ppt. Hooghly-Matlah estuarine systems are very rich in fish diversity but without any record of spot-fin porcupine fish from the regions. The present report is the first

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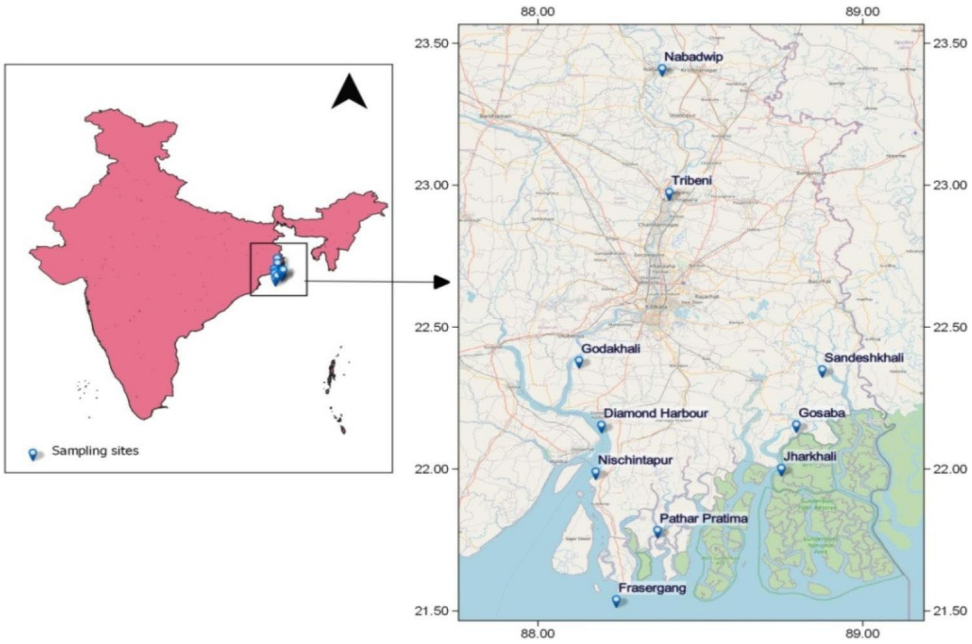

Fig. 1 Map showing the collection sites (Fraserganj) of *Diodon hystrix* from the Hooghly-Matlah estuarine systems

confirmed record of the spot-fin porcupine fish from the Hooghly-Matlah estuarine systems of India.

The species occur in the lagoon and seaward reefs to at least 50 m depth. Juveniles up to the size of 20 cm are in pelagic, and adults are benthic. It is a solitary and nocturnal fish, remains inactive during the daytime, that mainly feeds on hard-shelled invertebrates such as sea urchins, gastropods, and hermit crabs (Leis, 2001). Porcupine fish are usually not used as food fish, henceforth not being harvested as a part of capture commercial fish.

Materials and methods

Collection of samples and morphology study

During February 2021, we could collect a fresh specimen of *Diodon hysterix*, which was captured by a near-shore bag net (10 mm mesh size near the cod end) at Fraserganj fishing sites of the lower stretch of Hooghly-Matlah estuarine systems (Fig. 1). The fresh specimen was photographed, preserved in the icebox, and then brought to the laboratory for further study. The specimen was confirmed as *Diodon hysterix* with the standard taxonomic keys based on Leis (2001 and 2006) and Aizawa and Doiuchi (2013). With the help of digital Vernier calipers, all morphometric measurements were recorded to the nearest 0.01 mm, and meristic counts were made with necked eyes according to the methods of Hubbs and Lagler (2004). For molecular analysis, fin clips along the left side of the specimens were preserved in 95% ethanol before transferring the fish to formalin for morphometric measurement. The specimen was kept as a voucher specimen with a registration number (CIFRI/Mus/03) at the ICAR-CIFRI, Kolkata, India museum. All ecological data related to the habitat viz., physicochemical parameters of water were collected through on-field measurement as well as laboratory analysis with triplicate observations following Standard Methods (APHA 1998).

Results and Discussion

The recorded specimen was confirmed as *Diodon hysterix* as the morphological characters were reliable with the characters described by Leis (2001 and 2006) and Aizawa and Doiuchi (2013). The morphometric characters are presented in Table 1. The outer morphology is described as a hard body covered with erectile long spines; belly region is also spiny. The head portion is wider and blunt; the mouth is large with a beak-like appearance, and without any median structure, which divides both the jaws into right and left halves. Eyes are rounded and very large. Snout is short, and the interorbital width is long. Mouth is relatively small, upper jaw longer than the lower jaw. Posterior tip of lips is not reaching to anterior margin of eyes. Gill opening is very small, a vertical slit immediately before pectoral fin base.

Body is robust, teeth are united in each jaw but without a central division, 20 spines are recorded between snout and dorsal fin. Numbers of spines are found, 10 between the jaws and anus. Both dorsal and anal fins are situated posterior parts of the body, symmetric, lacking fin spines, and slightly rounded. Dorsal and anal fin are with 14 rays each and both the fins are found rounded, dorsal fin is slightly posterior position as compared to the anal fin. Pectoral fins

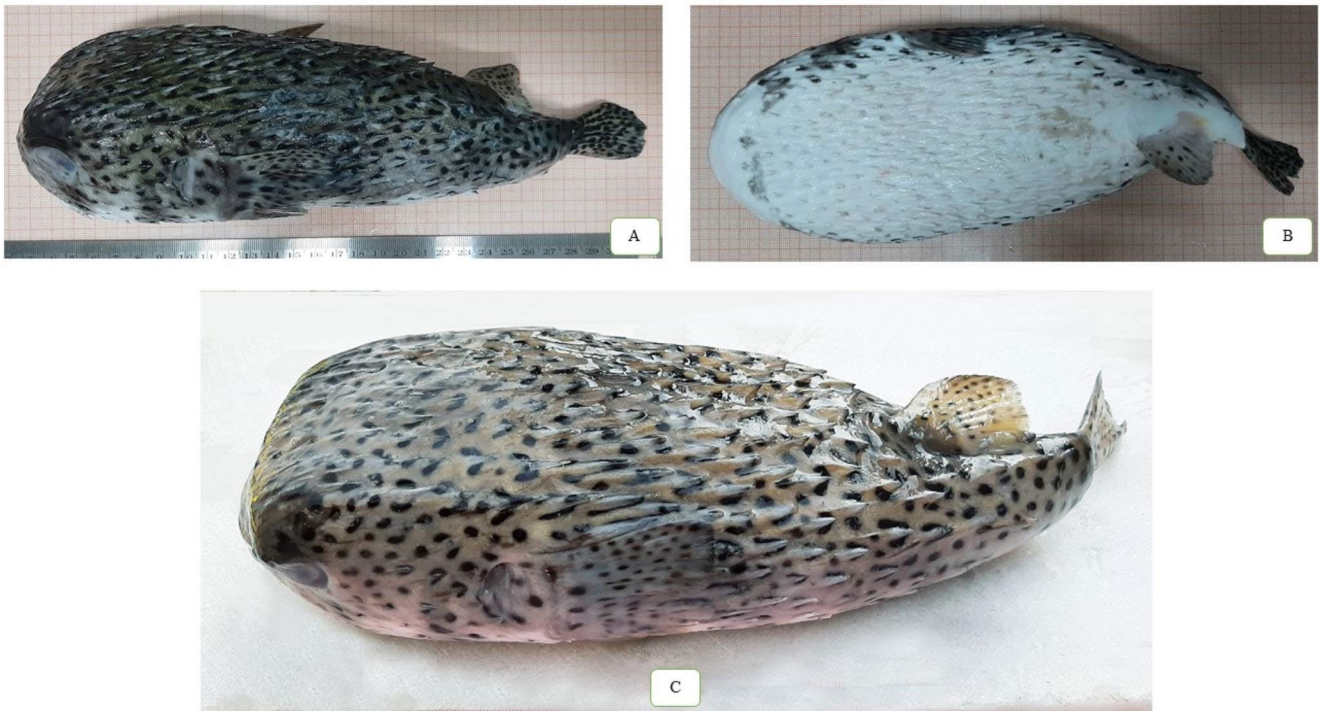

Fig. 2 A. Dorso-lateral, B. ventral, and C. dorsal view of *Diodon hysterix* (n = 01, TL = 280.13 mm) collected from Hooghly-Matlah estuary of West Bengal

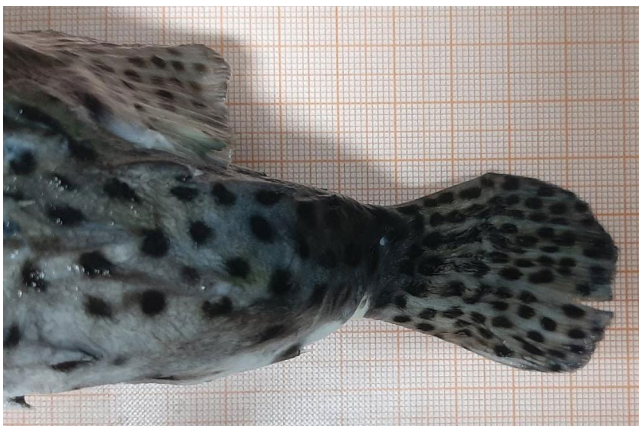

Fig. 3 Rounded and black spotted caudal fin of D*iodon hysterix*

were with 21 rays whereas no pelvic fins were found. Dorsal and ventral surfaces of caudal peduncle are with one or two small spines, respectively (Figs. 2 and 3). The caudal fin is rounded and having 9 fin rays. In a live specimen, the body color of the specimen grayish tan, with numerous small black spots, but without any large dark blotches. Belly portion is white and surrounded by dusky rings. All fins except anal are heavily spotted.

Table 1 Morphometric measurements of *Diodon hysterix* collected from Hooghly-Matlah estuary of West Bengal and comparison with other published data

Morphometric characters	Value		Ordines et al. 2018	Kleitou et al. 2020
	(mm)	(% TL)	(% TL)	(% SL)
Total length	280.13	-	-	60.77
Standard length	240.56	85.87	86.6	-
Head length	80.17	28.62	27.0	14.22
Eye diameter	18.23	6.51	4.4	14.78
Pre-orbital length	27.91	9.96	-	-
Post-orbital length	35.83	12.79	13.4	29.92
Pre-dorsal fin length	180.23	64.34	60.9	-
Pre-pectoral fin length	94.15	33.61	30.5	10.45
Pre-anal fin length	182.52	65.16	64.1	41.07
Post-anal fin length	40.12	14.32	-	-
Maximum body depth	83.65	29.86	-	20.67
Caudal peduncle depth	18.18	6.49	5.8	-
Pectoral fin height	43.5	15.53	14.4	-

Analysis of water quality data revealed that the estuarine condition prevailed at the site of the collection with an average salinity of 26.3 ± 0.87 ppt, sp. conductivity of 39.0 ± 0.10 mS/cm, and total hardness of 7366 ± 451 mg/l (Supp. Table 1). Water was relatively transparent (transparency 58.3 ± 10.79 cm; turbidity 12.57 ± 2.93 NTU) as

Table 2 Comparison of meristic characters of *Diodon hysterix* along with other published literature

Characters	Present study	Linnaeus 1758	Leis 1991	Aizawa and Doiuchi 2013	Kang et al. 2014	Jawad et al. 2019
Numbers of specimens	01	01	-	-	01	01
Total length (mm)	280.13	-	-	-	-	700
Standard length (mm)	240.0	-	-	-	199.0	625
Dorsal fin rays	14	14	14–17	14–17	14	14
Anal fin rays	14	14	14–16	14–16	14	14
Pectoral fin rays	21	22	21–25	21–25	21	21
Caudal fin rays	9	9	-	-	9	-

compared to other lower estuarine areas. Sufficient dissolved oxygen (6.67 ± 1.33 mg/l), suitable pH (8.21 ± 0.07), and total alkalinity (109 ± 3.61 mg/l) were recorded at the site. Low BOD (0.46 ± 0.31 mg/l) indicated a congenial estuarine environment for the fishes.

The spot-fin porcupine fish comes under the order Tetraodontiformes of the family Diodontidae, which is like the family Tetraodontidae, with certain differences such as having sharp spines on the surface of the body and head but not to the fins, and very strong teeth fused into a single beak-like plate in each of the jaw (Leis 1991; Nelson 2006). A total of 5 species are available in Indian waters from the family Diodontidae, namely *Cyclichthys orbicularis* (Bloch, 1785), *Cyclichthys spilostylus* (Leis & Randall, 1982), *Diodon holocanthus* Linnaeus, 1758, *D. hystrix* Linnaeus, 1758, and *Lophodiodon calori* (Bianconi, 1852) (Froese and Pauly 2021). The genus *Diodon*, is distinguishable from the other 5 genera of the family Diodontidae by having all the spines erectile (Leis 1991). The species *D. hystrix* is the most like the congeneric species *D. holocanthus* but differs from its by having small spines to the dorsal surface of the caudal peduncle, and many black spots on the dorsal and caudal fins (Leis 1991). In spot-fin porcupine fish, the length of the spines on the forehead is about 1.0-1.5 times the eye diameter; along with dorsal and ventral areas body spines are smaller than that of forehead spines. A comparative study of meristic characters of *Diodon hysterix* along with other published literature is shown in Table 2.

Diodon hysterix is also differentiated by the other closely related congeners species *D. liturosus* by the following characters: higher dorsal fin rays in *D. hysterix* (14–17) than *D. liturosus* (14–16), presence of small spines on caudal peduncle (no spine in *D. liturosus*), posterior ray of anal fin short, reaching middle of caudal peduncle (long and reaching base of caudal fin in *D. liturosus*), has small black spots scattered on body (presence of large black spots on head and body in *D. liturosus*).

In India, the species is recorded from Kavaratti atoll, Andaman and Nicobar Islands, and Gujarat (Talwar 1990), Gulf of Mannar of Tamilnadu region (Kumaraguru 2000), Bitra and Minicoy islands of Lakshadweep (Anand and Pillai 2003), Vizhinjam-Kerala (Bijukumar and Deepthi 2009), and Digha coast of West Bengal (Kar 1996; ZSI 2010; Bandyopadhyay 2014). All the reports are from the marine habitat, being a marine species, except the record of Suresh et al. (2017) from the Chilika Lagoon of Odisha, India.

We could find the length of the specimen as 280.13 mm, and weight 350 g, respectively. The maximum recorded length of *Diodon hystrix* was 91.0 cm (TL), and a weight of 2800 g from the Pacific coast (Eschmeyer et al. 1983; IGFA 2001). Other than this, the length and weight of the species was also reported as 640 mm, 7800 g along the northeastern coast of Menorca, Balearic Islands (Ordines et al. 2018), 60.77 mm (SL) in the Mediterranean Sea (Kleitou et al. 2020), 122.0 mm (ST) at off Jeju Island, Korea (Kang et al., 2014), 765 mm (TL) along with 2700 g at Mandarmani, Bay of Bengal Coast, West Bengal (Bandyopadhyay 2014), 600 mm length with 1800 g weight at Mandarmani, Bay of Bengal Coast, West Bengal (Kar 1996).

As reported, *D. hystrix* is being lagoon and coral reefs-associated species. In the present record, the species found from the lower stretch of Hooghly-Matlah estuarine systems during winter months, when freshwater influx is less, and salinity comparatively high, prevailing marine habitat. A comparatively calm, clear, and productive environment brings to the species in the new environments, which may be an accidental catch from the bag net.

Conclusions

The occurrence of spot-fin porcupinefish at the Fraserganj area of Hooghly-Matlah estuary, West Bengal, India is the first kind of record from the Hooghly-Matlah estuarine region, the lowermost stretch of river Ganga in India. The species was not found as a targeted species by the fishers (caught as an accidental catch) in the region and harvesting of such marine depleted stocks is not judicial due to its very rare appearance in the catch. Though not evaluated, conservation awareness may be in place for not catching such unique and rare species through mesh size regulations, restricted fishing, and release back in the system if caught accidentally in live condition.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s41208-022-00413-9.

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Author statement Dibakar Bhakta is involved in specimen collections, identification, and manuscript writing; Ranjan Kumar Manna a team member during the sampling and analysis of the water parameters, and revising the manuscript; Archisman Ray a team member of the sampling, is involved with taxonomic data collection and specimen photographing; Sangeetha Mohanachandran Nair helped in taxonomic analysis, and data analysis and entry; Kavita Kumari is involved in molecular analysis of the specimen, and manuscript writing; Srikanta Samanta is the principal investigator of the project and significantly helped in designing the manuscript; Basanta Kumar Das significantly helped in designing of the manuscript, critical revision, etc.

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Availability of data and materials The specimen is deposited in the ICAR-CIFRI fish diversity museum and available as preserved specimen with accession number CIFRI/FISH/2021-01.

Code Availability "Not applicable" for that section.

Declarations

Ethics approval "Not applicable" for that section.

Consent to participate "Not applicable" for that section.

Consent for publication All authors gave their consent for publication.

Declaration of competing interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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