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Taxonomy and length-weight relationship of torpedo electric rays of the genus *Torpedo* (Pisces: Torpedinidae) off Visakhapatnam coast of India

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ABSTRACT

Torpedo electric rays are caught as bycatch in demersal fisheries including coastal artisanal fisheries in trammel nets and in trawls. At present, species under this group are assessed as 'data deficient' (DD) globally due to very little information available on catch and population trends. Of the 22 species of the genus *Torpedo,* 4 species *viz*., *T. fuscomaculata, T. marmorata, T. panthera* and *T. sinuspersici* are represented in the catches at Visakhapatnam, along the east coast of India. The present paper deals with taxonomy and length-weight relationship of the above four species of torpedo electric rays. The present record of *Torpedo marmorata* from east coast of India extends its range to the Indian Ocean.

Keywords: Indian coast, Length-weight relationship, New record, Torpedo electric rays, *Torpedo* spp., Visakhapatnam

Introduction

Electric rays (Elasmobranchii: Torpediniformes : Torpedinidae) represent a complex group of restricted endemics susceptible to capture in trammel nets and trawl fisheries, which are generally discarded as bycatch. Rays of the family Torpedinidae have relatively restricted distribution. Larger specimens are capable of producing strong electric shocks reported to reach a discharge of 220 volts (Coates and Cox, 1942; Bigelow and Schroeder, 1953). To assess the impact of fishery, there is an urgent need to have information on species composition, distribution of these species in space and time, abundance behaviour and biology. This information is also needed to conserve and protect these groups from extinction. Species of the electric rays of the genus *Torpedo* Huttuyn 1764, are medium to large electric rays (up to 180 cm in total length), that occur in tropical and temperate waters, circum-globally from the shoreline down to about 600 m on the continental slope (Carvalho, 2002). The family Torpedinidae is identified by transversely elliptical disc, subcircular, not pear-shaped; teeth monocuspid; tail not greatly reduced, well developed with two moderate size dorsal fins and large caudal fin which is much higher than dorsal fins.

These ray species are known from only a few published records across a very patchy geographical distribution and as such little is known of its biology. Given its size, rarity, patchy and relatively restricted distribution, trawl fisheries may prove to be of conservation concern. These are assessed as 'data deficient' (DD) by IUCN owing to lack of sufficient information on distribution and biologicy mainly due to uncertainty over its systematic status (ICUN, 2013). The species level systematics of electric rays has been neglected, as studies to date have focused mainly on their electrogenic potential, or on the development and physiology of the electric organs *per se* (Mellinger *et al.,* 1978).

From Indian waters, Talwar (1981) gave notes on the taxonomy and distribution of four species of torpedo electric rays based on one specimen of *T. fuscomaculata* Peters, 1855, four specimens of *T. sinuspersici* Olfers, 1831, one specimen of *T. macneilli* (Whitey, 1932) and one specimen of *T. fairchildi* Houtton, 1872. Sujatha (2002) reported three species *viz., T. fuscomaculata, T. sinuspersici* and *T. panthera* and provided key to the species from Visakhapatnam waters. *T. sinuspersici* has been reported from Malabar coast (Anon., 2008) and from Tamil Nadu (Biswas *et al.,* 2012).

Of the 22 species listed under the genus Torpedo, (Froese and Pauly, 2013), 4 species *viz*., *T. fuscomaculata* Peters, 1855*, T. marmorata* Risso, 1810*, T. panthera* Olfers, 1831 and *T. sinuspersici* Olfers, 1831 are represented in the catches of Visakhapatnam (17º44'N, 83º23'E), in the east coast of India. These 4 species are

assessed as 'data deficient' (DD) in the IUCN Red list (Pheeha, 2004; Carvalho and McCord, 2006; Smale, 2006; Notarbartolo *et al.* 2009). There is very little information available on the taxonomy and biology of *Torpedo* species from Indian waters. Reliable identification of these species under study is necessary for comparison with the biology of other stocks of the same species or of closely related species, and also for following the trends in a multispecies fishery, considering the increasing exploitation of the resources of our coastal waters.

In this study, an attempt was made to describe the diagnostic characters and morphometric data of the four species of torpedo electric rays under the genus *Torpedo*, that are represented in the catches of Visakhapatnam and to generate knowledge on some aspects of biology and length-weight relationship of the above four species.

Materials and methods

Samples of torpedo electric rays were collected from Visakhapatnam Fisheries Harbour and local landing centres at Bheemunipatnam and Lawson's Bay, during June 2010 to May 2011. External measurements and morphometrics are based on Bigelow and Schroeder (1953) and terminology for morphological characters follows Carvalho (1999). The identification follows Carvalho *et al.* (2002) and Campagno and Heemstra (2007). Multivariate data analysis included principal component analysis (PCA) of all morphometric characters of the closely related species of the genus *Torpedo.* Before computation, information from different characters were pooled into a comparable scale following standard procedure of Thorpe (1983). Due to the variation in size of fish, morphometric data was statistically adjusted to permit comparative analysis in terms of shape independent of size. Principal component analysis (PCA) was carried out using SPSS version 13.0 software.

The total length was taken from tip of snout to caudal fin end (TL) measured to the nearest millimeter and weighed to the nearest gram. The data were pooled monthly from different landing sites and subsequently grouped into classes of 20 mm intervals. For size groups represented in the catch a total of 395 specimens of four species of the genus *Torpedo viz., T. fascomaculata* (n=55), *T. panthera* (n=49), *T. marmorata* (n=117) and *T. sinuspersici* (n=228) were collected. The length–weight relationship was calculated by the method of least square using the equation: $W= a L^b$ (or) log W = log a + b log L, where W = body weight (g), L = total length (mm), and 'a' and 'b' are constants.

Results and discussion

Taxonomy

Descriptions are provided based on the examination of 142 specimens belonging to 4 species of the genus *Torpedo*: *T. fuscomaculata* (17), *T. panthera* (14), *T. marmorata* (38) and *T. sinupersici* (73) that are represented in the catches off Visakhapatnam. Morphometric measurements for the four species of electric rays are given in Table 1. In view of the prevailing confusion in identification of these species and because, many of the available descriptions are not adequate for distinguishing these closely related species, in addition to the descriptions, results of multivariate analysis *i.e.,* principal component analysis are also considered for identifying the diagnostic characters.

Description of genus

Torpedo Huttuyn 1764

Type species : *Raja torpedo* Linnaeus, 1758

Disc broadly rounded in outline with relatively straight anterior margin. Snout length anterior to orbit less than the length of eye and spiracle combined. Spiracular opening itself constricted by anterior spiracular wall in some specimens and relatively small and crescent-shaped. Eye much smaller than spiracle. Interorbital distance more than interspiracle distance. Pseudobrachial fold present inside the spiracle, lining anterior spiracular wall. Kidney shaped electric organs are visible on either side of the head and can generate and control a charge when provoked. Capable of delivering high voltage EOD (electric organ discharge) up to 50 V, 1 kW. These organs are capable of producing a powerful electric current which can be used to stun prey or deter predators. Electric organs without a clearly visible outline dorsally but easily observed in ventral view. Electric organ originate very close to disc contour and ends at a level of middle of last gill opening. Electric organ length inflect somewhat abruptly toward midline. Electric organ with concave inner margins posteriorly and convex outer contours and widest anteriorly in between mouth and first gill slit.

Gill slits crescent-shaped, situated lateral to level of outer corners of mouth and nostrils at a level of pelvic fin origin. Distance between first gill slit greater than distance between last gill slit. Third gill slit length larger than others and fifth gill slit smallest. Nasal curtain extends posteriorly to mouth opening. Mouth arched, width of mouth greater than internarial width. Tooth base slightly arched at centre. Teeth in 18 rows, small, crowns with

acute point, obliquely directed backwards, bases wide; the mandibular band not reaching angles of mouth. Teeth morphologically similar among both upper and lower jaws, with well developed single cusps, more prominent towards central rows. Tooth bases slightly arched at centre.

Description of species

Torpedo fuscomaculata Peters, 1855 (Fig. 1)

Common name : Black spotted torpedo

Torpedo fuscomaculata Peters, 1855 *Arch. Naturgesch,* 21: 278 (type locality: Mozambique)

Distinguishing characters: Very small knob like papillae present around the posterior margin of the spiracle, central posterior papilla larger. Distance between second dorsal and caudal fin greater than the distance between both dorsal fins. First dorsal entirely above the pelvic fin base.

Colour: Reddish brown background dorsally with brownish-black spots and white periphery, spots towards margins smaller than those in the middle of the body. Ventrally white in colour with a thick line of reddish brown margins with spots present on disc, pelvic fins and tail. Spots present on dorsal, pelvic and caudal fins. A line of small spots present in margins of caudal fin.

Torpedo panthera *Olfers,* 1831 Fig. 2

Common name : Leopard torpedo

Torpedo panthera Von Olfer, 1831: 15 (original description, as "var. r" of *T. marmorata* Risso, 1510, based on several specimens (number not precisely known). Not figured: lectotype (here in designated): ZMB 4560, adult male 281 mm TL: Red Sea; collected by Hemprich and Ehrenberg).

Distinguishing characters: Disc broadly rounded in outline with relatively straight anterior margin, slight median protuberance anteriorly. Disc faintly overlaps origin of pelvic fins, not leaving a prominent free lobe posteriorly. Preorbital snout length slightly greater than prenasal length and smaller than preoral snout length. Space between eyes and spiracles equal to horizontal eye diameter. Spiracle with 7-8 knob-like papillae on its edges, as long as eye and placed close behind eyes. First dorsal base ending in front of pelvic base. The nasal curtain short and wide, its length slightly larger than internarial width. Posterior margin of nasal curtain with a slight median lobe. Nostril with prominent fold mostly surrounding outer margins, outer margins of nostrils situated just lateral to level of mouth corners. Posterior contour of nostrils confluent with conspicuous median lobes that contact nasal curtain at its corners and separate nostrils from mouth. Pelvic fin originate just anterior to posterior disc margins, pelvic fin long but not very wide, greatest width of pelvic fin just less than one-half of disc width. Inter-dorsal distance almost equal to the distance between the second dorsal and caudal fin.

Colour: Amber coloured above with small spots crowded at the anterior region. Small clusters of more or less isolated and sometime blurry, whitish spots on the disc. Caudal darker, brown with small whitish spots. All fins with paler posterior margin. Ventral colouration uniform white, disc, pelvic fin, tail with clearly darker margin with small spots similar to dorsal colour.

The specimens of *T. panthera* collected during the present study, closely resemble *T. fuscomaculata* with slight variation in the colour pattern. In *T. panthera* dorsal side is amber coloured with small spots crowded at the anterior region (Fig. 2) where as in *T. fuscomaculata* body

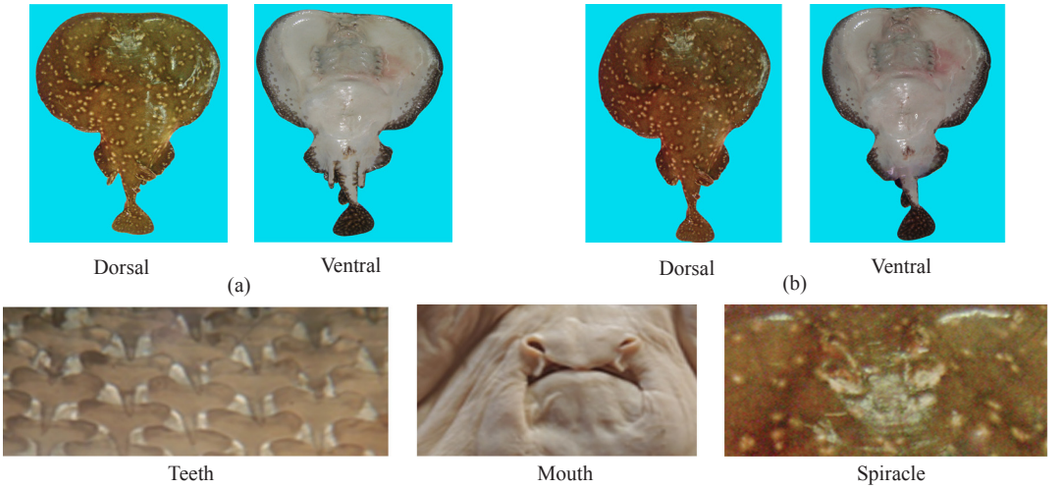

Fig. 1. *Torpedo fuscomaculata* (a) Male 450 mmTL, (b) Female 360 mmTL

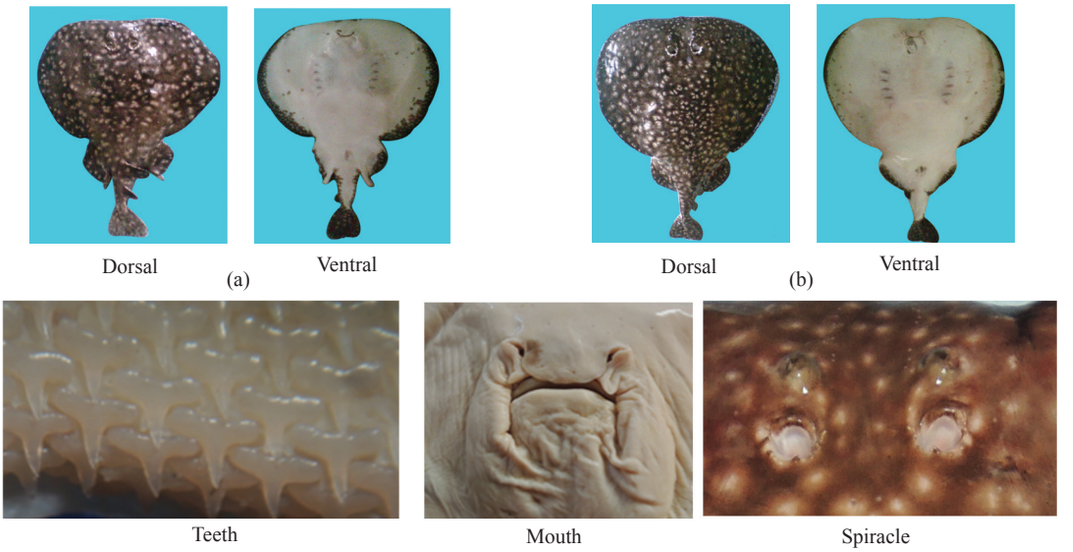

Fig. 2. *Torpedo panthera.* (a) Male 340 mmTL, (b) Female 380 mmTL

is reddish brown dorsally with brownish black spots with white periphery and the spots towards margins smaller than those in the middle of the body (Fig. 1).

Principal component analysis of T. fuscomaculata and T. panthera

The variance explained by first two components for *T. fuscomaculata* and *T. panthera* was 63.39%. Characters for which loadings are above 0.95 were considered significant. Factor loadings for the first two principal components for *T. fuscomaculata* and *T. panthera* are presented in Table 2. The first component was mainly defined by measurements of size (disc length DL, disc width DW, snout to maximum disc width and dorsal head length HLD); by the position of fins (pre-second dorsal, pre-ventral), size of fins (pectoral base, first dorsal height, caudal overall height, caudal margin length); gill slit length, electric organ length and space between second dorsal to caudal. Results of Tukey test are given in Table 3. Comparison of mean values revealed significant differences in the above thirteen factors (Table 1).

Torpedo marmorata Risso, 1810 (Fig.3)

Common name : Spotted torpedo

Torpedo marmorata Risso, *Ichth, Nice*, p. 20, pl.111, Fig 4, 1810. Smith, Fishes of Southern Africa, p. 75, pl. 4. Fig. 91. 1949.

Distinguishing characters: Eyes and spiracle relatively close together, space between them less than eye diameter. Nasal curtain short and wide, its length about half the length of internarial width. Origin of first dorsal at a level of middle of pelvic fin base and ends equally as pelvic fin. Interdorsal distance almost equal to the distance between second dorsal and caudal.

Colour: Body chocolate brown with light brown spots dorsally and white ventrally with thin spotted brown marginal edge. A line of closely small spots present along the rare margin of snout and extends up to pectoral end. Spots present on preorbital region smaller than the eye pupil. Spots below spiracle, interspiracle region are equal to pupil and on centre of disc up to first dorsal origin larger than pupil. On the disc, some spots are very closely set or joint together. On pelvic base large spots are present while towards margin a line of small spots present. Two dorsal fins and caudal fin, dark brown with pale spots.

The specimens of *T. marmorata* resemble *T. fuscomaculata* in the following aspects: Eyes and spiracle relatively close together, space in between them less than eye diameter; nasal curtain short and wide, its length about half the length of internarial width; posterior margin of nasal curtain with a median lobe, its tip reaches margin of upper jaw teeth.

Carvalho *et al.* (2002) stated that the description and figure of *Torpedo marmorata* of Annandale (1909) from Puri (off eastern India, in the Bay of Bengal) agrees with that of *T. panthera.* The present record of *T. marmorata* from east coast of India extends its range to the Indian Ocean.

Table 1. Proportional measurements for the four species of electric rays of the genus *Torpedo,* expressed as % of total length (TL)

	T. fuscomaculata		*T. panthera*		*T. marmorata*		*T. sinuspersici*	
Total length, TL (mm)	163 - 561, n=17		258 - 444, n=14		136 - 469, n=38		118 - 508, n=73	
Measurements	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Disc width*	60.11-69.15	64.83±2.78	59.46-67.96	63.76±2.76	58.65-68.97	63.95±2.99	58.51-69.96	64.24±2.94
Disc length*	56.23-62.85	59.44±1.81	57.75-60.23	59.05±0.89	54.22-64.68	57.96±2.32	50.25-61.25	56.15±2.31
Snout width	6.00-10.06	9.25±2.09	5.40-11.24	8.84±2.10	5.85-13.97	9.63±1.90	7.17-13.10	9.79±1.54
Snout, preorbital	7.33-10.42	8.56±0.87	6.58-9.62	7.92±0.78	7.14-10.66	8.62±0.89	6.87-10.77	8.48±0.91
Snout, preoral	7.76-11.04	9.26±0.92	6.58-10.06	8.94±0.96	7.45-10.76	9.24±0.77	7.29-11.89	9.62±0.85
Snout, prenasal	6.21-8.66	7.22±7.24	5.81-9.77	7.74±0.97	5.63-8.92	7.48±0.78	5.76-9.67	7.56±0.85
Eye diameter	1.94-3.57	2.59±0.45	1.93-3.66	2.59±0.41	1.13-3.58	2.31±0.57	1.01-3.91	2.48±0.63
Interorbital width	4.79-7.47	5.81±0.69	4.98-8.10	3.03±0.98	2.77-8.17	6.00±0.94	4.13-11.07	6.28±1.05
Spiracle cavity length	2.45-5.21	4.22±0.84	2.63-4.98	3.98±0.81	2.55-5.85	4.15±0.83	2.50-5.76	4.06±0.71
Spiracle width	2.14-4.76	3.80±0.67	3.37-3.84	3.64±0.15	3.58-4.29	4.01±0.27	1.67-5.16	3.79±0.57
Interspiracle width	2.85-3.66	3.35±0.35	3.34-5.03	4.15±0.53	4.01-0.27	3.58±4.29	2.39-5.93	4.19±0.63
Orbit+spiracle length	5.53-10.06	7.97±1.05	7.83-8.78	8.46±0.35	3.44-8.91	8.00±1.21	6.48-9.46	8.04±0.79
P base*	48.25-56.21	52.40±2.21	44.40-53.89	50.11±3.17	44.33-57.62	50.69±3.07	46.43-59.94	51.52±2.33
D1 height*	9.25-12.00	10.39±0.71	10.05-11.21	10.65±0.40	8.74-13.09	10.97±0.94	7.25-13.94	11.16±1.22
D1 base length	6.95-9.09	7.76±0.60	7.73-1.08	6.08±9.47	6.42-13.40	8.67±1.70	5.04-11.89	7.85±0.98
D2 height	6.56-9.48	7.90±0.81	6.17-10.02	7.93±0.96	5.85-9.74	7.77±0.84	5.42-11.58	8.29±1.04
D2 base length	4.15-5.56	5.01±0.49	4.13-5.57	4.85±0.58	4.10-6.70	4.89±0.53	3.33-6.76	4.96±0.59
Interdorsal space	2.49-4.51	3.50±0.62	2.34-4.22	3.23±0.62	2.00-4.54	3.33±0.61	1.58-5.12	3.33±0.69
Space D2 to upper C*	22.71-26.75	25.09±1.46	24.35-25.67	24.95±0.66	22.68-27.09	24.41±1.56	22.78-28.02	25.39±1.49
C overall height*	13.01-19.05	15.85±1.48	12.38-16.86	15.39±1.61	4.61-18.37	15.56±3.10	13.88-19.20	16.48±1.21
C height upper lobe	13.96-17.45	15.88±1.14	14.15-18.18	15.72±1.08	13.72-18.25	16.45±1.12	11.11-18.67	16.29±1.27
C height lower lobe	11.34-16.23	13.89±1.17	11.74-16.06	13.42±1.31	10.61-16.12	13.51±1.20	10.16-19.51	14.14±1.54
C margin length*	14.03-18.51	15.93±1.23	14.28-16.99	15.47±0.93	12.57-19.52	16.30±1.54	12.14-20.12	16.32±1.75
Tail, post D length	3.39-6.00	4.77±0.64	3.87-6.45	5.18±0.78	3.44-6.69	4.57±0.64	3.22-6.70	4.98±0.83
Tail, height at C origin	2.14-4.17	3.42±0.49	2.95-3.63	3.27±0.28	2.73-4.29	3.12±0.53	2.77-4.87	3.62±1.46
Tail, width at C origin	2.09-3.47	2.95±0.42	2.66-3.33	2.94±0.28	2.37-4.29	3.12±0.53	2.41-4.41	3.14±0.49
Lateral tail fold length	7.31-14.40	11.64±1.96	10.13-17.16	13.34±2.91	9.76-15.50	12.25±1.51	10.00-17.51	13.34±1.97
Head length, ventral*	33.51-39.26	35.79±1.72	22.94-37.16	35.14±1.31	31.76-39.03	35.39±1.73	31.60-38.30	35.42±1.55
Head length, dorsal*	13.37-17.95	15.84±1.18	15.04-16.55	16.02±0.68	15.32-16.83	15.98±0.44	13.88-18.54	16.08±1.18
Mouth width	4.63-9.03	7.04±1.46	5.81-9.33	7.50±1.28	4.68-9.66	7.23±1.08	5.36-9.22	7.37±0.98
Internarial width	3.33-7.34	4.65±0.95	3.47-5.27	4.40±0.46	3.78-5.57	4.58±0.73	3.61-6.09	4.69±0.45
Nasal curtain length	1.25-2.56	1.78±0.41	1.24-1.77	1.49±0.15	1.47-2.78	2.03±0.46	1.57-2.55	2.62±0.29
Length, 1st gill slit	2.50-4.55	3.38±0.54	2.95-4.22	3.79±0.46	2.73-4.43	3.67±0.48	2.36-4.95	3.68±0.51
Length, 3rd gill slit	2.67-4.87	4.00±0.52	3.25-4.87	4.20±0.62	3.12-5.12	4.20±0.58	3.11-5.31	4.17±0.46
Length, 5th gill slit	1.69-3.00	2.32±0.43	2.66-3.63	2.94±0.37	1.93-2.94	2.39±0.28	1.57-3.78	2.51±0.47
Space between 1st gill slits	15.80-19.00	17.54±1.07	15.54-18.38	16.71±0.88	14.90-21.29	17.33±1.39	14.28-19.18	17.07±1.04
Space between 5th gill slits	11.58-16.94	14.97±1.42	12.16-17.54	14.68±1.44	12.99-18.21	15.40±1.44	10.29-16.94	14.78±1.38
Pelvic fin length	9.14-15.22	12.13±1.65	0.67-1.16	0.93±0.16	6.26-13.59	11.11±1.58	9.35-17.23	11.91±1.57
Pelvic fin width	3.88-20.24	17.24±1.90	15.36-20.93	18.99±1.47	13.19-23.64	18.08±2.67	13.78-23.07	18.24±2.53
PDO	14.89-23.00	17.06±2.32	15.66-23.37	17.69±2.86	13.98-19.12	16.56±1.51	14.07-19.81	17.14±1.30
Clasper-cloaca length	1.30-18.84	16.47±1.63	15.83-17.82	16.71±0.82	11.62-21.08	16.40±3.37	10.71-20.12	17.76±2.09
Clasper from 1st hemal spine	5.49-7.90	6.94±0.73	5.73-8.91	6.59±1.09	2.99-14.12	7.04±2.31	5.34-10.72	7.69±1.37
Snout to mid-cloaca	58.72-64.12	61.39±1.80	60.46-64.18	61.81±1.13	56.20-66.91	60.16±2.41	53.74-65.32	60.53±2.31
Snout to pelvic origin*	50.96-60.57	56.61±2.11	49.26-59.05	55.36±2.89	48.21-60.80	54.65±2.72	50.13-59.69	55.09±2.26
Snout to dorsal 1 origin	60.55-67.39	63.54±1.76	61.14-65.31	63.52±1.37	57.03-69.41	62.85±2.66	60.20-69-97	64.19±2.19
Snout to dorsal 2 origin*	71.19-78.02	74.35±1.87	72.28-77.59	74.31±1.50	67.57-79.38	73.49±2.61	71.24-79.23	74.63±1.75
Snout to maximum disc width*	38.32-47.43	43.80±2.64	43.97-50.45	47.00±2.13	41.33-51.39	44.63±2.51	40.10-48.79	44.47±2.45
Snout to 1st gill slit	17.29-25.69	22.75±2.94	20.54-25.62	23.33±1.90	11.02-27.13	23.47±2.75	20.91-27.93	24.41±1.48
Mid-cloaca to tail end	35.12-41.82	38.51±1.90	37.27-40.17	39.06±0.86	36.30-46.09	39.71±2.11	34.18-43.63	39.40±1.95
Electric organ length*	31.00-38.96	33.04±2.26	16.23-32.65	28.40±8.11	30.04-40.20	33.93±3.09	28.81-39.85	32.43±2.05
Electric organ greatest width	12.30-19.78	16.14±2.19	13.31-19.81	15.86±3.03	12.68-19.92	17.04±1.90	12.03-19.82	16.11±1.69
Electric organ width at 1st gill slit	8.38-14.61	10.87±1.79	10.00-13.09	11.42±1.27	8.91-12.40	10.54±1.13	8.51-12.28	10.24±0.92

*significant characters in PCA

Table 2. Factor loadings for the first two principal components for *T. scomaculata* and *T. panthera*

Characters	Component	
	1	2
Total length	.956	-
Disc width	.983	-
Disc length	.985	-
Snout width	.752	-
Snout, preorbital	.712	.199
Snout, preoral	.871	.338
Snout, prenasal	.840	-
Eye diameter	.415	.522
Interorbital width	.783	-.179
Spiracle cavity length	.113	.575
Spiracle width	.817	.374
Interspiracle width	.746	-.388
Orbit+spiracle length	.871	.123
P base	.981	-
D1 height	.960	-
D1 base length	.753	.234
D2 height	.799	.323
D2 base length	.676	.380
Interdorsal space	.345	.305
Space D2 to upper C	.967	-
C overall Height	.968	.111
C Height upper lobe	.935	-
C height lower lobe	.924	.117
C margin length	.954	-
Tail, post D length	.350	-.315
Tail, height at C origin	.832	-.227
Tail, width at C origin	.624	-.324
Lateral tail fold length	.828	-.200
Head length, ventral	.989	-
Head length, dorsal	.965	-
Mouth width	.461	.189
Internarial width	.733	.450
Nasal curtain length	.329	.560
Length, 1st gill slit	.702	-.240
Length, 3rd gill slit	.837	-
Length, 5th gill slit	.340	-.490
Pelvic fin length	.822	-
Pelvic fin width	.898	-.114
PDO	.914	-
Clasper-cloaca length	.657	-.312
Snout to pelvic origin	.979	-
Snout to dorsal 1 origin	.541	-
Snout to dorsal 2 origin	.986	-
Snout to max disc width	.971	-
Snout to 1st gill slit	.732	-.320
Mid-cloaca to tail end	.941	-
Electric organ length	.973	-
Electric organ greatest width	.740	-.149
Electric organ width at 1st gill slit	.859	-.153

Torpedo sinuspersici Olfers, 1831(Fig. 4)

Common name : Mottled electric ray

Torpedo sinuspersici Kämpfer in Van Olfers, 1831: 15 (Type locality: Persian Gulf)

Distinguishing characters: Disc only faintly overlaps origin of pelvic fins. Space between eye and spiracle very less and not more than eye diameter. Spiracle large, rounded with small knob-like 8-11 papillae at its posterior margins. Nostril close together, nasal curtain short and wide, its length smaller than the internarial width. Nostrils with prominent folds mostly surrounding outer margin, outer margins of nostril situated just lateral to level of mouth corners.

Table 3. Tukey test (only for characters that became significantly different) for morphometric characters between *T. fuscomaculata* and *T. panthera* off Visakhapatnam

Characters	F value	P
Disc width	115.48	0.000
Disc length	239.62	0.000
P base	59.61	0.000
D1 height	10.01	0.000
Space D2 to upper C	36.68	0.000
C overall height	25.24	0.000
C margin length	11.40	0.000
Head length, ventral	77.57	0.000
Head length, dorsal	40.15	0.000
Snout to pelvic origin	87.03	0.000
Snout to dorsal 2 origin	40.59	0.000
Snout to max disc width	80.56	0.000
Electric organ length	30.24	0.000

First dorsal fin originating in front of posterior axil of pelvic fin and base entirely beyond the posterior apex of pelvic fin. First dorsal fin moderately slanted at its anterior margin, with a posterior free lobe about equal to one-third of its base length. Posterior margin of caudal fin more or less straight, both apexes of caudal fin slightly acute and not broadly rounded.

Colour: Dorsally uniform dark brown with close set of light brown or pale colour spots. These spots are fused and form rather thick vermiculations. Spots on margin of snout, pectoral margins are smaller than those on middle of dorsal disc. Spots on middle of the body larger than pupil. Small spots present on pelvic fin, rare margin of pelvic fin creamy. Posterior margin of dorsal fins with a very narrow edging of light, cream colour with small spots. Small spots present on anterior margin, dorsal and caudal fins, spots at base more in number than towards margin. Ventral colouration uniform creamy-white, but disc, pelvic fin, tail with clearly darker margin with small spots similar to dorsal colour.

The present specimens of *T. marmorata* closely resemble *T. sinuspersici* but with slight variation in the colour pattern. In *T. marmorata* body is chocolate brown dorsally with light brown spots (Fig. 3) where as in *T. sinuspersici* body is uniformly dark brown dorsallywith close set of light brown or pale spots which are fused to form rather thick vermiculations (Fig. 4).

Carvalho *et al.* (2002) reported that Jones and Kumaran (1980) illustrated a specimen of *T. sinuspersici* from the Laccadive Island, which is misidentified as *T. marmorata.*

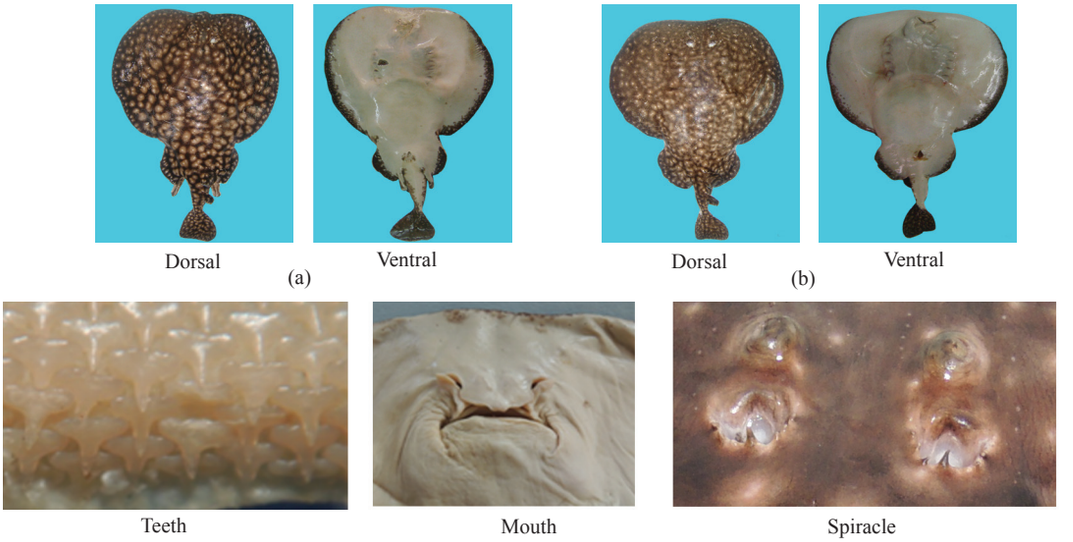

Fig. 3. *Torpedo marmorata* (a) Male 310 mmTL, (b) Female 330 mmTL

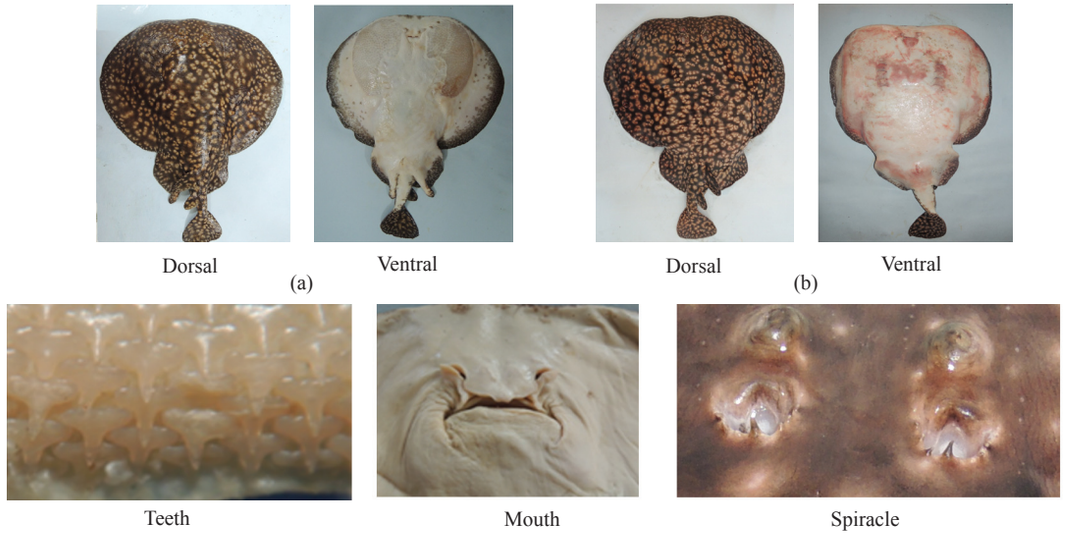

Fig. 4. *Torpedo sinuspersici* (a) Male 350 mmTL, (b) Female 322 mmTL

Principal component analysis of T. marmorata and *T. sinusperisci*

The variance explained by first two components for *T. marmorata* and *T. sinuspersici* was 66.78%. Characters for which loadings are above 0.95 were considered significant. Factor loadings for the first two principal components for *T. fuscomaculata* and *T. panthera* are presented in Table 4. The first factor was mainly defined by measurements of size (disc length, DL, disc width, DW), snout to maximum disc width, head length ventral, (HLV), head length dorsal (HLD); by the position of fins (pre first dorsal, pre second dorsal, pectoral base, pectoral end to dorsal origin, pre ventral caudal overall height), pre-first gill slit, electric organ length and electric organ width. Results of Tukey test are given in Table 6. Comparison of mean values revealed significant differences in the above fourteen characters (Table 1).

Length frequency distribution and length-weight relationship

Since torpedo electric rays are captured, albeit in small numbers, by the trawlers operating along the inner half of the continental shelf off Visakhapatnam, and since there is relatively little information on the species

Table 4. Factor loadings for the first two principal components for *T.marmorata* and *T. sinuspersici*

Characters	Component		Characters	Component	
	1	2		1	2
Total length	.958	.191	Tail, height at C origin	.761	-.442
Disc width	.963	.166	Tail, width at C origin	.700	-.450
Disc length	.959	.179	Lateral tail fold length	.919	-.163
Snout width	.930	.243	Head length, ventral	.981	-
Snout, preorbital	.843	.229	Head length, dorsal	.964	-.177
Snout, Preoral	.910	.191	Mouth width	.659	-
Snout, prenasal	.859	.202	Internarial width	-.873	.212
Eye diameter	-	.315	Nasal curtain length	.747	-.187
Interorbital width	.624	.118	Length, 1st gill slit	.818	-.395
Spiracle cavity length	-	.322	Length, 3rd gill slit	.855	-.398
Spiracle width	.757	-	Length, 5th gill slit	.743	-.286
Interspiracle width	.727	-	Pelvic fin length	.751	.234
Orbit+spiracle length	.908	-.200	Pelvic fin width	.867	-
P base	.964	.156	PDO	.961	-.178
D1 height	.832	.285	Clasper-cloaca length	.202	.150
D1 base length	.664	.298	Snout to pelvic origin	.960	.170
D2 height	.704	.189	Snout to dorsal 1 origin	.963	.171
D2 base length	.378	.317	Snout to dorsal 2 origin	.961	.157
Interdorsal space	.183	-	Snout to max disc width	.982	-
Space D2 to upper C	.886	-.155	Snout to 1st gill slit	.972	-.118
C overall height	.954	-.207	Mid-cloaca to tail end	.946	.179
C height upper lobe	.935	.155	Electric organ length	.973	-
C height lower lobe	.844	.223	Electric organ greatest width	.960	-
C margin length	.879	.286	Electric organ width at 1st Gill slit	.921	-.242
Tail, post D length	.265	.234			

Table 5. Tukey test (only for characters that are significantly different) for morphometric and meristic characters between *T. marmorata* and *T. sinuspersici* off Visakhapatnam

Character	F value	p
Disc width	93.29	0.000
Disc length	300.44	0.000
P base	58.55	0.000
C overall height	20.01	0.000
Head length, ventral	133.82	0.000
Head length, dorsal	18.68	0.000
PDO	15.60	0.000
Snout to pelvic origin	125.98	0.000
Snout to dorsal 1 origin	88.68	0.000
Snout to dorsal 2 origin	246.75	0.000
Snout to max disc width	58.20	0.000
Snout to 1st gill slit	51.23	0.000
Electric organ length	36.39	0.000
Electric organ greatest width	12.26	0.000

represented in Indian waters, it was felt worthwhile to carry out some aspects of biological studies of the species represented in this area. A perusal of relevant literature indicates that there are quite a few studies in the length frequency distribution and length-weight relationship of electric rays. Of the four species of electric rays of the genus *Torpedo* that are represented in the catches off Visakhapatnam, *T. sinuspersici* is represented in the catches throughout the year except in the month of May owing to trawl ban along the east coast of India.

A total of 395 specimens belonging to the four species of electric ray genus *Torpedo: T. fuscomaculata* (n=55), *T. panthera* (n=49), *T. marmorata* (n=117) and *T. sinuspersici* (228) were collected. From the pooled annual length frequency distribution graph it was observed that the above four species were represented in the catches predominantly by the size groups of 280-380 mm TL, 300-360 mm TL, 270-390 mm TL and 280-400 mm TL respectively (Fig. 5). The major modes for *T. fuscomaculata* were at 290, 330 mm TL, *T. panthera* at 310, 330 mm TL, *T. marmorata* at 320 mm TL and *T. sinuspersici* 330 mm TL and 340 mm TL respectively. The largest specimens recorded being 561 mm TL for *T. fuscomaculata,* 620 mm TL of *T. panthera,* 469 mm TL *T. marmorata* and 500 mm TL for *T. sinuspersici*. According to Froese and Pauly (2013) these species grow to 64 cm TL, 100 cm TL, 100 cm TL,

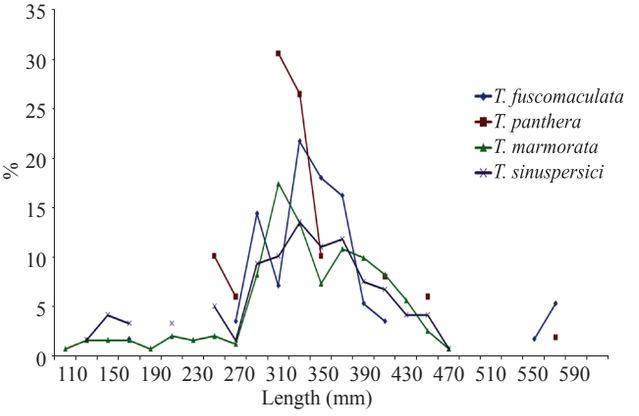

Fig. 5. Pooled length frequency distribution of four species of genus *Torpedo* represented in the catches of Visakhapatnam

Table 6. Data on monthly collection of four species of genus *Torpedo* off Visakhapatnam

Months	*T. fascomaculata*		*T. marmorata*		*T. panthera*		*T. sinuspersici*	
	♂	♀	♂	♀	♂	♀	♂	♀
June 2010	8	6	12	8	6	4	15	17
July 2010	1	9	2	2	2	2	7	3
August 2010	-	2	23	12	6	3	13	2
September 2010	1	2	4	1	-	1	7	2
October 2010	10	1	14	6	-	1	15	16
November 2010	-	-	-	-	-	-	25	12
December 2010	7	6	14	13	12	10	17	30
January 2011	1	-	-	-	-	-	6	6
February 2011	-	-	-	-	-	-	1	2
March 2011	-	-	2	1	-	-	1	1
April 2011	1	-	2	1	2	-	3	7
May 2011	-	-	-	-	-	-	-	-

130 cm TL respectively. Electric rays are caught year round, but adult individuals of these four species of both sexes are most frequently captured from August to October (Table 6). The length-weight relationships of the above four species of the genus *Torpedo* are presented in Fig. 6, 7, 8 and 9.

Pallaora *et al.* (2005) studied the length-weight relationship of *T. marmorata* and estimated b value as 2.851 from eastern Adriatic Sea. Filiz and Bilge (2004) estimated b value as 2.91 from Turkey and in the present study the estimated b value of 2.8879 coincided with these values.

The frequency distribution of sexes showed that females attained larger size than males in the three species *viz., T. marmorata, T. panthera* and *T. sinuspersici.* This difference was most evident in *T. sinuspersici* where the largest female measured 500 mm TL where as the largest male measured 446 mm TL. In *T. panthera* and *T. marmorata* males were conspicuously shorter than females, the largest male and female measured 401, 459

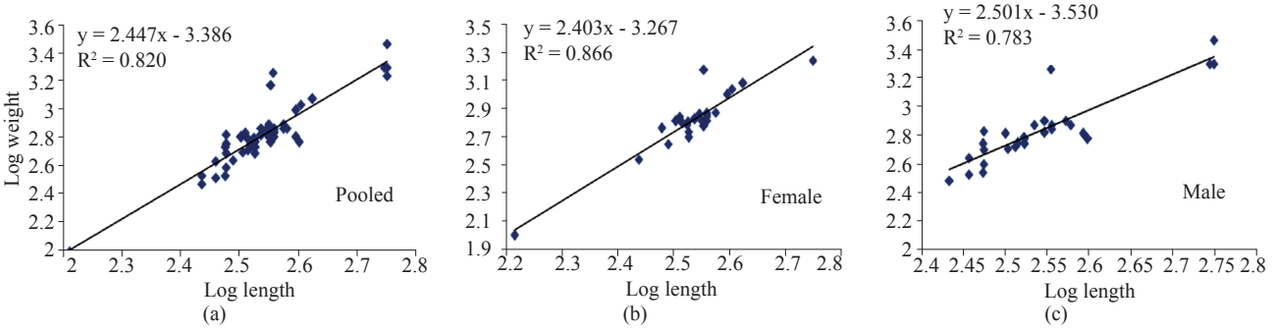

Fig. 6. Length-weight relationship of *Torpedo fuscomaculata* off Visakhapatnam

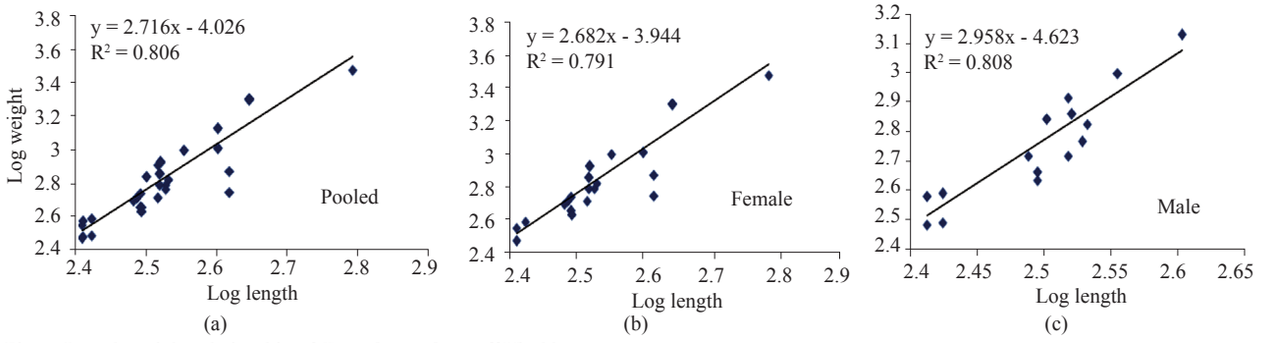

Fig. 7. Length-weight relationship of *Torpedo panthera* off Visakhapatnam

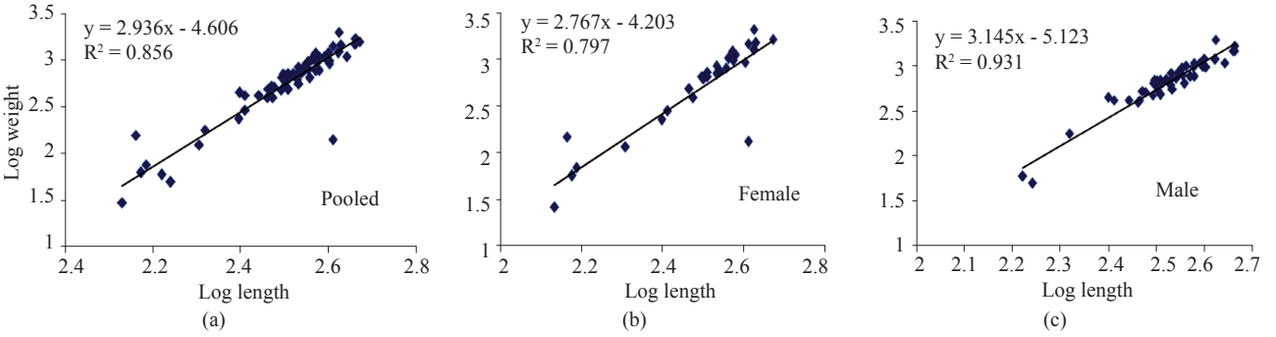

Fig. 8. Length-weight relationship of *Torpedo marmorata* off Visakhapatnam

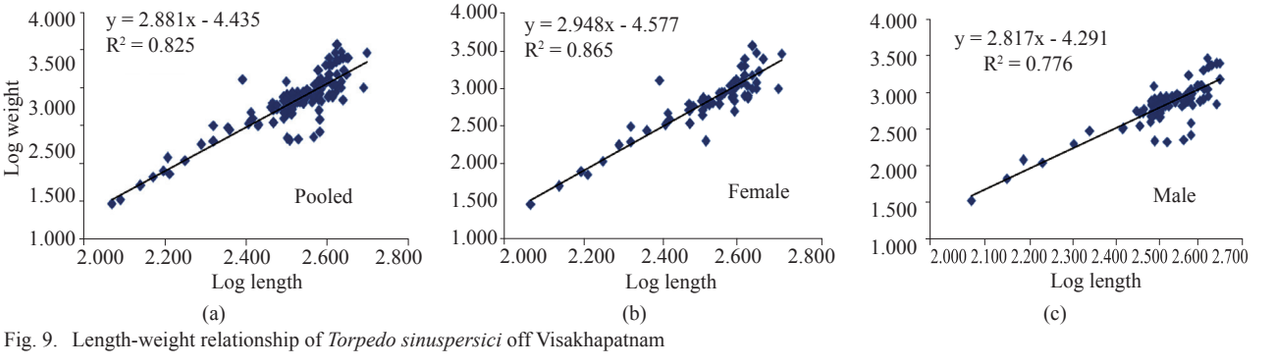

Fig. 9. Length-weight relationship of *Torpedo sinuspersici* off Visakhapatnam

and 444, 480 mm TL respectively. In *T. fuscomaculata* males attained larger size than females and the frequency distribution of sex shows that largest male measured 461 mm TL where as the largest female measured 393 mm TL.

The results of the present study contribute to the knowledge on certain biological parameters of the four species of electric rays in the genus *Torpedo viz., T. fuscomaculata, T. panthera, T. marmorata and T. sinuspersici*, represented in the catches off Visakhapatnam. The present record of *Torpedo marmorata* from east coast of India further extends its range to the Indian Ocean.

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