J. Exp. Zool. India Vol. 21, No. 1, pp. 103-118, 2018 | www.connectjournals.com/jez | *ISSN 0972-0030*

VENOMOUS FISH DIVERSITY REPRESENTED IN THE CATCHES OF CENTRAL EASTERN COAST OF INDIA

K. Sujatha*, Sneha Jha, V. Iswarya Deepti and V. Ravali

Department of Marine Living Resources, Andhra University, Visakhapatnam – 530 003, India.
*e-mail: sujatha.mlr@gmail.com

(Accepted 10 December 2017)

ABSTRACT : Huge range of venomous fish species are represented in the coastal waters of central eastern coast of India. Although, only a handful of species of venomous fish are thought to be capable of causing human mortality, many other species of fish can produce severe envenomation as their venoms contain many pharmacologically active components. Concise knowledge of taxonomy and biology of these venomous fishes is requisite for future studies on biotoxins produced by these fishes. The present paper provides a list of 117 venomous fish species belonging to 16 families along with 89 coloured photographs and a short description of their venom apparatus.

Key words : Offensive fishes, systematic list, spine structures, Indian waters.

INTRODUCTION

Venomous fishes are the most diversified and widely represented group in coastal Indian waters. Studies on venoms produced by marine finfishes for chemical nature, pharmacology, toxicology and evolution are sparse. Morphological examinations and phylogenetic analyses suggest that 585-650 species of spiny-rayed fishes that include stingrays, scorpionfish, zebrafish, stonefish, weeverfish, toadfish, stargazers, and some species of shark, ratfish, catfish, surgeonfish and blenny are venomous (Smith and Wheeler, 2006). Although, venomous fishes are circumglobal, their highest occurrences recorded are within the Indo-Pacific region, especially, within coral reef systems (Russell, 1965). The vast majority of venomous fish are non-migratory, slow moving and tend to live in shallow waters in protected habitats (Maretic, 1988). Huge range of these fish species are caught as by – catch of shrimp and trammel net fisheries along east coast of India (Sujatha, 1995).

Many fishes have well developed defensive organs in the form of armour, teeth, spines, poison-containing skin and/or venom glands but are generally regarded as venomous if they possess a offensive or traumatising apparatus, such as pungent spines, capable of both puncturing the skin and depositing a venom within the punctured wound. These apparatus are used to fulfil essential biological needs, such as self defence or catching prey. This venom apparatus invariably consists of a spine, that may be located on the dorsal (the most common), pectoral, opercular, shoulder, pelvic, anal and caudal areas of the fish, depending on the species. This spine is associated with venom secreting cells, all covered in an integumentary sheath enclosing the spine, when sheath is ruptured venom enters the wound (Williamson, 1995). Venomous spines can be observed in species from many evolutionary classes of fish, from the primitive cartilaginous fish (e.g., stingrays), to the more advanced bony fishes (e.g., stonefish). Although, only a handful of species of venomous fish are thought to be capable of causing human mortality, many other species of fish can produce severe envenomation as their venoms contain many pharmacologically active components.

To assist clinicians in assessing envenomed patients, it is important to provide a classification system that takes into consideration a clinician's limited knowledge of the biology and taxonomy of venomous and poisonous animals and the fact that, in most instances, the culprit has not been reliably observed by patients and bystanders and is not available for identification. Shukla (2009) stated ichthyoacanthotoxism is known to result from the stings of many fishes. The present paper provides a list of venomous fish species along with 89 coloured photographs of these species represented in Visakhapatnam waters, central eastern coast of India with an account of the families consisting of venomous fishes and a short description of their venom apparatus.

MATERIALS AND METHODS

The present study is based on samples of venomous fish species belonging to 16 families collected from Visakhapatnam (Lat $17^0$01'-$19^0$22'N; Long $83^0$23'E-$85^0$14'E). Samples were also collected from various fish

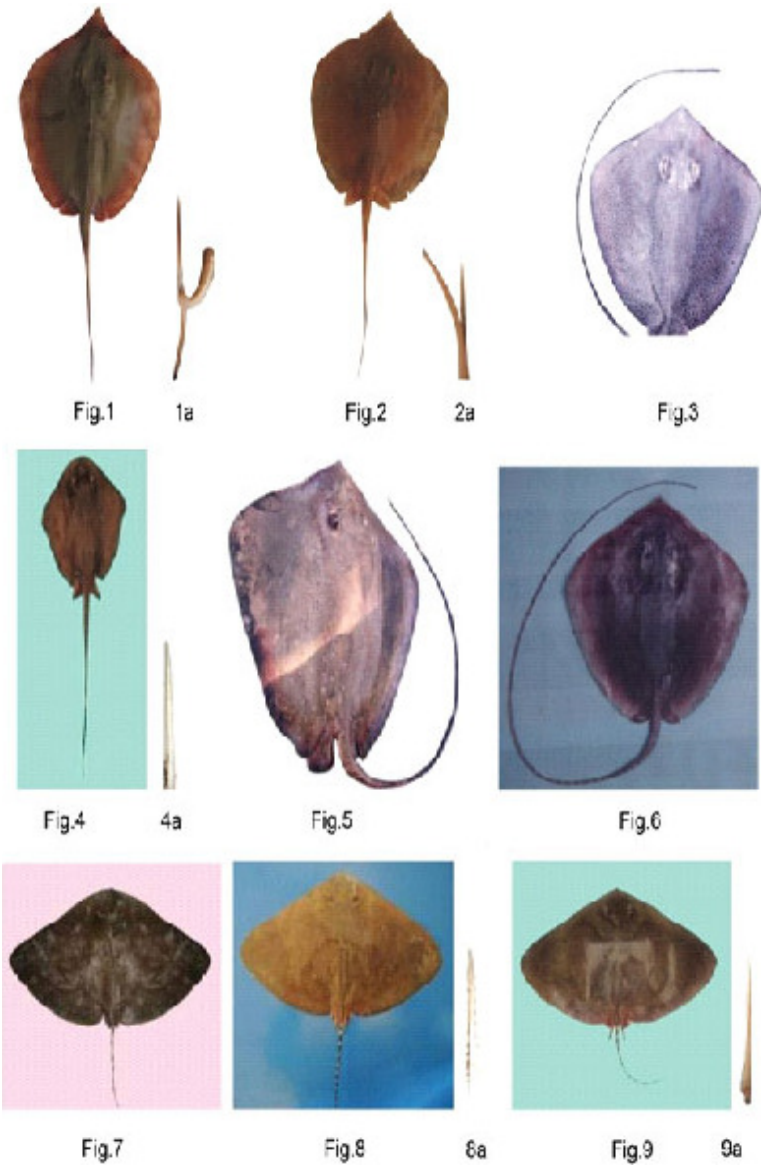

Plate I : Fig. 1 : *Brevitrygon imbricata* - 319 mm DW 1a; Fig. 2: *Brevitrygon walga* – 196 mm DW 2a; Fig. 3: *Himantura uarnak* – 652 mm DW; Fig. 4: *Neotrygon kuhlii* – 203 mm DW 4a; Fig. 5: *Pateobatis bleekeri* – 632 mm DW; Fig. 6 : *Pateobatis jenkinsii* – 240 mm DW; Fig. 7: *Gymnura japonica* – 390 mm DW; Fig. 8: *Gymnura poecilura* – 507 mm DW 8a; Fig. 9: *Gymnura zonura* – 442 mm DW 9a; a. Caudal spine.

landing centres - Balugaon, Srikakulam, Bheemili, Pudimadaka, Kakinada, Chennai, Mandapam and Kanyakumari along east coast of India (Fig. 1) during the period April, 2015 to March 2017. Samples were collected from shrimp trawl by-catches as well as from the catches of cast net, hook and line, shore seine, trammel net, boat seine and purse seine. Venomous fishes were identified using recent fish taxonomic works and revisions. Classification is based on Nelson *et al* (2016). The peculiar morphology of fishes of different families under study necessitates providing colour photographs. Photographs were taken for fresh specimens and their venom spine structures. Venomous spines were separated by boiling fresh specimens and defleshing them.

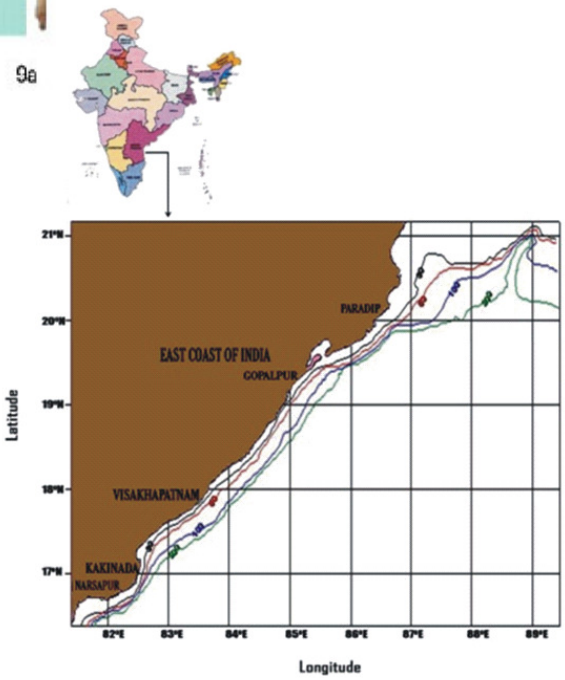

Fig. 1 : Map showing sample collection centres.

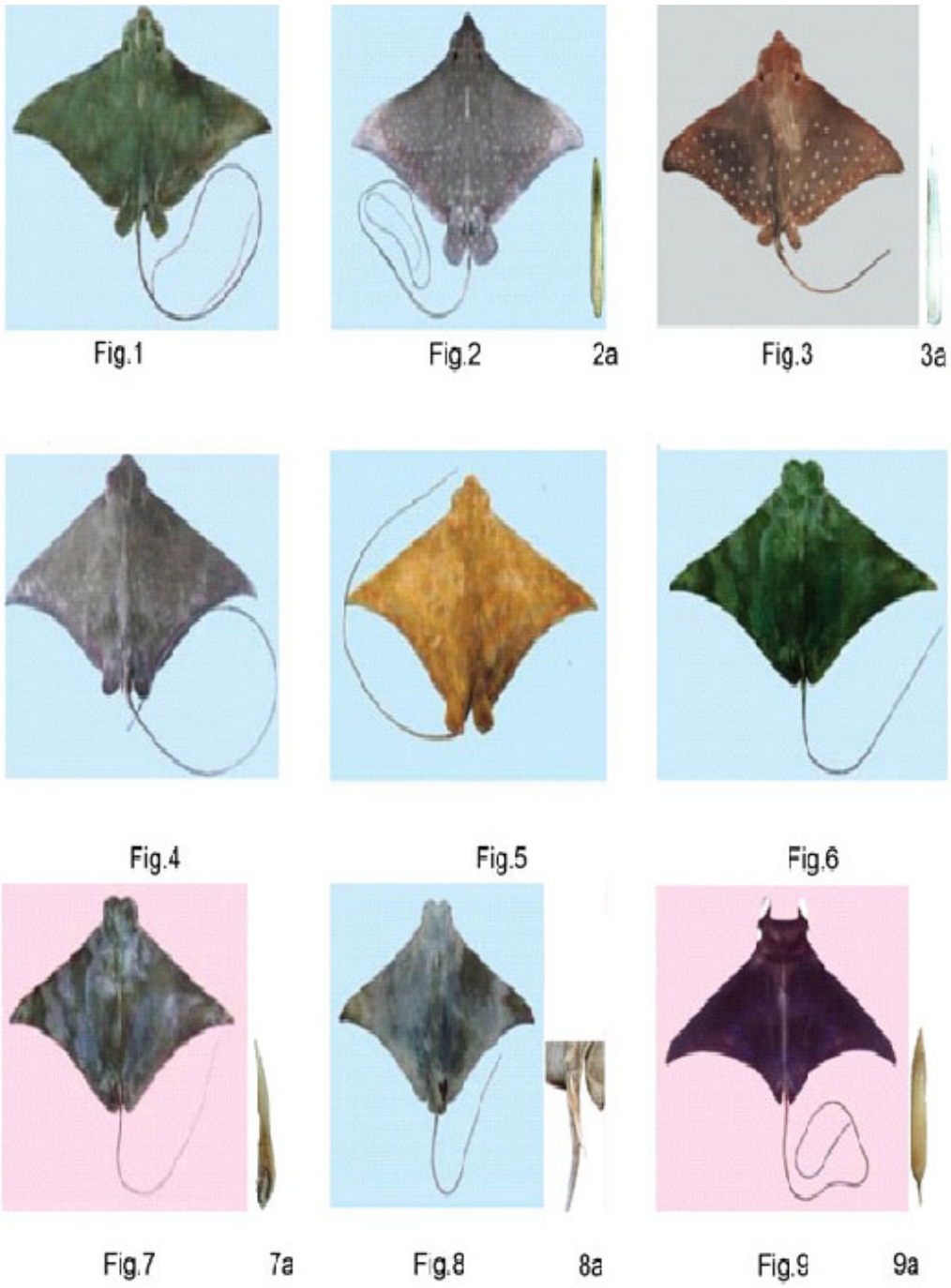

Plate II : Fig. 1: *Aetobatus flagellum* – 565 mm DW; Fig. 2: *Aetobatus narinari* – 771 mm DW; 2a; Fig. 3: *Aetobatus ocellatus* – 410 mm DW; 3a; Fig. 4 : *Aetomylaeus milvus* – 884 mm DW; Fig. 5: *Aetomylaeus nichofii* – 561 mm DW; Fig. 6: *Rhinoptera adspersa* – 635 mm DW; Fig. 7 : *Rhinoptera javanica* – 757 mm DW; 7a; Fig. 8 : *Rhinoptera sewelli* – 368 mm DW; 8a; Fig. 9: *Mobula japanica* – 1887 mm DW; 9a; a. Caudal spine.

RESULTS

The present work incorporates list of 117 venomous fish species belonging to 16 families in 10 orders and the length groups represented in the catches of central eastern coast of India (Tables 1, 2) that is helpful in understanding distribution of these species in space. Brief description of venom apparatus/spine structures of species of the above families are also provided.

In Chondrichthyes, twenty six venomous fish species of families: Dasyatidae - whiptail sting rays, ten species (Plate I Figs. 1 to 6); Gymnuridae - butterfly rays, four species (Plate I Figs. 7 to 9) and Myliobatidae - six

Table 1 : Systematic list of venomous fishes of Class Chondrichthyes represented in the catches of Visakhapatnam.

Name of the species	Length ranges (mm DW)	MRS * (mm DW)
Order: Myliobatiformes (sting rays)		
Suborder: Myliobatoidei		
Family : Dasyatidae		
Brevitrygon imbricata (Bloch & Schneider, 1801)	60-280	250
Brevitrygon walga (Müller & Henle, 1841)	160-460	450
Himantura marginata (Blyth, 1860)	1020	1790
Himantura uarnak (Gmelin, 1789)	640-860	2000
Maculabatis gerrardi (Gray, 1851)	220-420	2000
Neotrygon kuhlii (Müller & Henle, 1841)	203-290	700
Pateobatis bleekeri (Blyth, 1860)	230-680	1050
Pateobatis jenkinsii (Annandale, 1909)	200, 240	1300
Pastinachus sephen (Forsskål, 1775)	1220	1830
Telatrygon zugei (Müller & Henle, 1841)	62-180	290
Family : Gymnuridae		
Gymnura japonica (Temminck & Schlegel, 1850)	310-860	1000
Gymnura micrura (Bloch & Schneider, 1801)	260-900	1370
Gymnura poecilura (Shaw, 1804)	240-887	2500
Gymnura zonura (Bleeker, 1852)	170-566	1060
Family : Myliobatidae		
Subfamily Myliobatinae		
Aetobatus flagellum (Bloch & Schneider, 1801)	565-1377	720
Aetobatus narinari (Euphrasen, 1790)	354-1480	3300
Aetobatus ocellatus (Kuhl, 1823)	290-1164	1530
Aetomylaeus milvus (Müller & Henle, 1841)	250-1140	--
Aetomylaeus nichofii (Bloch & Schneider, 1801)	200-809	650
Manta birostris (Walbaum, 1792)	4300	9100
Subfamily Rhinopterinae		
Rhinoptera adspersa (Müller & Henle, 1841)	635	990
Rhinoptera javanica (Müller & Henle, 1841)	424-1628	1500
Rhinoptera sewelli (Misra, 1946)	368-725	--
Subfamily Mobulinae		
Mobula eregoodootenkee (Bleeker, 1859)	1220-2790	1000
Mobula japanica (Müller & Henle, 1841)	680-2450	3100
Mobula kuhlii (Müller & Henle, 1841)	675	1200

*MRS: Maximum Recorded Size.

species in sub families Myliobatinae – eagle rays, (Plate II Figs. 1 to 5); three species in Rhinopterinae - cownose rays, (Plate II Fig. 6 to 8); three species in Mobulinae - devil rays, (Plate II Fig. 9) are recorded from this region. Eagle rays are semi-pelagic and gregarious often forming large schools (McEachran and Capape, 1984).

Whiptail sting rays are dorsoventrally flattened fish, tail whip-like, sometimes very long, usually with one or more poisonous spines at the base. The sting rays' venom apparatus consists of a barbed spine on the caudal appendage or tail, with enveloping integumentary sheath, associated venom glands and "wedge-shaped" area of the integument.

Butterfly rays have a disc width considerably larger than disc length and a short 'rat-like' tail compared to other batoids. Some bear a venomous spine of approximately 2.5 cm on the middle or proximal third on their short tails and are considered far less dangerous than long tailed sting rays.

Eagle rays have a lozenge-shaped disc much broader than long. Head protrudes slightly beyond the disc and snout is rounded. Tail long, slender, whip-like, bearing a small dorsal fin and a serrated spine behind it with limited striking ability.

Cownose rays' body, head and pectorals are united in a broad lozenge-shaped disc, development of the pectorals greater in the anterior half. Tail long whip-like, with serrated spine. Anterior side greatly compressed,

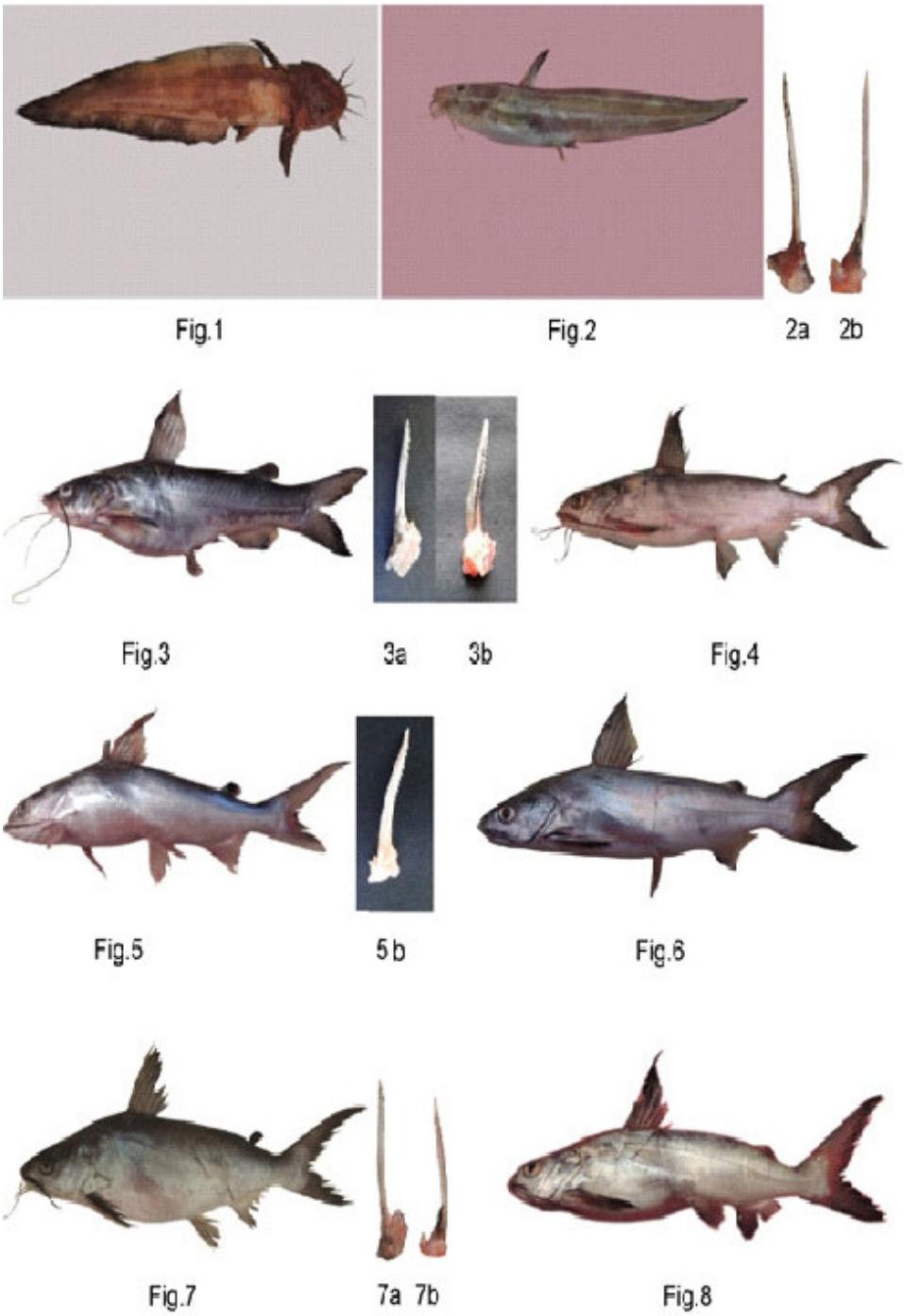

Plate III : Fig.1. *Plotosus canius* – 260 mm TL; Fig. 2: *Plotosus lineatus* – 121 mm TL; 2a, 2b; Fig. 3: *Mystus gulio* – 156 mm TL; 3a, 3b; Fig. 4: *Arius jella* – 170 mm TL; Fig. 5: *Arius maculata* – 260 mm TL; 5a; Fig. 6 : *Arius sumatranus* – 142 mm TL; Fig. 7: *Netuma thalassina* – 296 mm TL; 7a, 7b; Fig. 8: *Nemapteryx caelata* – 133 mmTL. a. Dorsal spine b. pectoral spine.

the rest flagelliform.

Devil rays have disc wider than long, rhomboidal, pectoral tips falcate. A pair of curling horn like flippers in front of the head. Tail slender, whip-like, with or without a serrated spine; dorsal fin between the ventrals.

In Class Osteichthyes, 91 species belonging to 9 orders and 13 families are recorded from this region. Small to moderate, brightly coloured, carnivorous fishes found in all depths are known to inhabit shallow coastal waters, camouflaged around rocks and reefs, some from deep waters. Sea catfishes are medium to large sized fish. Head covered with a bony shield. Posterior portion of bony shield extending backwards and medially to meet the predorsal plate. Many species of blennies live in tidal

Table 2 : Systematic list of venomous fishes of Class Osteichthyes represented in the catches of Visakhapatnam.

Name of the species	Length ranges (mm TL)	MRS* (mm TL)
Order: Siluriformes		
Family: Plotosidae		
Plotosus canius (Hamilton, 1822)	157-230	1500
Plotosus limbatus (Valenciennes, 1840)	134-167	452
Plotosus lineatus (Thunberg, 1787)	60-277	320
Family: Bagridae		
Mystus gulio (Hamilton, 1822)	150-197	460
Family : Ariidae		
Arius arius (Hamilton, 1822)	220-310	494
Arius jella Day, 1877	126-170	300
Arius maculatus (Thunberg, 1792)	214,260	800
Arius sumatranus (Bennett, 1830)	121-226	320
Batrachocephalus mino (Hamilton, 1822)	120,187	250
Hexanematichthys sagor (Hamilton, 1822)	219-270	450
Nemapteryx caelata (Valenciennes, 1840)	133	450
Netuma thalassina (Rüppell, 1837)	135-296	1850
Osteogeneiosus militaris (Linnaeus, 1758)	200-290	350
Plicofollis dussumieri (Valenciennes, 1840)	310	620
Plicofollis platystomus (Day, 1877)	211,213	310
Plicofollis tenuispinis (Day, 1877)	220	360
Sciades sona (Hamilton, 1822)	410	920
Order : Holocentriformes		
Family : Holocentridae		
Myripristis berndti Jordan & Evermann, 1903	124-180	300
Myripristis botche Cuvier, 1829	110-294	356
Myripristis kuntee Valenciennes, 1831	80-154	260
Myripristis murdjan (Forsskal, 1775)	112-198	600
Sargocentron caudimaculatum (Ruppell, 1838)	148	250
Sargocentron praslin (Lacepede, 1802)	240	320
Sargocentron rubrum (Forsskal, 1775)	75-226	320
Sargocentron spiniferum (Forsskal, 1775)	178	546
Order : Batrachoidiformes		
Family : Batrachoididae		
Allenbatrachus grunniens (Linnaeus, 1758)	141, 178	300
Perulibatrachus aquilonarius (Greenfield, 2005)	211, 248	354
Order : Blenniiformes		
Family : Blennidae		
Blenniella periophthalmus (Valenciennes, 1836)	79-90	185
Entomacrodus striatus (Valenciennes, 1836)	75	110
Istiblennius edentulous (Forster & Schneider, 1801)	89	160
Omobranchus elongatus (Peters, 1855)	64-82	61
Order : Callionymiformes		
Family : Callionymidae		
Callionymus carebares (Alcock, 1890)	132, 134	180
Callionymus gardineri (Regan, 1908)	163-170	280
Callionymus japonicus (Houttuyn, 1782)	155-200	340
Callionymus margaretae (Regan, 1905)	150-201	160
Synchiropus lineolatus (Valenciennes, 1837)	58	69
Order : Trachiniformes		
Family : Uranoscopidae		
Uranoscopus archionema (Regan, 1921)	110-291	330
Uranoscopus bicinctus (Temminck and Schlegel, 1843)	36-296	350
Uranoscopus cognatus (Cantor, 1849)	51-189	165
Uranoscopus crassiceps (Alcock, 1890)	177	334

Table 2 continued...

Table 2 continued...

Uranoscopus guttatus (Cuvier, 1829)	157, 194	200
Ichthyscopus lebeck (Bloch & Schneider, 1801)	354	600
Order : Perciformes		
Family : Scatophagidae		
Scatophagus argus (Linnaeus, 1766)	104-182	380
Family : Siganidae		
Siganus canaliculatus (Park, 1797)	54-244	300
Siganus guttatus (Bloch, 1787)	210- 297	420
Siganus javus (Linnaeus, 1766)	80-575	530
Siganus lineatus (Valenciennes, 1835)	200-255	430
Siganus rivulatus Forsskål & Niebuhr, 1775	135-208	270
Siganus stellatus (Forsskal, 1775)	193-237	400
Siganus sutor (Valenciennes, 1835)	88-245	529
Siganus vermiculatus (Valenciennes, 1835)	217, 239	450
Order : Scorpaeniformes		
Family : Scorpaenidae		
Subfamily : Scorpaeninae		
Brachypterois curvispina (Matsunuma, Sakurai and Motomura, 2013)	48-110	114
Brachypterois serrulata (Richardson, 1846)	31-129	155
Brachypterois serrulifer (Fowler, 1938)	81-120	155
Ebosia falcata (Eschmeyer & Rama-Rao, 1978)	82-116	136
Neomerinthe amplisquamiceps (Fowler, 1938)	55-112	208
Neomerinthe erostris (Alcock, 1896)	66-109	151
Parascopraena aurita (Ruppell, 1838)	112-140	1500
Parascorpaena picta (Cuvier, 1829)	98-168	160
Pterois antennata (Bloch, 1787)	76-166	200
Pterois miles (Bennett, 1828)	105-268	476
Pterois mombasae (Smith, 1957)	68-245	267
Pterois russelii Bennett, 1831	72-280	418
Pterois volitans (Linnaeus, 1758)	194-410	380
Scorpaenopsis cirrosa (Thunberg, 1793)	44-190	289
Scorpaenopsis oxycephala (Bleeker, 1849)	89-174	360
Scorpaenopsis rosea (Day, 1868)	66-188	250
Scorpaenopsis venosa (Cuvier, 1829)	112-150	250
Sebastapistes armata (Sauvage, 1873)	79-148	1270
Subfamily : Apistinae		
Apistus carinatus (Bloch and Schneider, 1801)	74-146	200
Subfamily : Tetraroginae		
Paracentropogon longispinis (Cuvier and Valenciennes, 1829)	107-113	130
Snyderina guentheri (Boulenger, 1889)	59-164	215
Subfamily : Synanceiinae		
Minous coccineus (Alcock, 1890)	45-136	105
Minous dempsterae (Eschmeyer, Hallacher & Ramarao, 1979)	103	150
Minous inermis (Alcock, 1889)	21-113	140
Minous monodactylus (Bloch and Schneider, 1801)	64-128	150
Minous pictus (Gunther, 1880)	44-110	110
Choridactylus multibarbus (Richardson, 1848)	69-133	154
Family : Aploactinidae		
Cocotropus roseus (Day, 1875)	46	49
Order : Acanthuriformes		
Family : Acanthuridae		
Acanthurus bariene (Lesson, 1831)	228-375	500
Acanthurus bleekeri (Gunther, 1861)	86-535	500
Acanthurus dussumieri (Valenciennes, 1835)	225-262	540

Table 2 continued...

Table 2 continued...

Acanthurus lineatus (Linnaeus, 1758)	240-242	380
Acanthurus mata (Cuvier, 1829)	103-290	500
Acanthurus triostegus (Linnaeus, 1758)	145-192	270
Acanthurus xanthopterus (Valenciennes, 1835)	104-400	700
Ctenochaetus striatus (Quoy & Gaimard, 1825)	120-132	260
Ctenochaetus strigosus (Bennett, 1828)	127-195	188
Naso brevirostris (Cuvier, 1829)	658	670
Naso hexacanthus (Bleeker, 1855)	77-520	820
Zebrasoma desjardinii (Bennett, 1836)	159, 190	400

*MRS: Maximum Recorded Size.

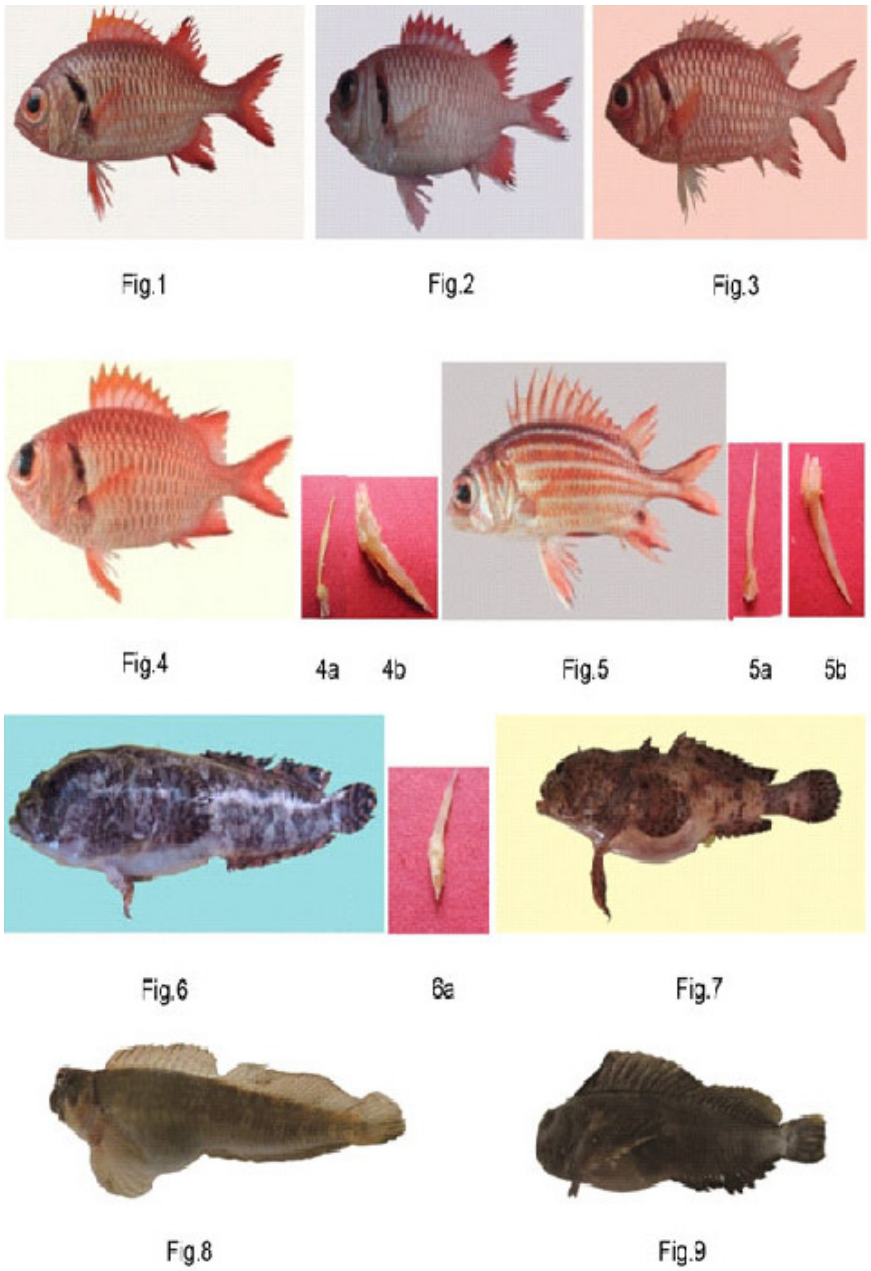

Plate IV : Fig.1: *Myripristis berndti* – 165 mm TL; Fig. 2: *Myripristis botche* – 231 mm TL; Fig. 3: *Myripristis hexagona* – 185 mm TL; Fig. 4 : *Myripristis murdjan* – 142 mm TL; 4a, 4b; Fig. 5: *Sargocentron rubrum* – 168 mm TL; 5a, 5b; Fig. 6: *Allenbatrachus grunniens* – 141 mm TL; 6a; Fig. 7: *Perulibatrachus aquilonarius* – 211 mm TL; Fig. 8 : *Blenniella periophthalmus* – 81 mm TL; Fig. 9: *Istiblennius edentulous* – 89 mm TL; a. Dorsal spine b. anal spine.

pools, sheltering in shells or under stones or weeds. Some are able to hop out of the water and crawl over mud and rocks in search of food. Scats are scavengers, often feed on excrement. Excellent aquarium fishes when small. Rabbitfishes and surgeon fishes are usually found in small schools in weedy areas in shallow waters, feed by scraping algal growth off rocks and coral.

Seventeen cat fish species of families Plotosidae – eeltail catfishes, three species (Plate III, Figs. 1 & 2); Bagridae – bagrid catfishes, single species (Plate III, Fig. 3) and Ariidae – sea catfishes, thirteen species (Plate III Figs. 4 to 8) are represented in the catches. They possess sharp and stout dorsal and pectoral spines, covered by poisonous mucus and capable of inflicting painful wounds. First dorsal fin spine or "buckler" long, rough, serrated on inner, sometimes also on outer edge, followed by seven rays; pectoral fins low on sides, with a strong, serrated spine. A thin layer of integument envelops these spines. Venom cells are concentrated at the lateral margins of stings; some are also equipped with axillary glands.

Nine species (Plate IV Figs. 1 to 5) belonging to family Holocentridae – squirrelfishes, are represented in the catches. These are very hard, dry fishes with sharp scales and bony, spiny heads. Some species of *Sargocentron* have a strong venomous spine at angle of preoperculum. Venom apparatus consists of 13 dorsal spines, 3 anal spines, 2 pectoral spines, 4 opercular spines and the associated integument and venom cells.

Two species (Plate IV Figs. 6, 7) of family Batrachoididae – toadfishes, are represented in the catches. These have three solid dorsal-fin spines, three solid opercular spines, not hollow and lacking connection to venom glands and one to three subopercular spines.

Four species (Plate IV Figs. 8, 9) of the family Blenniidae – combtooth blennies, are represented in the catches. These are armed with strong sharp canines with which they transfix their prey, or inflict a painful bite if carelessly handled.

Five species (Plate V Figs. 1 to 3) of the family Callionymidae – dragonets, are represented in the catches. These have preopercle armed with a characteristic stout spine; spinous fin consisting usually of four flexible spines with venomous glands. Dragonets can be very colourful and sexual dimorphism is common.

Six venomous fish species (Plate V Figs. 4 to 9) of family Uranoscopidae – stargazers, are represented in the catches. These have very large heads, almost vertical mouths. Two large double grooved cleithral spines with a venom gland at each base.

Single species (Plate V Fig. 10) of family Scatophagidae – scats, and eight species of family Siganidae – rabbitfishes (Plate VI Figs. 1 to 7) are represented in the catches. Scats' venom apparatus consists of paired anterolateral grooves alongside each fin spine and aggregation of large gland cells in the thickened epidermis of the integumentary sheath that fills the spine grooves. Venom glands of the larger specimens are shorter than those of smaller fishes. In rabbitfishes, dorsal, anal and pelvic fin spines are sharp and venomous, inflict painful, but not severe, wounds if handled without care. A narrow deep groove containing venom gland near the tips extends along both sides of the mid-line of the spine.

Venomous fishes of two families of Scorpaenidae – scorpionfishes, in four sub families: Scorpaeninae – eighteen species (Plate VI Figs. 8 to 11; Plate VII Figs. 1 to 14); Apistinae – single species (Plate VIII Fig. 1); Tetraroginae – wasp fishes, two species (Plate VIII Figs. 2, 3); Synanceiinae - six species (Plate VIII Figs. 4 to 8) and Aploactinidae – velvetfishes, single species (Plate VIII Fig. 9) are represented in the catches. Some species of scorpionfishes have venom gland in dorsal, anal and pelvic spines.

Scorpaeninae: Head armoured and spiny, fin spines well developed. Venom apparatus of genera like *Neomerinthe*, *Parascorpaena*, *Brachypterois*, *Ebosia*, *Scorpaena*, *Scorpaenopsis*, *Sebastapistes* consists of dorsal, anal and pelvic spines, short and heavy; integumentary sheath of the spine is moderately thick, distal two-third of the spine groove contains glandular tissue that produce venom. Highly venomous lion fishes possess long, slender, pointed and almost straight dorsal, anal and pelvic spines. Ventro-lateral grooves originate just above the base and extend the entire length of spine, which is enveloped in a thin layer of fibrous connective tissue.

Apistinae: One or three free lower pectoral rays, fin spines venomous (anterolateral glandular groove with venom gland).

Wasp fishes are extremely venomous, handled with utmost care or thrown away. Scanty records indicate they probably occupy habitats not easily reached by conventional methods of collection.

Synanceiinae: Venom glands present near base of hypodermic dorsal fin spines. Members of genera *Minous* and *Choridactylus* have lowermost ray of the pectoral fin separated from the rest of the fin, covered distally with a peculiar "cap" or "glov". Body of *Choridactylus* often has warts and lumps caused by

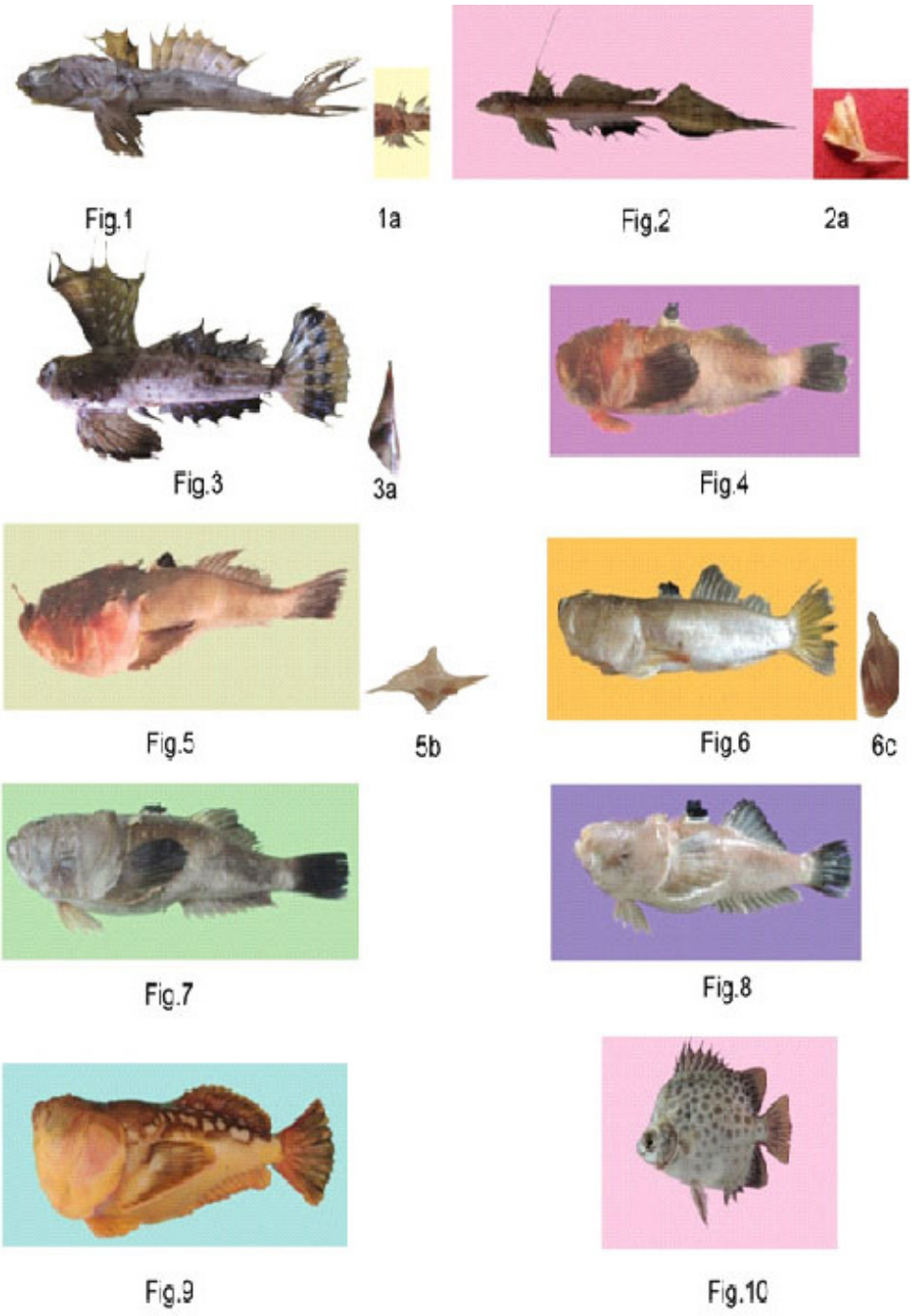

Plate V : Fig.1. *Callionymus carebares* – 132 mm TL; 1a; Fig. 2 : *Callionymus margaretae* – 201 mm TL; 2a; Fig. 3 : *Synchiropus lineolatus* – 58 mm TL; 3a; Fig. 4 : *Uranoscopus archionema* – 190 mm TL; Fig. 5 : *Uranoscopus bicinctus* – 267 mm TL; 5b; Fig. 6: *Uranoscopus cognatus* – 182 mm TL; 6c; Fig. 7: *Uranoscopus crassiceps* – 209 mm TL; Fig. 8 : *Uranoscopus guttatus* – 194 mm TL; Fig. 9 : *Ichthyscopus lebeck* – 354 mm TL; Fig. 10 : *Scatophagus argus* – 111 mm TL; a. Preopercular spine b. cleithral spine c. basipterygial process.

buried scales.

In velvetfishes, body is usually covered with modified, prickly scales. Head armed with knob-like lumps (rarely with pungent spines), some species have venomous spines. Wounds can result in intense pain and swelling.

Ten species (Plate IX Figs. 1 to 10) of family Acanthuridae – surgeonfishes, are represented in the catches. These have dorsal and anal fins with elaborate spine locking mechanism, also armed with one or more movable, retractile dermal spines on caudal peduncle in deep fusiform depression. Spine is enveloped in an integument sheath and depression lined with epithelium, which is believed to secrete mucus and venom.

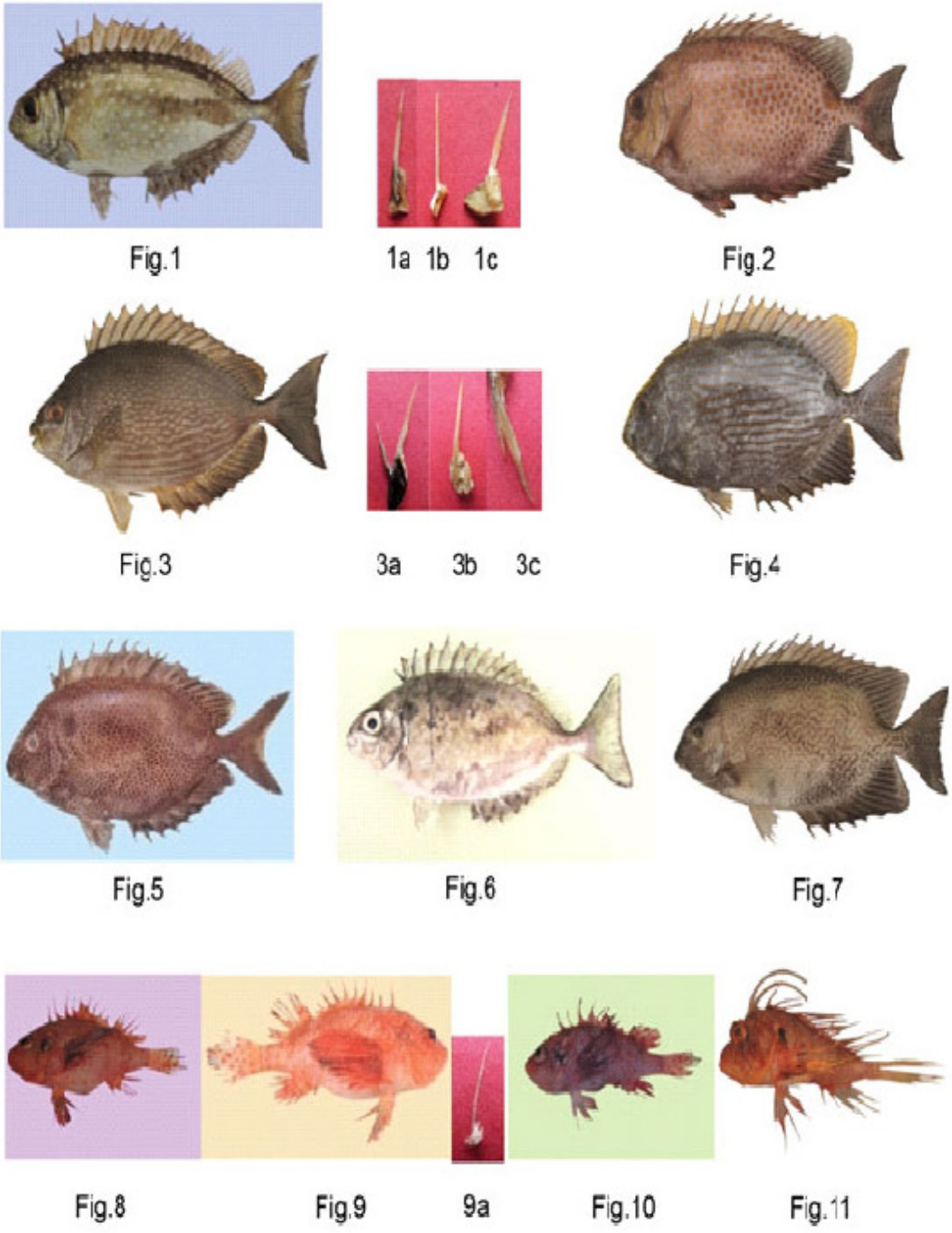

Plate VI : Fig. 1 : *Siganus canaliculatus* – 184 mm TL; 1a, 1b, 1c; Fig. 2 : *Siganus guttatus* – 270 mm TL; Fig. 3 : *Siganus javus* – 218 mm TL; 3a, 3b, 3c; Fig. 4 : *Siganus lineatus* – 253 mm TL; Fig. 5 : *Siganus stellatus* – 215 mm TL; Fig. 6 : *Siganus sutor* – 145 mm TL; Fig. 7 : *Siganus vermiculatus* – 239 mm TL; Fig. 8 : *Brachypterois curvispina* – 106 mm TL; Fig. 9 : *Brachypterois serrulata* – 105 mm TL; 9a; Fig. 10 : *Brachypterois serrulifer* -106 mm TL; Fig. 11 : *Ebosia falcata* – 114 mm TL; a. Dorsal spine b. pelvic spine c. anal spine.

DISCUSSION

Ziegman and Alewood (2015) stated that the venom apparatus and pharmacology are similar throughout the venomous fish species despite their wide taxonomic range. Although studies on marine venomous fish species have been carried out from different regions of the world, they are meagre from east coast of India. Dasyatids comprise of largest number of stingray species, most frequently encountered in temperate and tropical oceans causing majority of venomous marine stings in humans (Smith *et al*, 2016). Twenty six venomous fish species of Dasyatids, Gymnurids and Myliobatids are recorded from east coast of India (Sujatha, 2002; Bhavani, 2014).

Fig.1 Fig.2 Fig.3 Fig.4 4a 4b 4c

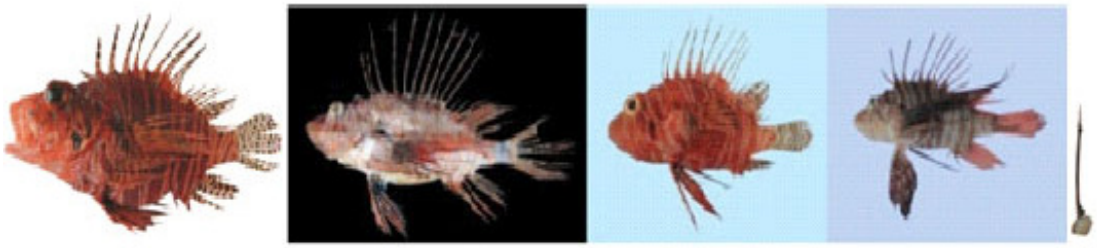

Fig.5 Fig.6 Fig.7 Fig.8 8a

Fig.9 Fig.10 Fig.11

Fig.12 12a 12b 12c Fig.13 Fig.14

Plate VII : Fig. 1: *Neomerinthe amplisquamiceps* – 84 mm TL; Fig. 2 : *Neomerinthe erostris* – 99 mm TL; Fig. 3 : *Parascopraena aurita* – 122 mm TL; Fig. 4 : *Parascorpaena picta* – 123 mm TL; 4a, 4b, 4c; Fig. 5 : *Pterois antennata* – 171 mm TL; Fig. 6 : *Pterois miles* – 247 mm TL; Fig. 7 : *Pterois mombasae* – 160 mm TL; Fig. 8 : *Pterois russelii* – 137 mm TL; 8a; Fig. 9 : *Pterois volitans* – 141 mm TL; Fig. 10 : *Scorpaenopsis cirrosa* – 245 mm TL; Fig. 11 : *Scorpaenopsis oxycephala* – 148 mm TL; Fig. 12 : *Scorpaenopsis rosea*– 149 mm TL; 12a, 12b, 12c; Fig. 13 : *Scorpaenopsis venosa* – 162 mm TL; Fig. 14 : *Sebastapistes armata* – 79 mm TL; a. Dorsal spine b. pelvic spine c. anal spine.

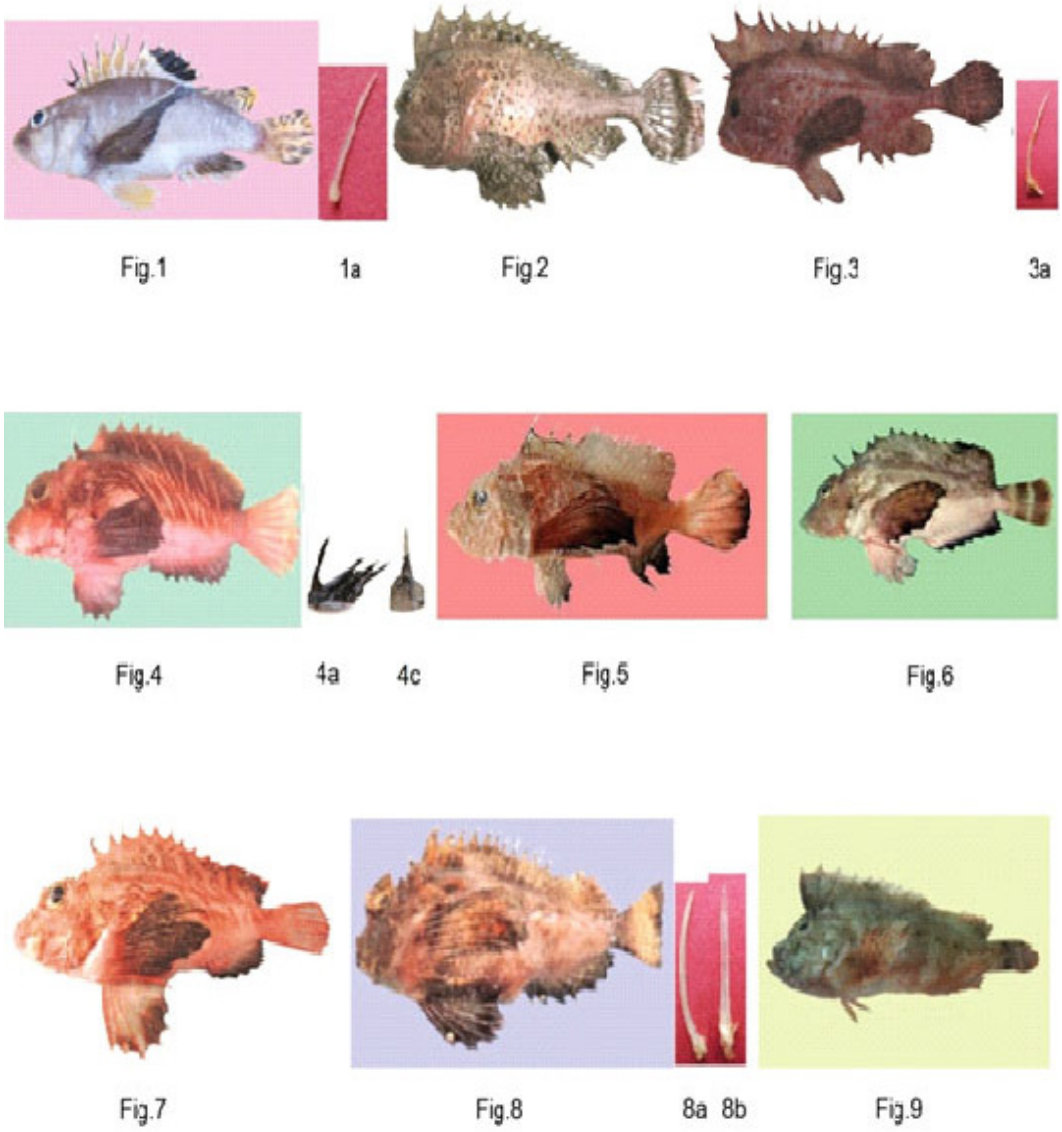

Plate VIII : Fig.1. *Apistus carinatus* – 120 mm TL; 1a; Fig. 2 : *Paracentropogon longispinis* – 107 mm TL; Fig. 3 : *Snyderina guentheri* – 96 mm TL; 3a; Fig. 4 : *Minous coccineus* – 105 mm TL; 4a, 4c; Fig. 5 : *Minous inermis* – 86 mm TL; Fig. 6 : *Minous monodactylus* – 116 mm TL; Fig. 7 : *Minous pictus*- 92 mm TL; Fig. 8 : *Choridactylus multibarbus* - 112 mm TL; 8a, 8b; Fig. 9 : *Cocotropus roseus* - 46 mm TL; a. Dorsal spine b. pelvic spine c. anal spine.

Some recent studies on the venom organs of stinging marine fishes, injuries and envenomations include Halstead (1988; 1992), Scharf (2002), Smith & Wheeler (2006) and Junghanss & Bodio (2006). Family specific studies on various osteichthyes fish envenomation were carried out by Perriere & Goudey-Perriere (2003), Devi & Rao (2003), Haddad *et al* (2008), Shukla (2009) and Wright (2015) for catfishes; Sutherland (1983) for soldierfishes; Greenfield *et al* (2008) for batrachoids; Smith & Wheeler (2006) for blennids, callionymids and siganids; Halstead & Dalgleish (1967) for uranoscopids; Cameron & Endean (1970) and Ghafari *et al* (2015) for scatophagids; Carcasson (1977), Kizer *et al* (1985) and Burnett (1998) for scorpaenids and Liao *et al* (1997), Tam *et al* (2007) and Bauman *et al* (2014) for acanthurid fishes. Tetrarogines are extremely venomous. All stonefishes have very efficient poisonous spines; some, such as the true stonefishes are among the most dreaded of marine creatures and so far these are not encountered in the catches of this region.

CONCLUSION

The present study reports venomous fish diversity of central eastern coast of India for the first time along with the length groups represented in the catches. This list incorporates new records of following species for the first time: *Parascorpaena aurita*, *Brachypterois curvispina*, *Brachypterois serrulifer*, *Minous pictus*

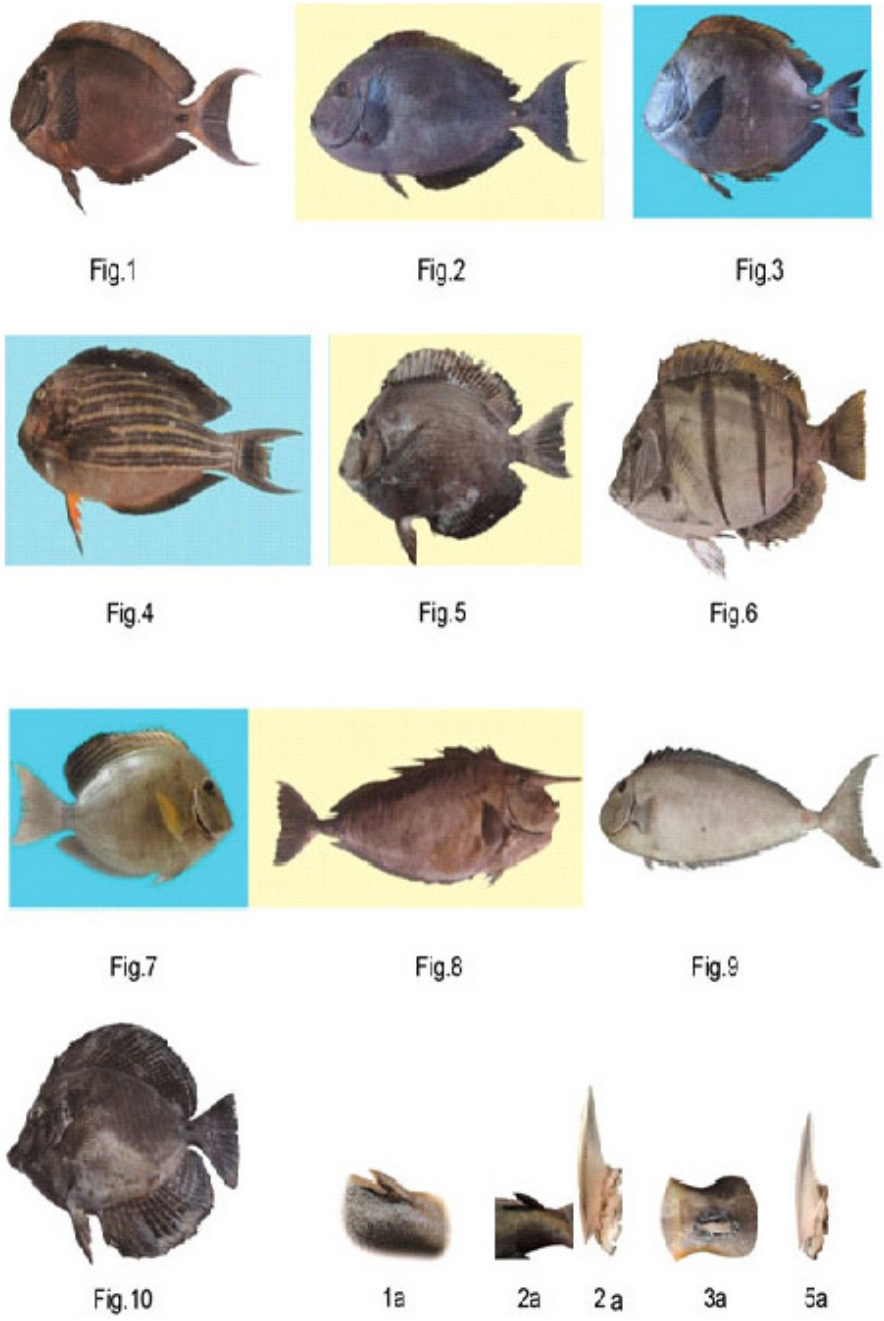

Plate IX : Fig. 1 : *Acanthurus bariene* – 375 mm TL; 1a; Fig. 2 : *Acanthurus bleekeri* - 535 mm TL; 2a, 2a; Fig. 3 : *Acanthurus dussumieri* - 225 mm TL; 3a; Fig. 4 : *Acanthurus lineatus* – 240 mm TL; Fig. 5 : *Acanthurus mata* – 123 mm TL; 5a; Fig. 6 : *Acanthurus triostegus* – 145 mm TL; Fig. 7: *Acanthurus xanthopterus* – 238 mm TL; Fig. 8 : *Naso brevirostris* – 658 mm TL; Fig. 9 : *Naso hexacanthus* – 510 mm TL; Fig. 10 : *Zebrasoma desjardinii* – 190 mm TL; a. Caudal peduncle spine.

and *Uranoscopus bicinctus* from Indian waters; *Neomerinthe amplisquamiceps* from main land waters of India; *Scorpaenopsis cirrosa*, *Ebosia falcata*, *Snyderina guentherii*, *Rhinoptera sewelii*, *Mobula kuhlii* from east coast of India and *Pterois antennata*, *Pterois miles*, *Minous coccineus*, *Minous inermis*, *Rhinoptera adspersa* from Visakhapatnam waters. Detailed descriptions of these species will be published later. This study contributes to the knowledge on distribution of non-conventional venomous fish species thus helping to assess the state of exploitation of these resources. Maximum size reported in the present study for species *Brevitrygon imbricata, Brevitrygon walga, Aetobatus flagellum*, *Aetomylaeus nichofii, Rhinoptera javanica, Mobula eregoodootenkee, Omobranchus elongates, Callionymus margaratae, Uranoscopus bicinctus, Uranoscopus cognatus, Siganus javus, Parascorpaena picta, Pterois volitans,*

Minous coccineus, *Acanthurus bleekeri*, *Naso brevirostris* is the maximum in world waters (Tables 1 and 2). According to IUCN Red List, six species enlisted here are data deficient (DD), six species vulnerable (VU), four species near threatened (NT) and one species is endangered (EN) due to overfishing (targeted and incidental). Large-bodied, shallow water species are at great risk. Most of the venomous teleostean fishes have not been evaluated for IUCN Red List. Many of these species are increasingly threatened with extinction as a result of intense fishing throughout coastal and pelagic waters, habitat loss, environmental degradation and pollution. Concise knowledge of taxonomy and biology of venomous fishes is requisite for future studies on biotoxins produced by these fishes.

ACKNOWLEDGEMENTS

The authors are thankful to the Head, Department of Marine Living Resources, Andhra University for providing facilities to carry out this research work. Authors are also grateful to Ministry of Earth Sciences (MoES)-Centre for Marine Living Resources and Ecology (CMLRE), Kochi for providing financial assistance for this research work under ITIS project. First and third authors are thankful to University Grants Commission (UGC), New Delhi for awarding Emeritus and Post Doctoral Fellowships, respectively.

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