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DEEP-SEA CARTILAGINOUS FISHES OF THE INDIAN OCEAN

Volume 2. Batoids and Chimaeras



DEEP-SEA CARTILAGINOUS FISHES OF THE INDIAN OCEAN

Volume 2

Batooids and Chimaeras

by

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*Support to the implementation of the International Guidelines on the
Management of Deep-Sea Fisheries in the High Seas (GCP/GLO/323/NOR)
and
Fisheries management and marine conservation within a changing ecosystem
context (GCP/INT/253/JPN)*

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ISBN 978-92-5-108452-6 (print)
E-ISBN 978-92-5-108453-3 (PDF)

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PREPARATION OF THIS DOCUMENT

This document was prepared under the “FAO Deep-sea Fisheries Programme”, thanks to a generous funding from the Governments of Norway and Japan (Support to the implementation of the International Guidelines on the Management of Deep-Sea Fisheries in the High Seas and Fisheries management and marine conservation within a changing ecosystem context projects) for the purpose of assisting states, institutions, the fishing industry and RFMO/As in the implementation of FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas. This catalogue was developed in close collaboration with the FishFinder Programme of the Marine and Inland Fisheries Branch, Fisheries Department, Food and Agriculture Organization of the United Nations (FAO).

Its production follows the recommendations made during a workshop on “Deep-sea Species Identification” held in Rome in 2009 organized in response to the need for a strategy for the development of appropriate deep-sea species identification tools for fishery purposes, in particular, to address the broadened requirements for reporting on not only target species, but also associated species following recent international developments with respect to fisheries management guidance and biodiversity conservation. The workshop recommended that a series of identification guides be developed for certain vulnerable groups of species affected by bottom gear, with an initial focus on three of the most impacted groups: cartilaginous fishes, corals and sponges. As a starting point, in consideration of the extensive information available on cartilaginous fishes from other FAO guides and publications, it was decided to develop deep-sea identification guides for this group at a regional level.

The present publication is the second of a two-volume set dedicated to the identification of deep-sea cartilaginous fishes known to occur in the Indian Ocean, encompassing FAO Fishing Areas 51 and 57, and that portion of Area 47 off South Africa from about 18°42'E to 30°00'E. It focuses on batoid and chimaera species, providing accounts for all orders, families, and genera and for one representative species of each genus. Moreover, fully illustrated keys to all taxa are included. It is aimed at facilitating the species specific identification of deep-sea batoids and chimaeras occurring in the Indian Ocean by fishery observers, crew members, scientists, fishery officers and the interested public.

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Deep-sea Cartilaginous Fishes of the Indian Ocean. Volume 2. Batoids and Chimaeras.
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ABSTRACT

This volume is a comprehensive, fully illustrated Catalogue of the Deep-sea Batoids and Chimaeras of the Indian Ocean, encompassing FAO Fishing Areas 51 and 57, and that portion of Area 47 off South Africa from about 18° 42'E to 30° 00'E. The present volume includes 4 orders, 10 families, 28 genera, and 78 species of batoid and chimaera-like fishes occurring in the Indian Ocean Deep-sea. The Catalogue includes a section on standard measurements for batoids and chimaeras with associated terms. It provides accounts for all orders, families, and genera and all keys to taxa are fully illustrated. A species representative of each genus is also provided and includes: valid modern names and original citation of the species; synonyms; the English, French, and Spanish FAO names for the species; a lateral view and often other useful illustrations; field marks; diagnostic features; distribution, including a GIS map; habitat; biology; size; interest to fisheries and human impact; local names when available; a remarks sections; and literature. The volume is fully indexed and also includes sections on terminology and measurements including an extensive glossary, a list of species by FAO Statistical Areas, a glossary, and a dedicated bibliography.

ACKNOWLEDGEMENTS

I wish to thank all of those who have been extremely helpful and generous with their time in responding to my numerous questions, providing data and information from their own research (some of it unpublished), and providing much needed literature. The generic and species accounts were improved immensely from the contribution of colleagues and friends. I wish to apologize beforehand if I have forgotten anybody, which will inevitably happen with a work of this magnitude, but I do thank you all for your help and assistance. I would like to extend my thanks to the following individuals for general discussions and information on various aspects of this project: Peter Kyne (Charles Darwin University), Colin Simpfendorfer (James Cook University), Rob Leslie (Department Agriculture Forestry and Fisheries, Cape Town), Leonard Compagno, Wayne Florence, Dylan Clarke, and Michael Bougaardt (South African Museum), Matthias Stehmann (ICHTHYS, Ichthyological Research Laboratory); Simon Wiegmann (University Hamburg), Hajime Ishihara (W and I Associates), Dean Grubbs (Florida State University), Michelle Hulls (Hobart, Tasmania), Cristina Oddone (Universidade Federal de Rio Grande–FRUG), Malcolm Francis (NIWA), Marcelo de Carvalho (University of São Paulo), Hans Ho (National Museum of Marine Biology and Aquarium, Taiwan, Province of China), Ivy Baremore and John Carlson (NOAA Fisheries Southeast Fisheries Science Center, Panama City, Florida); David Catania, William Eschmeyer, and Jon Fong (California Academy of Sciences, San Francisco); Aaron Henderson (Sultan Qaboos University, Sultanate of Oman); Gavin Naylor and Nico Straube (College of Charleston, Charleston, South Carolina, USA); Bernard Séret (IRD–MNHN Paris, France); William White and Peter Last (CSIRO Marine Laboratories, Hobart, Tasmania, Australia); Paul Cowley (South African Institute of Aquatic Biodiversity); Paul Clerkin (Pacific Shark Research Center, Moss Landing Marine Laboratories); Ross Shotton (Southern Indian Ocean Deep–sea Fishers Association); Graham Patchell, Daryl Smith, the Captain and crew of the F/V Will Watch (Sealords Corporation); Daroomalingum Mauree (Director of Fisheries, Ministry of Fisheries, Mauritius); Rajiv Bacorisen, Asaid Morrarby, Nankishore Toofany, and the staff at the Albion Fisheries Research Center, Mauritius; K.V. Akhilesh and K.K. Bineesh (Central Marine Fisheries Research Institute, India).

A special thanks to Joan Parker and the library staff (Moss Landing Marine Laboratories, Moss Landing, California, USA) for tracking down those hard to find, usually obscure, references, and to Kelley Andrews, Jenny Bigman, Paul Clerkin, James Knuckey, Mark Breen–Klein and Melissa Nehmens (Pacific Shark Research Center, Moss Landing Marine Laboratories, Moss Landing, California, USA) who provided general assistance on various aspects of this project.

Sincere thanks go to the FAO FishFinder team for providing assistance during the preparation of the manuscript and to Merete Tandstad and Jessica Sanders (FAO, Rome) who served as coordinators for the Deep–sea Fisheries Programme activity related to the development of species identification guides for potentially vulnerable deep–sea species.

Finally, thanks to John McEachran (Department of Wildlife and Fisheries Sciences Research, Texas A&M University), Hajime Ishihara (W&I Associates Co. Ltd.), Matthias Stehmann (ICHTHYS, Ichthyological Research Laboratory), Dominique Didier (Millersville University) and Marcelo de Carvalho (University of São Paulo) for critically reviewing the final draft and for their precious suggestions and useful information.

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1. INTRODUCTION

Knowledge of chondrichthyan biodiversity in general, and especially deep-sea species, is relatively uneven, with some areas such as Australia, Europe, and North America being better known, while other regions, often those considered biodiversity “hotspots” being poorly known. The deep-sea Indian Ocean, which has one of the more diverse chondrichthyan faunas in the world has been relatively little studied outside those waters adjacent to Australia. Although the shark-like fishes have received some attention, the lesser known members of this group, e.g. batoids and chimaeras, are still very poorly known. Therefore, this second volume of the Deep-sea Cartilaginous Fishes of the Indian Ocean Catalogue focuses on the deep-sea batoids and chimaeras occurring primarily in FAO Fishing Areas 51 and 57, and that part of Area 47 that extends from Cape Point, South Africa to the east, e.g. the extreme southwestern Indian Ocean.

Similar to the first volume, which focuses on the sharks, the second volume here presented includes species of major, moderate, minor, and minimal importance to fisheries as well as those of doubtful or potential use to fisheries. It also covers those little known species that may be of research, educational, and ecological importance. The catalogue is intended to be a comprehensive review of the batoids and chimaeras of the deep-sea Indian Ocean in a form accessible to fisheries workers as well as researchers on systematics, biodiversity, distribution, and general biology.

Biogeography of Region. The Indian Ocean region includes two major FAO Fishing Areas, the western Indian Ocean (Area 51) and the eastern Indian Ocean (Area 57). The western Indian Ocean extends from the southeast coast of India at 77°00'E longitude where the states of Kerala and Tamil Nadu meet at the sea, and extends southward to the equator, then east to 80°00'E longitude and south to 45°00'S latitude where it runs parallel westward to 30°00'E longitude and north to the coast of Africa. Also, included in this region is the extreme southeastern portion of Area 47, extending from Cape Point at about 18°42'E longitude eastwards to the boundary of Area 51 at 30°00'E longitude. The eastern Indian Ocean region extends essentially from the boundary with Area 51 on its western edge, although it extends further south to 55°00'S latitude, where it runs parallel to 150°00'E longitude and then north to about 37°31'S latitude to the southeast coast of Australia. The eastern boundary of Area 57 runs along the coast of southern Australia and around to the boundary of the states of Western Australia and the Northern Territory at 129°00'E longitude. At that boundary it extends northwards to 08°00'S latitude and then west along 113°28'E longitude where it meets the south coast of Java at 08°23'S latitude and extends westwards along the coasts of Java and Sumatra running south in the Strait of Malacca, where it crosses the Strait at 02°30'N latitude to meet the coast of the Malay Peninsula, where it goes in a northerly and westerly direction along the coasts facing the Bay of Bengal to the point of departure. The Indian Ocean encompasses 10 Large Marine Ecosystems, five in the western Indian Ocean and six in the eastern Indian Ocean; one of the large marine ecosystems crosses the boundary of both areas off India. This includes the Agulhas Current,

Somali Coastal Current, Arabian Sea, Red Sea, and a portion of the Bay of Bengal large marine ecosystems in the western Indian Ocean (Area 51), and in the eastern Indian Ocean (Area 57) this includes most of the Bay of Bengal, North Australia, Northwest Australia, West-Central Australia, Southwest Australia, and Southeast Australia large marine ecosystems (Figure 1 – Map of the Indian Ocean FAO Areas 51 and 57).

The Indian Ocean is the warmest ocean with a minimum surface temperature north of 20°S of 22 °C, but often exceeding 28 °C. Two major circular ocean currents, a clockwise flowing current in the northern hemisphere and a counterclockwise flowing current south of the equator, dominate the flow patterns. However, during the winter monsoon season, which heavily influences these currents, the northern current reverses flow. The continental shelves surrounding the Indian Ocean are generally narrow, averaging 200 km in width, except off the western coast of Australia where the shelf exceeds 1,000 km. The average depth is 3,890 m with a maximum depth of 8,047 m in the Diamantia Trench. The Indian Ocean topography is quite dynamic as three crustal plates, African, Indian and Antarctic, converge with their junctures forming an inverted “Y” with the stem originating from the edge of the continental shelf off Mumbai, India and extending to the southern Indian Ocean where all three plates meet at a geologic feature called Rodrigues Triple Point, named after the island of Rodrigues that is located nearby. This geologic feature subdivides the Indian Ocean into three basins, eastern, western and southern. Geologically the region, as the youngest of the major oceans, has active spreading ridges with several distinct subsurface features including the Ninety East Ridge that runs north-south at the 90°E meridian, which bisects the Indian Ocean into its eastern and western halves.

Classification and systematic arrangement used here. The higher classification of these fishes includes the class Chondrichthyes that is divided into two major groups, each with a long and separate pre-Devonian history, the chimaeroids, Holocephali (with a single living order Chimaeriformes), and the sharks and batoids proper, with the surviving group Neoselachii divided into two cohorts, the Selachii (sharks) and the Batoidea (rays and skates). The cohort Selachii is further divided into two superorders, the Squalomorphii and Galeomorphii. The Squalomorphii includes the orders Hexanchiformes, Squaliformes, Squatiniformes, and Pristiophoriformes, while the Galeomorphii includes the Heterodontiformes, Orectolobiformes, Lamniformes, and Carcharhiniformes. The cohort Batoidea recognizes four orders, Torpediniformes, Pristiformes, Rajiformes, and Myliobatiformes, although the higher classification is still unresolved for this group. The higher classification and the taxonomic arrangement of the batoid fishes and chimaeras follows recent classifications by Nelson (2006), Aschliman, Claeson and McEachran (2012), Aschliman *et al.* (2012), and by Didier, Kemper and Ebert (2012) for the batoids and chimaeras, respectively.

The following classification to order is based on the above

discussion on higher ordinal classifications (* starred orders are covered in this volume):

- Class Chondrichthyes (cartilaginous fishes)
 - Subclass Holocephali (chimaeras and fossil relatives)
 - Order Chimaeriformes (chimaeras or silver sharks)*
 - Subclass Neoselachii (modern sharks and batoids)
 - Cohort Selachii (modern sharks)
 - Superorder Squalomorphii (squalomorph sharks)
 - Order Hexanchiformes (cow and frilled sharks)
 - Order Squaliformes (dogfish sharks)
 - Order Squatiniformes (angel sharks)
 - Order Pristiophoriformes (sawsharks)
 - Superorder Galeomorphii (galeomorph sharks)
 - Order Heterodontiformes (bullhead sharks)
 - Order Lamniformes (mackerel sharks)
 - Order Orectolobiformes (carpet sharks)
 - Order Carcharhiniformes (ground sharks)
 - Cohort Batoidea (batoids)
 - Order Torpediniformes (electric rays)*
 - Order Pristiformes (sawfishes)
 - Order Rajiformes (skates and guitarfishes)*
 - Order Myliobatiformes (stingrays)*

Indian Ocean Deep-sea Biodiversity. Similar to the sharks, the batoids are one the most successful groups of fishes having penetrated most marine ecosystems, including continental and insular shelf waters from the intertidal out to, and into, the deep-sea as well as occupying oceanic and pelagic habitats; some species have even penetrated into and occupy estuarine and freshwater river ecosystems. Recent reviews on the biodiversity and distribution of batoids in various ecosystems have shown that the deep-sea and tropical marine ecosystems have the highest diversity, with the epipelagic and freshwater ecosystems having a much lower diversity of species (Ebert and Winton, 2010; Kyne and Simpfendorfer, 2010; Rosa *et al.*, 2010; Stevens, 2010; White and Sommerville, 2010). Worldwide there are more than 650 known living and valid species of batoids comprising 4 orders, 20 families, and 88 genera, with additional species requiring description (Nelson, 2006; Ebert and Winton, 2010; D.A. Ebert, pers. database, 1 March 2013). Globally, of these totals, 3 orders, 10 families, 33 genera, and about 220 batoid species are considered to primarily inhabit the deep-sea (FAO, 2011; D.A. Ebert, pers. database, 1 March 2013).

The deep-sea Indian Ocean has a very diverse batoid fauna with 3 orders, 8 families, 23 genera, and at least 61 species being represented (Table 1). However, this number is likely an under-representation of the actual number as there are several species currently being described as of this writing and the taxonomy of deep-sea batoids in the Indian Ocean is very poorly known. The most speciose group of batoids in the deep-sea Indian Ocean are the skates (Rajiformes) that have at least 15 genera and 51 species represented, most of which are in the families Rajidae ($n = 38$) and Arhynchobatidae ($n = 12$); the Rhinobatidae, included in the Rajiformes, are primarily a shallow water group, but have a single deep-sea genus and species represented in the Indian Ocean. The Myliobatiformes, which are quite speciose in shallow waters, only have three families, each with a single genus and species represented; two of the families (Plesiobatidae and Hexatrygonidae) are monotypic. The dearth of myliobatid species in the Indian Ocean deep-sea stands in contrast to the shallow water environs of this region where this group

is quite diverse with at least 59 known species; a number that will likely increase in the future with improved taxonomic resolution of several genera.

Of these totals, the diversity of numbers of families, genera, and species between the eastern and western Indian Ocean deep-sea is remarkably similar (Table 1). The only families not represented in the western Indian Ocean are the Rhinobatidae, Torpedinidae, and Urolophidae, while in the eastern Indian Ocean all 8 families are present. The number of genera and species occurring in the western Indian Ocean ($n = 14$ genera and 30 species) is slightly lower than in the eastern Indian Ocean ($n = 17$ genera and 34 species). The number of species occurring in both regions is low ($n = 3$) when compared to the number of shark species ($n = 38$) that occur in both regions. This shows the relatively high degree of endemism within this group when compared to the sharks.

The chimaeras, which are mostly a deep-sea group, are well represented with 17 species or about 37% of all known species occurring in the Indian Ocean deep-sea. Two families (Chimaeridae and Rhinochimaeridae) and five genera occur in this region; the Callorhynchidae occurs in the Indian Ocean, but this is a coastal, shallow water group and is not discussed further. Both families, and all genera, except for the *Neoharriotta*, which is only found in the western Indian Ocean, are represented in the eastern and western Indian Ocean. The number of species is slightly higher in the eastern Indian Ocean with 11 species compared to 9 in the western Indian Ocean. However, there are at least 3 undescribed chimaerids occurring in the western Indian Ocean that are under investigation by the author as of this writing. The number of species occurring in both the eastern and western Indian Ocean regions is low, with only 3 species, all members of the Rhinochimaeridae.

Indian Ocean (Tot.)	Sharks	Batoids	Chimaeras	Tot.
Orders	8	3	1	12
Families	23	8	2	33
Genera	46	23	5	74
Species	117	61	17	195
Indian Ocean (Area 51)				
Orders	7	3	1	11
Families	22	5	2	29
Genera	42	14	5	61
Species	78	30	9	117
Indian Ocean (Area 57)				
Orders	6	3	1	10
Families	21	8	2	31
Genera	38	17	4	59
Species	77	34	11	122

Table 1 – The families, genera, and species represented within the Deep-sea Indian Ocean (total for Areas 51 and 57), western Indian Ocean (Area 51), and eastern Indian Ocean (Area 57).

1.1 Plan of the Catalogue

The format for this catalogue follows volume 1 of the Deep-sea Cartilaginous Fishes of the Indian Ocean Catalogue (Ebert, 2013), with orders as the highest taxonomic group dealt with here, followed by family, genus, and species accounts. A key to the families, genera and species, where appropriate is also included. Similar to volume 1 the present catalogue does not include a detailed account of each species, but does include a list of all deep-sea species known to occur in the Indian Ocean, with a representative species of each family and genus presented in detail. For those genera where more than a single member of the genus, e.g. *Dipturus*, has a species that is possibly subjected to intense fishing pressures or are considered especially vulnerable, more than one species is presented in detail. In total, 25 of 61 batoid species and 6 of 17 chimaera species are presented in detail here.

The species specific information on the biology, conservation status, distribution, habitat, fisheries, and systematics of Indian Ocean batoids and chimaeras was compiled from primary literature sources including, but not limited to, Compagno, Ebert and Smale (1989), Last *et al.* (2008a, b), Last and Stevens (2009), Ebert and Winton (2010), Kyne and Simpfendorfer (2010), FAO (2011), and from primary literature sources. Electronic sources were also of invaluable help. These included, but were not limited to, the California Academy of Sciences Catalogue of Fishes (<http://www.calacademy.org/research/ichthyology/catalog/fishcatsearch.html>) and IUCN Shark Specialist Group (<http://www.iucnredlist.org>). A comprehensive bibliography of the literature, including primary, grey, and electronic sources is provided at the end of this volume.

Order accounts include the valid modern form of the order name with author and year; the original citation of the order name with its author, year, reference and pagination; the number of recognized families in the Indian Ocean deep-sea; common order **Synonyms** mainly from the Indian Ocean deep-sea region with the name, author, year, and pagination; the FAO order **Vernacular Names** in English, French and Spanish; **Field Marks** and **Diagnostic Features** of members of the order; an account of the natural history of the order under separate sections covering **Distribution**, **Habitat** and **Biology**; a section on **Interest to Fisheries and Human Impact**, a synopsis of the human issues affecting shark families; **Local Names** when available; a **Remarks** section mostly with systematic comments; and a **Key to Deep-sea Indian Ocean Families**, when orders have more than one family.

Family accounts include the valid modern form of the family name with author and year; the original citation of the family name with its author, year, reference and pagination; the valid type genus with author and date; the number of recognized deep-sea Indian Ocean genera in the family; family **Synonyms** with names mostly associated with the Indian Ocean region and with the name, author, year, and pagination; the FAO family **Vernacular Names** in English, French and Spanish; **Field Marks** and **Diagnostic Features** of members of the family; an account of the natural history of the family under separate sections covering **Distribution**, **Habitat** and **Biology**; a section on **Interest to Fisheries and Human Impact**, a synopsis of

the human issues affecting shark families; **Local Names** when available; a **Remarks** section mostly with systematic comments; a **Literature** section covering references to the entire family; and a **Key to Deep-sea Indian Ocean Genera**, when families have more than one genus.

Generic accounts include the valid modern form of the genus name with author and year; the original citation of the genus (or subgenus), with its author, year, reference and pagination, and, if a subgenus, the original genus name with author and year that the subgenus was originally placed in; the type species and means of designating it (for example, by original designation, monotypy, absolute tautonymy, or subsequent designation); the number of recognized Indian Ocean species in the genus; the **Synonyms** of genera, with their rank (genus, subgenus, or other genus-group ranking), author, year, pagination, and genus they were described in, if originally ranked as subgenera or equivalents; **FAO Names** if they exist; **Field Marks** if genera are large and distinctive; **Diagnostic Features** of the genus; **Local Names** where available; a **Key to Deep-sea Indian Ocean Species** if the genus has more than one species (is not monotypic); and a **Remarks** section.

Species accounts include the valid modern names of the species, with author and date; the original citation of the species, with its author, year, reference pagination; the holotype, syntypes, lectotype or neotype of each species (paratypes are not listed in the present account), including the total length and sex of the specimen, its institutional deposition, and its catalogue number; the type locality including the location, coordinates and depth if available, where the holotype, syntypes, lectotype or neotype were caught; **Synonyms** of the species, including their names, authors and dates; a section listing other scientific names recently in use; the English, French, and Spanish **FAO Names** for the species; a lateral view illustration, and often other useful illustrations (lateral view drawings are given of each shark species, usually ventral views of heads, and often teeth and denticles of the shark in question); **Field Marks**; **Diagnostic Features** (except in monotypic genera); **Distribution**, including a map; **Habitat**; **Biology**; **Size**; **Interest to Fisheries and Human Impact**; **Local Names** when available; a **Remarks** section when necessary; and **Literature**.

Synonyms commonly seen in the Indian Ocean literature are listed, where appropriate, and include only true taxonomic synonyms of the valid family, genus and species given. For species, another category, **Other Combinations**, is provided for common misidentifications of a given species with another, valid species, as well as commonly used combinations that place a valid species in different genera.

FAO Family and Species Names. English, French and Spanish names for each family and species, primarily for use within FAO, were selected by the following criteria: (a) each name applies to a single family or species worldwide; (b) the name conforms with FAO spelling nomenclature; (c) the name conforms to prior usage when possible. FAO names are not intended to replace local species names, but are necessary to overcome the confusion caused by the use of a single name for more than one species or several names for one species. The FAO names used here conform to prior FAO usage. The common French

and Spanish names of species from other FAO Regional Guides, including Namibia (Bianchi *et al.*, 1999), Western Central Pacific (Compagno, 1998, including family accounts with authorship within this volume), Red Sea and Gulf of Aden (Bonfil and Abdallah, 2004), and North Atlantic (Ebert and Stehmann, 2013), were used when appropriate.

Keys, Field Marks, and Diagnostic Features. These sections include identification data in different forms. **Keys** to families, genera and species are standard dichotomous biological keys that are followed in steps of alternate choices to single out the taxa covered. It should be noted that the Keys include only those families, genera, and species that occur in FAO Areas 51 and 57, or within the scope of the present Catalogue and does not include those groups not occurring with the area. **Field Marks** generally include a few obvious characters of use in field identification, extracted from Diagnostic Features at various levels, but included in a separate section. Field Marks are listed at the ordinal, familial and species levels, and occasionally the generic level in cases of large genera with many species. The arrangement of Field Mark characters is semihierarchical and pragmatic and may include characters from a higher level such as an order in lower level taxonomic accounts such as those of species. Field Marks include characters that are obvious in live or fresh-caught individuals but may be obscure in frozen or preserved material. **Diagnostic Features** are lists of characters at the ordinal, familial, generic, and species level, with the character choice generally limited to external characters, particularly at the species level, because of their primary purpose of identification rather than indication of relationships. The Diagnostic Features sections are hierarchical, with characters at the ordinal level generally not duplicated at the family, genus and species levels.

Distribution. Geographic distributions for nearly all species of batoids and chimaeras are given by listing the countries off the coasts of or oceanographic features, e.g. seamounts and troughs, of where the species occur. In compiling distributional data and preparing maps it was noted that the distributions of those wide-ranging species are very patchily known at present. In many cases gaps in distribution may not indicate absence of a given species but absence of knowledge. Continental slope faunas are poorly known for much of the world, and a number of deepwater species probably have wider ranges than are currently known. Much effort was made to screen out distribution errors, based on misidentifications of species, at a cost of presenting distributional lists and maps that are patchy, but possibly more accurate.

Habitat. Habitat covers information on physical conditions where various sharks are found. The known depth range of the species (in metres), position in the water column, type of substrate occupied, and preferences relative to coasts are noted when available. In most cases data on salinity, oxygen content, and specific temperature of the water in which they occur was not available or was not in an easily usable form and has not been regularly compiled here.

Biology. Includes data on reproduction, age and growth, diet, and behaviour and movement patterns. Compilation of these data suggests that very few deep-sea species are biologically well known, and several are known only a very few specimens that have ever been observed.

Size. All size data are given as total lengths, except for those batoids with whip-like tails and the chimaeras, which have a filamentous tail that is often missing; in those instances disc width or body length is provided when this information is available.

Total length (or disc width) data presented includes maximum size, size at maturity (in some cases, a size range at maturity, when abundant data were available) and maximum size for both sexes, and size at birth or hatching. Sometimes size at sexual maturity for either or both sexes is not known, in which cases reported minimum and maximum sizes of adult individuals are given. In some cases maximum size exceeds that recorded for either sex, in which case the sex of the oversized individual or individuals representing the maximum size measurements was not indicated. In some poorly known species only immature individuals are known, in which case the hypothetical maximum adult size is almost certainly larger than the known immature maximum.

Interest to Fisheries and Human Impact. This section includes fisheries information, including whether the species is taken in targeted or non-targeted (bycatch) fisheries and if taken as bycatch whether it is retained or discarded. Data on localities of fisheries, gear used, and uses of the particular species are noted when available. National fisheries data for deep-sea batoids and chimaeras is rarely reported in the Indian Ocean, and if available, the data is often sketchy and combined for a number of species. Thus, catch statistics are generally unavailable for most species. Other aspects of human interaction is presented if available or known, although the average person rarely encounters most of these deep-sea batoids or chimaeras. The current conservation Red List status of each species as evaluated by the IUCN Species Survival Commission's Shark Specialist Group (<http://www.iucnredlist.org>) is provided. At the end of the Bibliography section an electronic reference section has been added with a link to the Red List Assessment for each species included in the Catalogue.

Local Names. Many deep-sea species have no vernacular names whatsoever or are lumped under catchall names. Wherever possible common local names are presented. The broadening interest in batoids and chimaeras and the urgent need to acquire species-specific data for their management and conservation should encourage fisheries biologists and other researchers to compile local names for their own countries or regions, and add to the sketchy knowledge of local names.

Remarks. Important information, especially on systematics and nomenclature, are given in the remarks section. Also, the relative number of families per order, genera per family, and species per genus worldwide is given when appropriate for comparison to the groups occurring within FAO Areas 51 and 57.

Literature. References cited here include specific works with important information for each species and family as well as comprehensive accounts, but are not intended as a comprehensive bibliography.

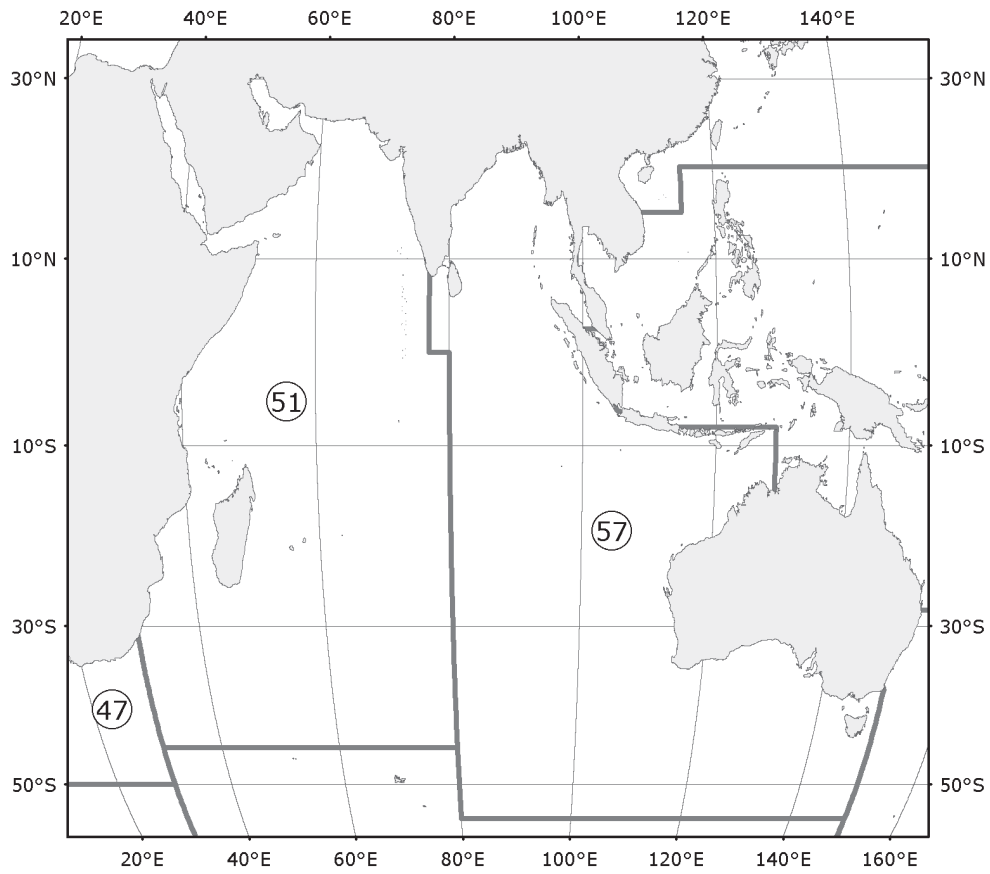


Fig. 1 Map of FAO Area 51 (Western Indian Ocean), Area 57 (Eastern Indian Ocean) and the southeastern portion of Area 47 (Southeastern Atlantic Ocean)

1.2 Technical Terms and Measurements

1.2.1 Picture Guide to External Terminology and Measurements used for Batoids

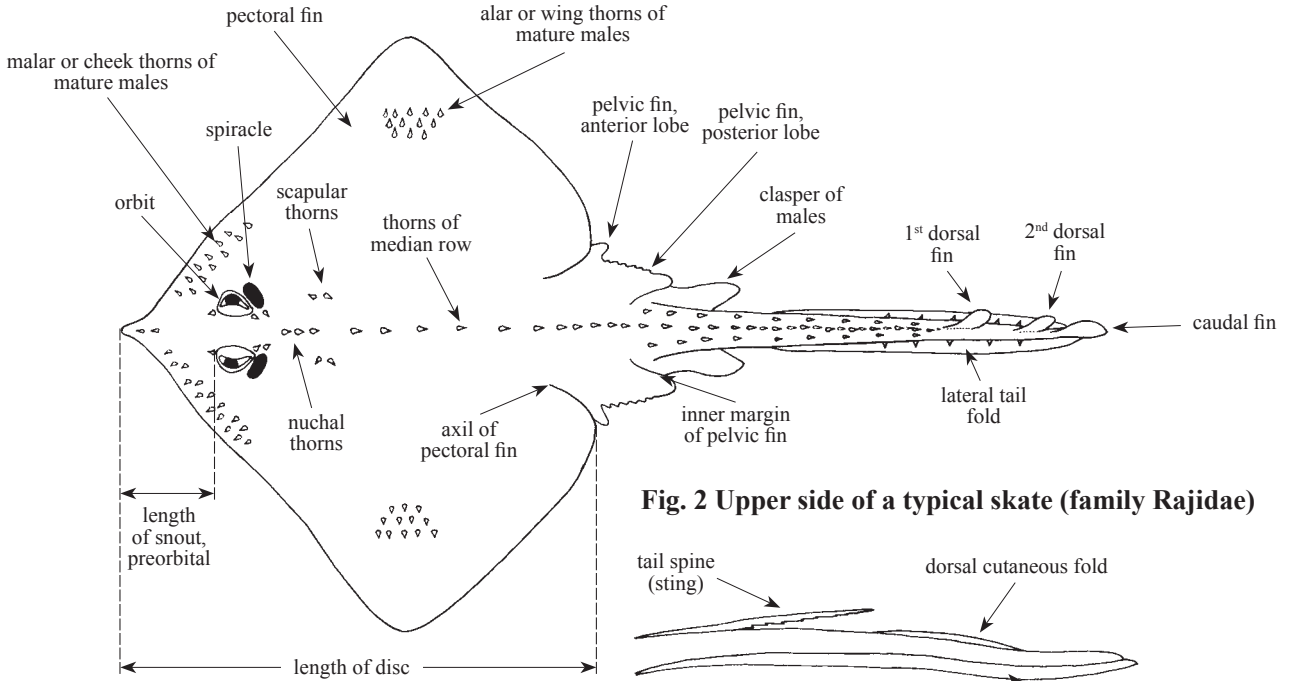


Fig. 2 Upper side of a typical skate (family Rajidae)

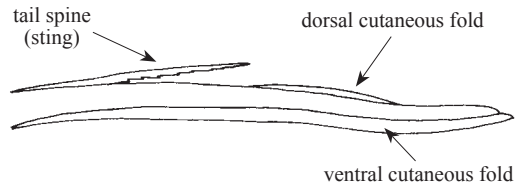


Fig. 3 Base of tail in stingrays (family Dasyatidae)

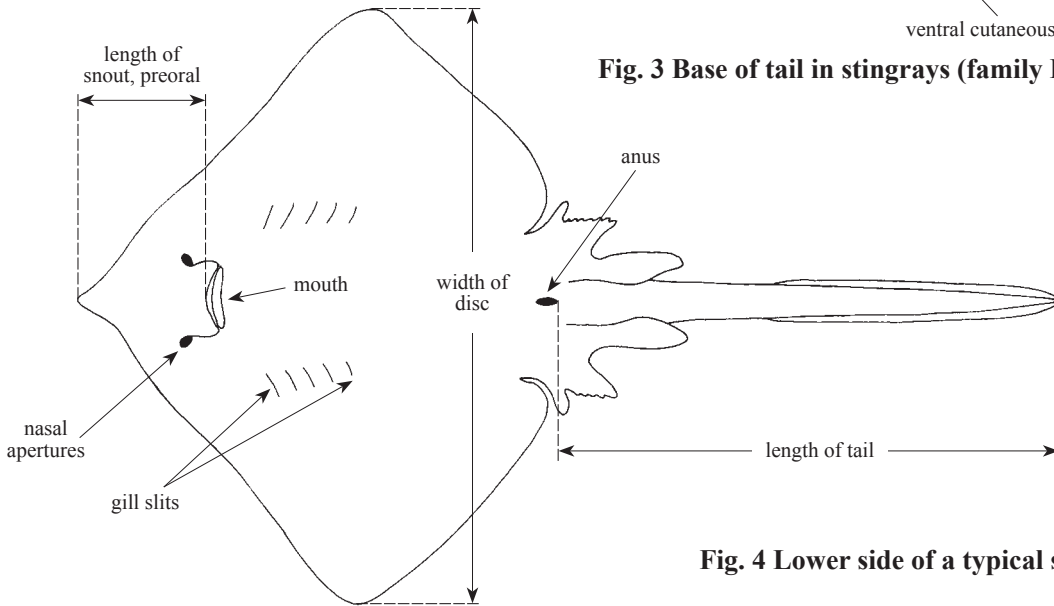


Fig. 4 Lower side of a typical skate

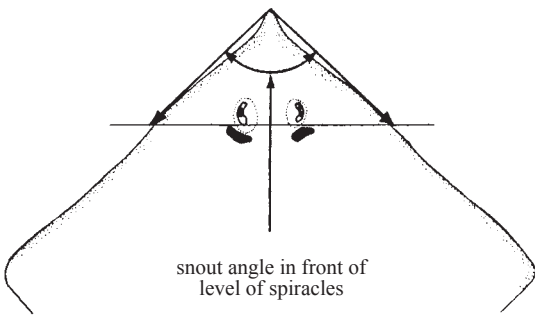


Fig. 5 Anterior part of disc of a skate

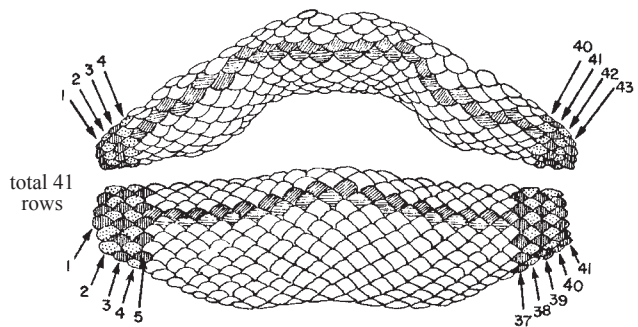


Fig. 6 Teeth of a stingray (arrows indicate method of counting pavement pattern in batoids)

1.2.2 Picture Guide to External Terminology and Measurements used for Chimaeras

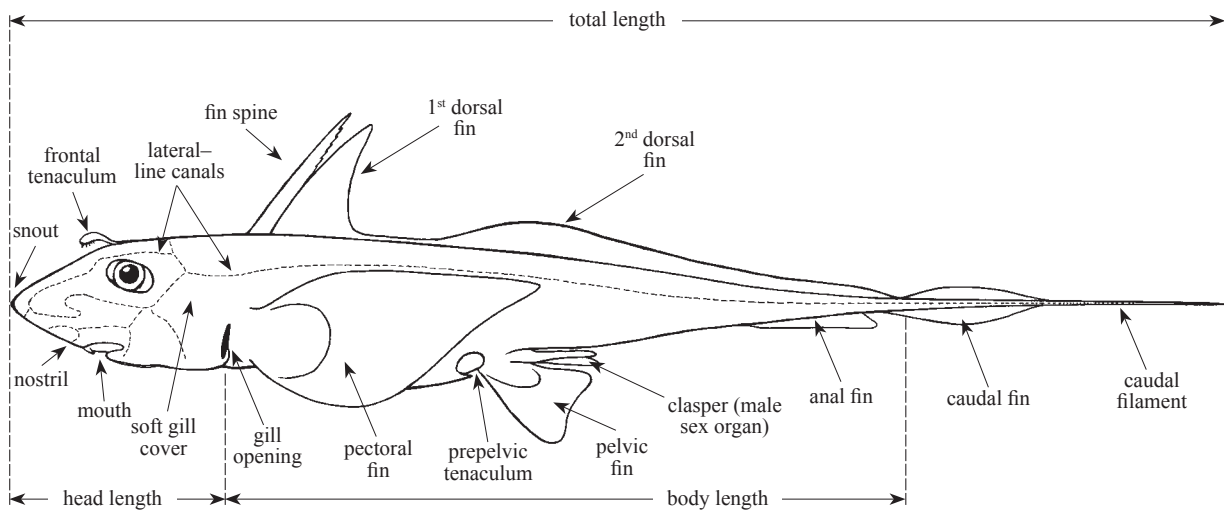


Fig. 7 Lateral view of a typical Chimaera

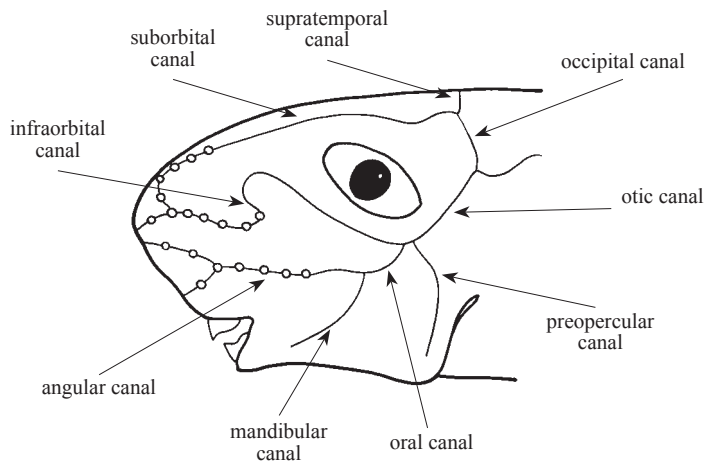


Fig. 8 Lateral line canals of the head of a typical Chimaera

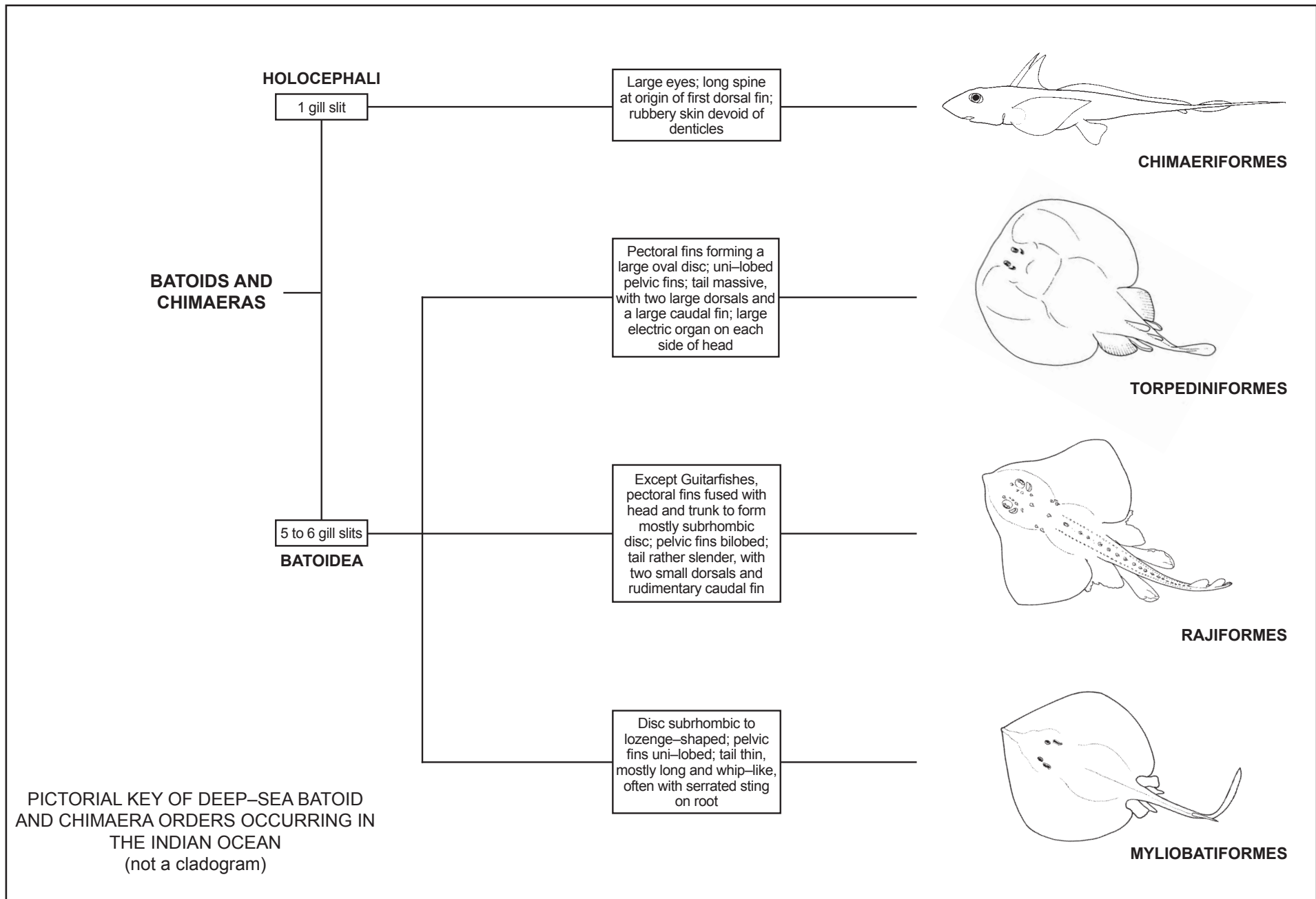


Fig. 9 Higher classification of Batoids and Chimaeras (Orders)

1.2.3 Glossary of Technical Terms

The following glossary of terms used for the anatomy and biology of shark-like fishes is modified from Ebert and Stehmann (2013).

Abyss: The deep sea bottom, ocean basins or abyssal plain descending from 4500 m to about 6000 m.

Accessory dorsal marginal: In the clasper skeleton, a flat cartilage on the posterior end of the dorsal marginal cartilage that supports the cover rhipidion

Acute: Pointed or sharp at tip.

Alar thorns: Enlarged hooked shaped spines on the outer pectoral fins of adult male skates.

Amphitemperate: Referring to a species that occurs in temperate water in the northern and southern hemispheres, but is absent from the tropics.

Anal fin: A single fin on the ventral surface of the tail between the pelvic fins and caudal fin of some sharks, absent in batoids, dogfish, sawsharks, angel sharks, and some chimaeras.

Annular rings or **annuli:** In a vertebral centrum in cross section, rings of calcified cartilage separated by uncalcified cartilage that occupy the intermedialia only, or concentric rings that cross both the intermedialia and basalia.

Anterior: Forward, in the longitudinal direction of the snout tip. Also, **cranial**.

Anterior margin: In precaudal fins, the margin from the fin origin to its apex.

Anterior nasal flap: A flap on the front edges of the nostrils, that serves to partially divide the nostril into incurrent and excurrent apertures or openings.

Anterior teeth: Enlarged, tall, narrow-rooted oral teeth near the symphysis, often with lingually curved cusps.

Apex: In precaudal fins, the distal tip, which can be acutely pointed to broadly rounded.

Apical: In oral teeth, towards the tip of the crown or cusp. Can also be used as indicating direction towards the apex or tip of a fin, fin-spine, etc.

Basal: In oral teeth, a proximal direction towards the crown foot and roots.

Basal groove: In oral teeth, a deep groove proximal to the basal ledge on the labial surface of the crown neck and apical root margin.

Basal ledge: In oral teeth, a shelf-like projection on the labial surface of the crown foot.

Basal plate: The floor of the cranial cavity of the neurocranium, a ventral, medial plate extending from the ethmoid region between the orbits and otic capsules and below the cranial cavity to the occipital condyles, occipital centrum and foramen magnum.

Basals or **basalia:** In a vertebral centrum, the diagonal spaces below the attachment surfaces of the basidorsal cartilages, above the basiventral cartilages, and between

the two halves of the double cone. Basalia may be filled with uncalcified cartilage, may have diagonal calcifications penetrating the uncalcified cartilage, or may have calcified annuli or solid calcified cartilage that are continuous with calcification of the intermedialia. See diagonal calcifications and intermedialia.

Base: In precaudal fins, the proximal part of the fin between the origin and insertion, extending distally, and supported by the cartilaginous fin skeleton. In the caudal fin, that thickened longitudinal part of the fin enclosing the vertebral column and between the epaxial and hypaxial lobes or webs of the fin. In oral teeth, the proximal root and crown foot, in apposition to the distal cusp. In denticles, the proximal anchoring structures, often with four or more lobes, holding the denticles in the skin.

Bathypelagic zone: That part of the oceans beyond the continental and insular shelves, from about 1000 m to 3000 to 6000 m and above the middle and lower continental rises and the abyssal plain, the sunless zone. Some oceanic sharks may transit the epipelagic, mesopelagic and bathypelagic zones to the bottom while migrating vertically.

Batoid: A ray or flat or winged shark, a neoselachian of the superorder Squalomorpii, order Rajiformes: a sawfish, sharkray, wedgfish, guitarfish, thornray, panray, electric ray, skate, stingray, butterfly ray, eagle ray, cownose ray, devil ray or manta. Rays are closely allied to the sawsharks (Pristiophoriformes) and angel sharks (Squatiformes), but differ from them in having the pectoral fins fused to the sides of the head over the gill openings, which are ventral rather than laterally or ventrolaterally placed.

Benthic or **Demersal:** referring to organisms that are bottom-dwelling.

Blade: In oral teeth, an arcuate, convex-edged section of the cutting edge of the crown foot, without cusplets.

Body: Can refer to an entire shark, batoid, or chimaera, sometimes restricted to the trunk and precaudal tail.

Branchial arches: The paired visceral arches behind the hyoid arch and just in front of the scapulocoracoid that support the gills. In elasmobranchs the five to seven branchial arches primitively consist of a pair of dorsomedial and wedge-shaped cartilages, the **pharyngobranchials**, closely situated against the roof of the pharynx, a pair of dorsolateral and more cylindrical **epibranchials** that are connected dorsomedially to the pharyngobranchials, a pair of ventrolateral cylindrical **ceratobranchials** that are connected ventrolaterally to the epibranchials, a pair of ventromedial **hypobranchials** that are connected ventrolaterally to the ceratobranchials, and unpaired ventromedial **basibranchials** that are connected ventrolaterally to the hypobranchials. The hypobranchials and basibranchials along with the expanded ventral ends of the ceratobranchials form the **basibranchial skeleton** of the floor of the branchial pharynx. The branchial skeleton is variably modified in elasmobranchs, with basibranchials and sometimes hypobranchials often lost, the last two pharyngobranchials and the last epibranchial often fused together, and the last basibranchial often expanded into a long, broad **copula** with which the anterior hypobranchials and posterior ceratobranchials articulate.

Calcified cartilage: Shark skeletons are formed of hyaline cartilage or gristle, but this is often reinforced with layers

of calcified cartilage, cartilage impregnated with a mineral, hydroxyapatite, similar to that of bone but organized differently, in a hard, tile-like pavement of tiny **tesserae**, or more compactly as in the calcified structures of vertebral centra.

Carcharhinoid: A ground shark, a member of the order Carcharhiniformes, and including the catsharks, false catsharks, finbacked catsharks, barbeled houndsharks, houndsharks, weasel sharks, requiem sharks and hammerheads.

Cartilaginous fishes: Members of the class Chondrichthyes.

Caudal filament: The long, thin, whip-like structure that extends behind the end of the caudal fin in chimaeras.

Caudal fin: The fin on the end of the tail in shark-like fishes, lost in some batoids.

Caudal peduncle: That part of the precaudal tail extending from the insertions of the dorsal and anal fins to the front of the caudal fin.

Centrum (plural, Centra): A spool-shaped, partially or usually fully calcified structure that forms as a segmental constriction in the notochordal sheath of neoselachians, and which as an articulated string forms the principal structural units of the vertebral column. Centra are primarily formed by the calcified double cones in the notochordal sheath, which may be their only calcification, but additional secondary calcification may occur in the centrum between the outer surfaces of the calcified double cones, including calcified intermedialia, radii, annuli, and diagonal calcifications.

Ceratotrichia: Slender soft or stiff filaments of an elastic protein, superficially resembling keratin or horn, from the Greek *keratos*, horn, and *trichos*, hair. Ceratotrichia run in parallel and radial to the fin base and support the fin webs. The prime ingredient of shark-fin soup.

Chimaera: A member of the order Chimaeriformes, subclass Holocephali, see also **Chimaeroid**, **Holocephali**.

Chimaeroid: A chimaera, ratfish, silver shark, ghost shark, spookfish or elephant fish, a member of the order Chimaeriformes.

Chondrichthyan: Referring to the class Chondrichthyes.

Chondrichthyes: The class Chondrichthyes, from Greek *chondros*, cartilage, and *ichthos*, fish, a major taxonomic group of aquatic, gill-breathing, jawed, finned vertebrates with primarily cartilaginous skeletons, 1 to 7 external gill openings, oral teeth in transverse rows on their jaws, and mostly small, tooth-like scales or dermal denticles. Chondrichthyes include the living elasmobranchs and holocephalans and their numerous fossil relatives, and also can be termed shark-like fishes or simply sharks.

Chondrocranium: See **neurocranium**.

Circumglobal: Occurring around the world.

Circumnarial fold: A raised semicircular, lateral flap of skin around the incurrent aperture of a nostril, in heterodontoids, orectoloboids, and a few batoids, defined by a circumnarial groove.

Circumnarial groove: A shallow groove defining the lateral bases of the circumnarial folds.

Circumtropical: Occurring around the tropical regions of the world.

Clasper groove: The longitudinal groove through the clasper, surrounded by the axial and marginal cartilages, and connecting the apopyle and hypopyle.

Clasper sacs: Dermal sacs with longitudinally ribbed walls on the ventral and medial surfaces of the claspers of hexanchoids.

Clasper shaft: That part of the clasper skeleton from its origin on the pelvic fin basipterygium to the hypopyle; also, that part of the external clasper from its base to the hypopyle.

Clasper spine: In the external clasper, a projection of the terminal 3 cartilage on the lateral surface of the clasper glans, which forms a short to long, acutely pointed, spine that is covered with shiny hard tissue, possibly enameloid, dentine or both. In some squaloids other terminal cartilages may have spines.

Clasper spur: In the external clasper, a projection of the terminal 3 cartilage on the lateral surface of the clasper glans, which may be pointed but is not covered with shiny hard tissue.

Clasper tip: The posterior end of a clasper.

Claspers: The paired copulatory organs present on the pelvic fins of male cartilaginous fishes, for internal fertilization of eggs, also termed **mioxopterygia**.

Classification: The ordering of organisms into groups on the basis of their relationships, which may be by similarity or common ancestry.

Cloaca: The common chamber at the rear of the body cavity of elasmobranchs through which body wastes and reproductive products including sperm, eggs, and young pass, to be expelled to the outside through a common opening or **vent**.

Common name: The informal or regional vernacular name of an organism; these names may change from region to region.

Concave: Curving inwards as opposed to **convex** (curving outwards).

Confluent: Joined together, without a space.

Continental shelf: The portion of the seabed surrounding the continents and islands from the shore-line to approximately 200 m depth.

Continental slope: The portion of the seabed that slopes steeply from the edge of the outer continental shelf down to the ocean floor; below approximately 200 m depth.

Convex: Arching or curving outwards as opposed to **concave** (see above).

Cover rhipidion: On the external clasper glans, an elongated, longitudinal blade or flap on its dorsomedial external edge, often supported by an accessory dorsal marginal cartilage.

Crown: The distal part of the oral tooth, almost entirely covered with shiny enameloid except for the neck. In denticles, a flat dorsal plate-like or thorn-like structure, elevated above the denticle base on a stalk or pedicle or confluent with the base.

Crown foot: The expanded, proximal, basal part of the crown, often bearing cusplets or blades.

Cusp: A usually pointed large distal projection of the crown. A **primary cusp** is situated on the midline of the crown foot.

Multicuspid refers to oral teeth or denticles with more than one cusp. In lateral trunk denticles, the posterior ends of the crown may have **medial** and **lateral cusps**, sharp or blunt projections associated with the medial and lateral ridges.

Cusplet: As with a cusp, but a small projection in association with a cusp, and usually mesial and distal but not medial on the crown foot.

Cutting edge: In oral teeth, the compressed sharp longitudinal ridge on the mesodistal edges of the crown.

Deciduous: Usually referring to denticles that are easily rubbed off, especially common in Chimaeras.

Dentine: The primary material of shark oral teeth, a hard tissue with numerous vascular and nonvascular canals.

Dermal denticle or **placoid scale:** A small tooth-like scale found in cartilaginous fishes, covered with enameloid, with a core and base of dentine and usually small and often close-set to one another and covering the body. A few non-batoid sharks, many batoids, and chimaeroids generally have them enlarged and sparse or reduced in numbers.

Demersal: Living on the bottom.

Diphycercal: A caudal fin with the vertebral axis running horizontally into the fin base, which is not elevated.

Diplospondylous vertebrae: Vertebrae of the tail with two centra and two basidorsal and basiventral elements per segment, and mostly with a haemal arch formed by the basiventral and interventral elements. These include diplospondylous precaudal vertebrae between the monospondylous vertebrae and the base of the caudal fin, and diplospondylous caudal vertebrae in the caudal fin.

Disc: The fused unit of the head, snout, and pectoral fins and body on batoids; also referred to as the **Pectoral disc**.

Distal: In any direction, at the far end of a structure. In oral teeth, used in a special sense for structures on the teeth towards the posterolateral mouth corners or rictuses. See **apical** and **basal**.

Dorsal: Upwards, in the vertical direction of the back. See **ventral**.

Dorsal fin: A fin located on the trunk or precaudal tail or both, and between the head and caudal fin. Most sharks have two dorsal fins, some batoids one or none.

Dorsal fin spine: A small to large enameloid-covered, dentine-cored spine located on the anterior margins of one or both of the dorsal fins, found on bullhead sharks (Heterodontiformes), many dogfish sharks, fossil (but not living) batoids, chimaeroids, but lost entirely or buried in the fin bases of other shark-like fishes.

Dorsal lobe: In the caudal fin, the entire fin including its base, epaxial and hypaxial webs but excepting the ventral lobe.

Dorsal margin: In the caudal fin, the margin from the upper origin to its posterior tip. Usually continuous, but in angel sharks (Squatiniiformes) with their hypocercal, superficially inverted caudal fins, it is subdivided.

Dorsal marginal: In the clasper skeleton, a flat semicylindrical cartilage that is partially fused to the medial edge of the axial cartilage, and forms the medial wall of the clasper groove.

Egg case: A stiff-walled elongate-oval, rounded rectangular, conical, or dart-shaped capsule that surrounds the eggs of oviparous sharks, and is deposited by the female shark on the substrate. It is analogous to the shell of a bird's egg and is made of protein, which is a type of collagen that superficially resembles horn or keratin. Egg cases often have pairs of tendrils or horn-like structures on their ends, or flat flanges on their sides or spiral flanges around their lengths, which anchor the cases to the bottom. As the egg travels from the ovaries into the oviducts and through the nidamental glands, the egg case is secreted around it and the egg is fertilized. Live-bearing sharks may retain egg cases, and these vary from being rigid and similar to those of oviparous sharks to soft, bag-like, degenerate and membranous. Soft egg cases may disintegrate during the birth cycle.

Elasmobranch: Referring to the subclass Elasmobranchii.

Elasmobranchii: The subclass Elasmobranchii, (from Greek *elasmos*, plate, and *branchos*, gills, in allusion to their plate-like gill septa), the shark-like fishes other than the Holocephali or chimaeras, and including the living non-batoid sharks, batoids, and a host of fossil species. They differ from holocephalans in having 5 to 7 pairs of gill openings open to the exterior and not covered by a soft gill cover, oral teeth separate and not formed as tooth plates, a fixed first dorsal fin with or without a fin spine, and a short spined or spineless second dorsal.

Embryo: An earlier development stage of the young of a live-bearing shark, ranging from nearly microscopic to moderate-sized but not like a miniature adult. See **foetus**.

Endemic: A species or higher taxonomic group of organisms that is only found in a given area. It can include **national endemics** found in a river system or along part or all of the coast of a given country, but also **regional endemics**, found off or in adjacent countries with similar habitat, but not elsewhere.

Epipelagic zone: That part of the oceans beyond the continental and insular shelves, in oceanic waters, from the surface to the limits of where most sunlight penetrates, about 200 meters. Also known as the sunlit sea or 'blue water'. Most epipelagic sharks are found in the epipelagic zone, but may penetrate the mesopelagic zone.

Euselachian: Referring to the Euselachii.

Euselachii: The cohort Euselachii (Greek *Eu*, true, good or original, and *selachos*, shark or cartilaginous fish), the spined or 'phalacanthous' sharks, including the modern sharks or Neoselachii, and fossil shark groups including the hybodonts, the ctenacanth, and the xenacanth, all primitively with anal fins and having two dorsal fins with fin spines.

Excurrent apertures: The posterior and ventrally facing openings of the nostrils, which direct water out of the nasal cavities and which are often partially covered by the anterior nasal flaps. These are usually medial on the nostrils and posteromedial to the incurrent apertures, but may be posterior to the incurrent apertures only.

Exorhipidion: In claspers, a longitudinally elongated, external blade or flap with its base attached to the dorsolateral edge of the clasper glans, and with its free edge directed medially. It is supported by the **ventral terminal 2 cartilage**.

Eye notch: A sharp anterior or posterior indentation in the eyelid, where present cleanly dividing the upper and lower eyelids.

Eye spots: Large eye-like pigment spots on the dorsal surface of some batoids; they are usually located on the dorsal surface of the pectoral fins.

Filter screens: In the whale shark (*Rhincodontidae*) and devil rays (*Mobulidae*), transverse bars with lateral dermal lobes on the internal gill openings that form devices for screening out plankton.

Fin skeletons: In unpaired precaudal fins, the basal plates and radials; in the caudal fin, the vertebral column including expanded neural and haemal arches; and in the paired fins, the fin girdles, basals, and radials.

Fin web: The usually thin, compressed part of the fin, distal to the base, that is supported by ceratotrichia alone (in aplesodic fins) or by ceratotrichia surrounding expanded fin radials or by radials only (plesodic fin).

First dorsal fin: The anteriormost dorsal fin of two, ranging in position from over the pectoral fin bases to far posterior on the precaudal tail.

Foetus: A later development stage of the unborn young of a live-bearing shark, that essentially resembles a small adult.

Term foetuses are ready to be born, and generally have oral teeth and denticles erupting, have a colour pattern (often more striking than adults), and, in viviparous sharks, have their yolk-sacs reabsorbed.

Filament or Filamentous: A thread-like structure usually associated with the tail.

Free rear tips: The pectoral, pelvic, dorsal, and anal fins all have a movable rear corner or flap, the free rear tip, that is separated from the trunk or tail by a notch and an inner margin. In some sharks the rear tips of some fins are very elongated.

Functional series: A series of oral teeth that are in functional position on the jaw.

Galeomorph: Referring to the Galeomorphii.

Galeomorphii: The neoselachian superorder Galeomorphii, including the heterodontoid, lamnoid, orectoloboid, and carcharhinoid sharks.

Gill openings or slits: In elasmobranchs, the paired rows of five to seven transverse openings on the sides or underside of the head for the discharge of water through the gills. Chimaeras have their four gill openings hidden by a soft gill cover and discharge water through a single external gill opening.

Girdle: A bar of cartilage buried in the body wall that supports the basals of the paired fins: the pectoral girdle (scapulocoracoid) and pelvic girdle (puboischiadic bar).

Hadal: The benthic zone of the deep trenches, 6000 to about 11000 m, from which no cartilaginous fishes have been observed or recorded to date.

Hadopelagic zone: The pelagic zone inside the deep trenches, 6000 to about 11000 m, from which no chondrichthyans have been observed or recorded.

Haemal arch: The arch ventral to the notochord or vertebral centra on tail vertebrae that is formed by the basiventrals and interventrals and which houses the caudal artery and caudal vein in a **haemal canal**.

Haemal spines: On the haemal arches of the diplospondylous precaudal and caudal vertebrae, elongated ventral surfaces forming vertical plates, particularly well-developed on the caudal fin.

Head: That part of a cartilaginous fish from its snout tip to the last or (in chimaeras) only gill slits.

Heterocercal: A caudal fin with the vertebral axis slanted dorsally into the fin base, which is also dorsally elevated.

Heterodonty: In oral teeth, structural differences between teeth in various positions on the jaws, between teeth in the same position during different life stages, or between teeth in the same positions in the two sexes.

Holocephalan: Referring to the Holocephali.

Holocephali: The subclass Holocephali (from Greek *holos*, entire, and *kephalos*, head), the living chimaeras and their numerous fossil relatives, a major subdivision of the class Chondrichthyes. The name is in reference to the fusion of the upper jaws or palatoquadrate to the skull in all living species and in many but not all fossils. The living holocephalans include three families in the order Chimaeriformes. The living species differ from elasmobranchs in having four pairs of gill openings covered by a soft gill cover and with a single pair of external gill openings, oral teeth fused and reduced to three pairs of ever-growing tooth plates, an erectile first dorsal fin with a spine and a long, low spineless second dorsal.

Holotype: Either the only specimen used and mentioned in an original description of a species, with or without a designation of such, or one of two or more specimens used and mentioned in an original description of a species and designated as such. This becomes the 'name-bearer' of the species, and is used to validate the species or scientific name by anchoring it to a single specimen.

Homodonty: In oral teeth, structural similarity between teeth in various positions on the jaws, between teeth in the same position during different life stages, or between teeth in the same positions in the two sexes.

Hypopyle: On the external clasper and clasper skeleton, the posterior opening of the clasper groove onto the clasper glans.

Incurrent apertures: The anterior and ventrally facing openings of the nostrils, which direct water into the nasal cavities. These are usually lateral on the nostrils and anterolateral to the excurrent apertures, but may be anterior to the excurrent apertures only.

Independent dentition: Teeth along a mesodistal series in which the roots do not overlap and are separated by a space. See **overlapping dentition**.

Inner margin: In precaudal fins including the pectoral, pelvic, dorsal and anal fins, the margin from the fin insertion to the rear tip.

Insertion: The posterior or rear end of the fin base in precaudal fins. The caudal fin lacks insertions except with many batoids and some chimaeroids that have a caudal filament that extends posterior to the fin. See **origin**.

Intermediate teeth: Small oral teeth between the laterals and anteriors of the upper jaw, found in most lamnoids.

Internasal plate or septum: On the neurocranium, a plate or partition between the two nasal capsules. It ranges from a vertical plate to a broad horizontal plate.

Intestinal valve: A dermal flap inside the intestine, protruding into its cavity or lumen, and of various forms in different cartilaginous fishes. Often formed like a corkscrew or augur. See **spiral, ring** and **scroll valves**.

Jaws: See **mandibular arch**.

Labial cartilages: Paired cartilages that are internal and support the labial folds at the lateral angles of the mouth. Living neoselachians typically have two pairs of upper labial cartilages, the **anterodorsal** and **posterodorsal** labial cartilages, and one pair of **ventral labial cartilages**, but these are variably reduced and sometimes absent in many sharks. Chimaeras have more elaborate labial cartilages than living elasmobranchs.

Labial flange: On tooth crowns of many squaloids and some orectoloboids, a narrow, vertically elongated labial basal ledge.

Labial folds: Lobes of skin at the lateral angles of the mouth, usually with labial cartilages inside them, separated from the sides of the jaws by pockets of skin (labial grooves or furrows).

Labial furrows or **labial grooves:** Grooves around the mouth angles on the outer surface of the jaws of many cartilaginous fishes, isolating the labial folds. Primitively there is a distinct **upper labial furrow** above the mouth corner and a **lower labial furrow** below it.

Labial: In oral teeth, the outer face of the tooth that is directed outside the mouth and towards the lips. See **lingual**.

Lateral or **laterad:** Outwards, in the transverse direction towards the periphery of the body. See **medial**.

Lateral teeth: Large broad-rooted, compressed, high crowned oral teeth on the sides of the jaws between the anteriors and posteriors.

Lateral trunk denticle: A dermal denticle from the dorsolateral surface of the back below the first dorsal fin base.

Lectotype: One of two or more specimens that were syntypes in an original description, designated as a lectotype by a subsequent writer. It then becomes equivalent to a holotype, and anchors the name of the species to a specimen unless invalidated by a ruling of the International Commission on Zoological Nomenclature or a previous designation of a lectotype.

Lingual: In oral teeth, the inner face of the tooth that is directed inside the mouth and towards the tongue. See **labial**.

Littoral zone: That part of the oceans over the continental and insular shelves, from the intertidal to 200 m.

Live-bearing: A mode of reproduction in which female sharks give birth to young sharks, which are miniatures of the adults. See **viviparity**.

Longitudinal ridges: In lateral trunk denticles, parallel ridges that extend anteroposteriorly on the distal surface of the crown. These may be in the form of a single **medial ridge** (sometimes paired), and paired **lateral ridges**, and may terminate in medial and lateral cusps.

Lower eyelid: The ventral half of the eyelid, separated by a deep pocket (conjunctival fornix) from the eyeball. In some derived batoids the pocket also fuses with the eyeball.

Lower origin: In the caudal fin, the anteroventral beginning of the hypaxial or lower web of the caudal fin, at the posterior end of the anal-caudal or pelvic-caudal space (see measurement illustrations).

Lower postventral margin: In the caudal fin, the lower part of the postventral margin of the hypaxial web, from the ventral tip to the posterior notch.

Malar: Rows of thorn patches found only on adult males (in some skate species) along anterior margin of disc in front of the eyes.

Medial teeth: Small oral teeth, generally symmetrical and with narrow roots, in one row at the symphysis and often in additional paired rows on either side of the symphyseal one.

Medial: Inwards, in the transverse direction towards the middle of the body. See **lateral**.

Mesial: In oral teeth, mesial structures are towards the midlines of the jaws, the symphyses. See **distal**.

Mesopelagic zone: That part of the oceans beyond the continental and insular shelves, in oceanic waters, from about 200 to 1000 m, the twilight zone where little light penetrates.

Molariform: In oral teeth, referring to a tooth with a broad flat crown with low cusps or none, for crushing hard-shelled invertebrate prey.

Monospondylous precaudal vertebrae: Vertebrae with one centrum and one pair of basidorsals, basiventrals, and ribs per body segment (myotome), and generally extending from the occiput to the end of the body cavity and to over the pelvic girdle. However there is much variation in the position of the monospondylous–diplospondylous transition, which can range well in front or behind the pelvic girdle.

Monospondylous–diplospondylous transition: The position on the vertebral column where monospondylous centra end and diplospondylous centra begin. In lateral view the transition often appears as an abrupt decrease in length of the diplospondylous centrum compared to the last monospondylous centrum, but this can be obscure in various sharks with very numerous, very short centra. Often a centrum of intermediate length appears between a long monospondylous centrum and a short diplospondylous centrum. In a few sharks there is a **stutter zone** of alternating

long and short centra that marks the transition. Also, the basidorsals and basiventrals have foramina for the spinal nerves on every other vertebra, rather than on each vertebra as in monospondylous vertebrae. The transition from long to short centra is generally coordinated with the transition of vertebrae with free ribs and no haemal arches to those without ribs and with haemal arches. However, in some sharks the two transitions can be anterior or posterior to each other.

Nasal aperture: On the neurocranium, an aperture in the anteroventral surface or floor of each nasal capsule, through which the nostril directs water into and out of the nasal organ.

Nasal capsules: On the neurocranium, a pair of spherical, oval or trumpet-shaped, thin-walled structures behind the rostrum (when present) and in front of the orbits, cranial roof and basal plate. They serve as containers for the nasal organs or organs of smell, and have passages into the cranial cavity to connect the nasal organs with the brain.

Nasal curtain: Anterior nasal flaps that are expanded medially and posteriorly and have fused with each other. Nasal curtains are found in some carcharhinoid sharks and in many batoids.

Nasal flap: One of a set of dermal flaps associated with the nostrils, and serving to direct water into and out of them, including the anterior, posterior, and mesonarial flaps.

Nasoral grooves: Many bottom-dwelling, relatively inactive sharks have nasoral grooves, shallow or deep grooves on the ventral surface of the snout between the excurrent apertures and the mouth. The nasoral grooves are covered by expanded anterior nasal flaps that reach the mouth, and form water channels that allow the respiratory current to pull water by partial pressure into and out of the nostrils and into the mouth. This allows the shark to actively irrigate its nasal cavities while sitting still or when slowly moving. Nasoral grooves occur in heterodontoids, orectoloboids, chimaeroids, some carcharhinoids, and most batoids. Also termed **oronasal grooves**.

Neck: A narrow band of finely porous dull tissue (possibly orthodontine) encircling the proximal end of the crown of a tooth, and apparently covered with dental membrane.

Neoselachian: Referring to the Neoselachii.

Neoselachii: From Greek *neos*, new, and *selachos*, shark. The modern sharks, the subcohort Neoselachii, consisting of the living elasmobranchs and their immediate fossil relatives. See **Euselachii**.

Neotype: A specimen, not part of the original type series for a species, which is designated by a subsequent author, particularly if the holotype or other types have been destroyed, were never designated in the original description, or are presently useless.

Neurocranium: In sharks, a box-shaped complex cartilaginous structure at the anterior end of the vertebral column, containing the brain, housing and supporting the nasal organs, eyes, ears, and other sense organs, and supporting the visceral arches or splanchnocranium. Also termed **chondrocranium**, **chondroneurocranium**, or **endocranium**.

Nomenclature: In biology, the application of distinctive names to groups of organisms.

Nostrils: The external openings of the cavities of the nasal organs, or organs of smell.

Nuchal thorns: One or more thorns on the nape of skates, located just behind the spiracles; some juvenile skates may have an enlarged nuchal thorn to aid in escaping the egg case, but this thorn disappears soon after birth while in some species this thorn may remain throughout the skate's life.

Oceanic: Referring to organisms inhabiting those parts of the oceans beyond the continental and insular shelves, over the continental slopes, ocean floor, sea mounts and abyssal trenches. The open ocean.

Ocelli or eyespots: Large eye-like pigment spots located on the dorsal surface of the pectoral fins or bodies of some sharks including rays, angel sharks, and some bamboo sharks, possibly serving to frighten potential enemies.

Orbital thorns: Thorns around the eyes of some skate species.

Orbits: Large, paired cavities on the sides of the neurocranium, behind the nasal capsules, mostly in front of the otic capsules, and separated medially by the cranial cavity. They are bounded anteriorly by the preorbital walls and processes, dorsally by the supraorbital crests, ventrally by the suborbital shelves (reduced or lost in various squalomorphs), and posteriorly by the postorbital processes and walls. The orbits contain the eyeballs and their muscles, venous sinuses, several arteries that connect to the cranial cavity, and most of the cranial nerves.

Origin: The anterior or front end of the fin base in all fins. The caudal fin has **upper** and **lower** origins but no insertion. See **insertion**.

Overlapping dentition: Teeth along a mesodistal series in which the roots overlap and are not separated by a space. Two types of overlap patterns occur, **alternate overlap**, in which teeth in a series alternate from more labial to more lingual, and **imbricate overlap**, in which the distal end of each tooth lingually or labially overlaps the mesial end of the succeeding tooth, repeating to the distal ends of the dental band. **Alternate-imbricate dentitions** combine both alternate and imbricate overlap. See **independent dentition**.

Oviparity: A mode of reproduction in which female sharks deposit eggs enclosed in oblong or conical egg-cases on the bottom, which hatch in less than a month to more than a year, producing young skates which are miniatures of the adults.

Paired fins: The pectoral and pelvic fins.

Palpebral aperture: The eye opening, defined by the upper and lower eyelids.

Papillae: Elongated finger-like processes of skin, located around the spiracles of torpedo rays, and in the mouths and on the gill arches of other sharks.

Papillose gill rakers: See **gill raker papillae**.

Paralectotype: One of two or more specimens that were syntypes in an original description, but which became a paralectotype or paralectotypes when a subsequent author

designated one of the syntypes as a lectotype. Paralectotypes are equivalent to paratypes.

Paratype: Each specimen of a type series other than the holotype. Specimens other than the holotype automatically become paratypes unless the author designates them as referred specimens that are not part of the type series.

Pectoral fins: A symmetrical pair of fins on each side of the trunk just behind the head and in front of the abdomen. These are present in all cartilaginous fishes and correspond to the forelimbs of a land vertebrate (a tetrapod or four-footed vertebrate).

Pectoral or shoulder girdle: See **scapulocoracoid**.

Pedicle: In lateral trunk denticles, a narrow stalk separating the crown from the base.

Pelagic: Referring to organisms that are free-swimming, not bottom-dwelling.

Pelvic fin: Asymmetrical pair of fins on the sides of the body between the abdomen and precaudal tail which correspond to the hindlimbs of land vertebrate (a tetrapod or four-footed vertebrate). Also, **ventral fins**.

Pelvic girdle: See **puboischial bar**.

Placenta: See **yolk-sac placenta**.

Placoid scale: See **dermal denticle**.

Pores, pigmented: In a few sharks and skates, the pores for the lateral line and ampullae of Lorenzini are conspicuously black-pigmented, and look like little black specks.

Posterior: Rearwards, in the longitudinal direction of the caudal-fin tip or tail filament. Also **caudal**.

Posterior margin: In precaudal fins, the margin from the fin apex to either the free rear tip (in sharks with distinct inner margins) or the fin insertion (for those without inner margins).

Posterior nasal flaps: Low flaps or ridges arising on the posterior edges of the excurrent apertures of the nostrils.

Posterior notch: In the caudal fin, the notch in the postventral margin dividing it into upper and lower parts.

Posterior teeth: Small or sometimes enlarged irregular oral teeth near and at the distal ends of the dental bands, with low crowns and sometimes missing cusps.

Posterior tip: The posteriormost corner or end of the terminal lobe of the caudal fin.

Postventral margin: In the caudal fin, the margin from the ventral tip to the subterminal notch of the caudal fin. See **lower** and **upper** postventral margins.

Preanal ridges: A pair of low, short to long, narrow ridges on the midline of the caudal peduncle extending anteriorly from the anal fin base.

Precaudal fins: All fins in front of the caudal fin.

Precaudal pit: A depression at the upper and sometimes lower origin of the caudal fin where it joins the caudal peduncle.

Precaudal tail: That part of the tail from its base at the vent

to the origins of the caudal fin.

Precaudal vertebrae: Vertebrae from the occiput to the dorsal origin of the caudal fin.

Predorsal ridge: A low narrow ridge of skin on the midline of the back anterior to the first dorsal fin base.

Preventral margin: In the caudal fin, the margin from the lower origin to the ventral tip of the caudal fin.

Proximal: In any direction, at the near end of a structure.

Pseudopera: On the external clasper glans, a dorsally opening blind pocket along the lateral edge of the clasper, and about opposite the anterior edge of the glans.

Pseudosiphon: On the external clasper glans, a dorsally opening blind pocket along the medial edge of the clasper, and about opposite the cover rhipidion.

Radial cartilages or radials: The small, segmented, more distal cartilages of the precaudal fins, attached proximally to the distal edges of the basal cartilages. In the pectoral fin skeleton of living neoselachians, the radials mostly have three segments but range from no segments to 30 or more. The radial segments adjacent to the pectoral basals are the **proximal radials**, the radial segments furthest from the basals are the **distal radials**, and any segments between them are **intermediate radials**.

Radii: In a vertebral centrum in cross-section, branching plates of calcified cartilage in the intermedialia. These have a radial orientation from the centre of the centrum.

Ray: See **batoid**.

Replacement series: A series of oral teeth that are lingual to the functional series, and not in a functional position on the jaw.

Rhipidion: In non-batoid sharks, a longitudinal, elongated flap attached to the floor of the glans along its base and with its free edge directed laterally. In skates (Rajoidei) rhipidion is used for a soft mass of erectile tissue in the glans, not necessarily homologous to the rhipidion of non-batoid sharks.

Rhomboidal: In the form of a rhombus or diamond.

Ring valve: A type of spiral intestinal valve in which the valve turns are very numerous and short and resemble a stack of washers.

Rise: The transitional and less steep bottom zone from the lower slope to the abyss or ocean floor, between 2250 m and 4500 m. The rise can be divided into upper (2250 to 3000 m), middle (3000 to 3750 m) and lower (3750 to 4500 m) rises. Few sharks are known from the rise, and those mostly from the upper rise. See **Abyss**, **Hadal**, **shelf** and **slope**.

Root lobe: Sharks often have the roots of their oral teeth divided into separate lobes at their midlengths, which are termed **mesial** and **distal root lobes**.

Root: The proximal part of the oral tooth, made of porous osteodentine and anchoring the tooth in the dental membrane of the jaw.

Rostral thorns: Thorns on the rostrum of some skate species.

Rostrum: On the neurocranium, the cartilaginous anteriormost structure which supports the prenasal snout including lateral line canals and masses of ampullae, and is located in front of the nasal capsules and anterior fontanelle. The rostrum is very variable, and in squalomorph sharks is primitively trough or basin-shaped, while it may be primitively rod-shaped or tripodal in galeomorph sharks. It is absent in a few non-batoid sharks and in many batoids. See **rostrum, tripodal**.

Rostrum, tripodal: The rostrum of the neurocranium in lamnoid and carcharhinoids is primitively tripodal, with a pair of dorsolateral **lateral rostral cartilages** that arise from the posterolaterodorsal surfaces of the nasal capsules or from the preorbital wall, and a **medial rostral cartilage** that arises from the anteromedial surface of the internasal septum. The medial and lateral rostral cartilages extend anteriorly and articulate or fuse at the rostral node. Living orectoloboids have only the medial rostral cartilage although a tripodal rostrum may be present in some fossil orectoloboids, while heterodontoid sharks lack a rostrum as adults but apparently lose it as embryos.

Row: In oral teeth, a single replicating line of teeth, approximately transverse to the longitudinal jaw axis, which includes functional teeth and their replacements, derived from one tooth-producing area on the jaw.

Saw or saw-snout: The elongated snout in sawfish and sawsharks, with side and (in sawsharks) ventral teeth formed from enlarged denticles, used to kill, ensnare or dig for prey. Also termed rostral saw.

Scapular thorns: Thorns on the shoulder girdle of some skate species.

Scroll valve: A type of spiral intestinal valve in requiem and hammerhead sharks in which the valve has uncoiled and resembles a rolled-up bib or scroll.

Second dorsal fin: The posteriormost dorsal fin of two in cartilaginous fishes, ranging in position from over the pelvic-fin bases to far posterior on the precaudal tail.

Secondary lower eyelid: The eyelid below or lateral to the nictitating lower eyelid, separated from it by a subocular groove or pocket, and, in many carcharhinoids with internal nictitating lower eyelids, functionally replacing them as lower eyelids. Some orectoloboids have shallow subocular grooves separating their non-nictitating lower eyelids from weakly developed secondary lower eyelids. They may, however, be able to close their eye openings by retracting the eyeballs.

Series: In oral teeth, a line of teeth along the jaws which is parallel to the jaw axis and includes teeth from all rows present.

Serrations: In oral teeth, minute teeth formed by the cutting edge of the crown that enhance the slicing abilities of the teeth.

Sexual dimorphism: Differences in physical shape or form usually found in skates.

Shark: Generally used for cylindrical or flattened cartilaginous fishes with 5 to 7 external gill openings on the sides of their heads, pectoral fins that are not attached to the head above the gill openings, and a large, stout tail with a large caudal fin; that is, all living elasmobranchs except the rays or

batoids. Living sharks in this sense are all members of the Neoselachii, the modern sharks and rays. Shark is also used loosely for fossil chondrichthyans that are not neoselachians but have a shark-like form, and even for 'spiny sharks' (acanthodians) and for certain teleosts. Rays are essentially flattened sharks with the pectoral fins attached to their heads and are cladistically nested within the squalomorph sharks, while living chimaeras are the immediate sister group of living neoselachians and are called ghost sharks or silver sharks. Hence shark is used here in an alternate and broader sense to include the rays and chimaeras.

Shelf, continental and insular: The sloping plateau-like area along the continents and islands between the shoreline and approximately 200 m depth. It is roughly divided into inshore (intertidal to 100 m), and offshore (100 to 200 m) zones. The shelves have the greatest diversity of cartilaginous fishes. See **Abyss, rise and slope**.

Shoulder: In oral teeth, an arcuate or straight, convex-edged section of the crown foot, without cusplets and similar to a blade but without a cutting edge.

Siphons: A pair of dermal sacs in the ventral abdominal wall of male sharks, connecting posteriorly with the apophyses of the claspers, and extending anteriorly a variable distance from about opposite the pelvic origins to opposite the pectoral bases.

Skull or cranium: The skull or head skeleton of sharks includes the **neurocranium** and the **splanchnocranium** or visceral arches. The visceral arches articulate with and are associated with the neurocranium, but, except for the upper jaws of many holocephalans, are not fused to it. Also termed **syncranium**.

Slope, continental and insular: The precipitous bottom zone from the edge of the outer shelf down to the submarine rise, between 200 m to 2250 m. The slope can be divided into upper (200 to 750 m), middle (750 to 1500 m) and lower (1500 to 2250 m) slopes, of which the upper and middle slope has the highest diversity of deepwater benthic sharks. See **Abyss, rise and shelf**.

Snout: That part of a cartilaginous fish in front of its eyes and mouth, and including the nostrils.

Spiracle: A small to large opening between the eye and first gill opening of most sharks and rays, representing the modified gill opening between the jaws and hyoid (tongue) arch. This is secondarily lost in chimaeras and some sharks.

Spiral or conicospiral valve: An intestinal valve shaped like a corkscrew or augur, with the valve angled anteriorly and medially in the intestine.

Squalene: Along-chain oily hydrocarbon present in the liver oil of deepwater cartilaginous fishes. It is highly valued for industrial and medicinal use.

Squalomorph: Referring to the Squalomorphii.

Squalomorphii: The neoselachian superorder Squalomorphii, including the hexanchoid, squaloid, squatinoid, pristiphoroid, and batoid sharks.

Subcaudal keel: In a few dogfish sharks (family Centrophoridae), a single longitudinal dermal keel on the underside of the caudal peduncle.

Suborbital shelf: On the neurocranium, a horizontal plate arising on the ventral junction of the orbital wall and basal plate on each side which extends from the nasal capsule to the otic capsule; it forms the floor of the orbit. A well-developed suborbital shelf is apparently primitive for shark-like fishes but is variably telescoped, reduced or lost in many squalomorph sharks and a few galeomorphs.

Subterminal margin: In the caudal fin, the margin from the subterminal notch to the ventral beginning of the terminal margin.

Subterminal mouth or **ventral mouth:** Mouth located on the underside of the head, behind the snout. Also termed an **inferior mouth**, in reference to its ventral position but not its function. A **superior mouth** (not found in living cartilaginous fishes) is on the dorsal surface of the head.

Subterminal notch: On the caudal fin of most non-batoid sharks and at least one batoid, the notch in the lower distal end of the caudal fin, between the postventral and subterminal margins, and defining the anterior end of the terminal lobe.

Symphyseal or **symphyseal groove:** A longitudinal groove on the ventral surface of the lower jaw of some orectoloboid sharks, extending posteriorly from the lower symphysis.

Symphysial teeth: Larger oral teeth in one row on either side of the symphysis, distal to medials or alternates where present. Symphyseals are broader than medials and usually have asymmetrical roots.

Symphysis: The midline of the upper and lower jaws, where the paired jaw cartilages articulate with each other.

Syntype: Two or more specimens used and mentioned in an original description of a species, where there was no designation of a holotype or a holotype and paratype(s) by the describer of the species.

Systematics: Scientific study of the kinds and diversity of organisms, including relationships between them.

Tail: That part of a cartilaginous fish from the cloacal opening or vent (anus in chimaeroids, which lack a cloaca) to the tip of the caudal fin or caudal filament, and including the anal fin, usually the second dorsal fin when present, and caudal fin.

Taxon, plural **taxa:** A taxonomic group at any level in a classification. Thus the taxon Chondrichthyes is a class with two taxa as subclasses, Elasmobranchii and Holocephali, and the taxon *Galeorhinus*, a genus, has one taxon as a species, *G. galeus*.

Taxonomy: Often used as a synonym of systematics or classification, but narrowed by some researchers to the theoretical study of the principles of classification.

Temperate: Two circumglobal bands of moderate ocean temperatures usually ranging between 10° and 22°C at the surface, but highly variable due to currents and upwelling; including the **north temperate zone** between the Tropic of Cancer, 23°27'N latitude, to the Arctic Circle, 66°30'N; and the **south temperate zone** between the Tropic of Capricorn, 23°27'S latitude, to the Antarctic Circle, 66°30'N.

Tenaculum: A unique reproductive organ found on adult male chimaera. The **frontal tenaculum** is located on the forehead and is curved with hook-like denticles and a knob

at the end. The **pelvic tenaculum** is located just in front of the pelvic fins. All these structures are used during courtship and copulation in chimaeras.

Term foetus: See **foetus**.

Terminal 3 cartilage: A wedge-shaped or elongated cartilage articulating with the posterior edge of the ventral marginal cartilage and over the ventral terminal cartilages. It supports a variety of structures, including clasper spines and spurs, the shields of many skates (Rajoidae), and the mesorhipidion of some carcharhinoid sharks.

Terminal lobe: In the caudal fin of most non-batoid sharks and at least one batoid, the free rear wedge-shaped lobe at the tip of the caudal fin, extending from the subterminal notch to the posterior tip.

Terminal margin: In the caudal fin, the margin from the ventral end of the subterminal margin to the posterior tip.

Terminal mouth: Mouth located at the very front of the animal. Most cartilaginous fishes have subterminal mouths, but some species (viper sharks, wobbegongs, angel sharks, frilled sharks, whale sharks, megamouth sharks, and *Manta*) have it terminal or nearly so.

Thorn: In many batoids, most angel sharks and the bramble shark (*Echinorhinus brucus*), enlarged, flat conical denticles with a sharp, erect crown and a flattened base (which may grow as the shark grows).

Tongue arch: See **hyoid arch**.

Transverse groove: In oral teeth, a deep groove transverse on the lingual root surface, transecting it into mesial and distal root lobes.

Transverse notch: In oral teeth, a distinct notch in the proximal labial edge of the root at about its midlength.

Transverse ridges: Small narrow ridges on the labial and lingual surfaces of the crown, apicobasally oriented and sometimes extending to the cusp edges.

Tribasal pectoral fin: A pectoral fin skeleton with three basal cartilages, the propterygium, mesopterygium, and metapterygium, primitively found in most euselachians including living neoselachians.

Trilobate lower lip: In advanced orectoloboids, shallow orolabial grooves divide the lower lips into a medial section and a pair of lateral sections.

Tropeic folds: Longitudinal paired ridges on the ventral midline of the abdomen in frilled sharks (Chlamydoselachidae).

Tropical: Circumglobal band of warm coastal and oceanic water, usually above 22°C at the surface (but varying because of currents and upwelling), between the latitudes of 23°27'North (Tropic of Cancer) and 23°27' South (Tropic of Capricorn) and including the Equator.

Truncate: Blunt, abbreviated.

Trunk: That part of a cartilaginous fish between its head and tail, from the last gill openings to the vent, including the abdomen, back, pectoral and pelvic fins, and often the first dorsal fin.

Umbilical cord: A modified yolk stalk in placental viviparous sharks, carrying nutrients from the placenta to the foetus.

Unpaired fins: The dorsal, anal, and caudal fins.

Upper eyelid: The dorsal half of the eyelid, separated by a deep pocket (conjunctival fornix) from the eyeball. The upper eyelid fuses with the eyeball and the pocket is lost in all batoids.

Upper origin: In the caudal fin, the anterodorsal beginning of the epaxial or upper web of the caudal fin, at the posterior end of the dorso-caudal space (see measurement illustrations).

Upper postventral margin: In the caudal fin, the upper part of the postventral margin of the hypaxial web, from the posterior notch to the subterminal notch.

Uterine cannibalism or **cannibal viviparity:** A mode of reproduction in which foetuses deplete their yolk-sacks early and subsist by eating nutritive eggs produced by the mother (see **oophagy**) or first eat smaller siblings and then nutritive eggs (see **adelphophagy**).

Vent: The opening of the cloaca on the ventral surface of the body between the inner margins and at the level of the pelvic fin insertions.

Ventral: Downward, in the vertical direction of the abdomen. See **dorsal**.

Ventral fin: See **pelvic fin**.

Ventral lobe: In the caudal fin, the expanded distal end of the preventral and lower postventral margins, defined by the posterior notch of the caudal fin.

Ventral margin: In the caudal fin, the entire ventral margin from lower origin to posterior tip, either a continuous margin or variably subdivided into preventral, postventral, subterminal and terminal margins.

Ventral marginal: In the clasper skeleton, a flat semicylindrical cartilage that is partially fused to the lateral edge of the axial cartilage, and forms the lateral wall of the clasper groove.

Ventral terminal: On the skeleton of the clasper glans, an often triangular, elongated, curved, plate-like cartilage that articulates or is attached to the lateral or ventrolateral edge of the end-

style and to the posterior end of the ventral marginal cartilage.

Ventral tip: In the caudal fin, the ventral apex of the caudal fin where the preventral and postventral margins merge.

Vertebra, plural **vertebrae:** A single unit of the vertebral column, including a vertebral centrum and associated cartilages that form neural arches and ribs or haemal arches.

Vertebral axis: That part of the vertebral column inside the base of the caudal fin.

Vertebral column: The entire set or string of vertebrae or 'backbone' of a shark, from the rear of the chondrocranium to the end of the caudal base. Living elasmobranchs range from having as few as 35 vertebrae (some squaloids of the family Somniosidae) to as many as 477 vertebrae (thresher sharks).

Web, fin: See **fin web**.

Yolk sac or **yolk sack:** Almost all sharks start embryonic development somewhat like a chicken, as a large spherical yolky egg inside an elongated shell, the egg case. A small disk of dividing cells represents the pre-embryo or blastula atop the huge yolk mass. The blastula expands around the sides and ventral surface of the yolk mass, and differentiates into an increasingly shark-like embryo, the yolk sac or bag-like structure containing the yolk, and a narrow tubular yolk stalk, between the abdomen of the embryo and the yolk sac.

Yolk stalk: The connecting passage between embryo or foetus and yolk sac, which allows yolk to pass from the sac into the embryonic gut.

Yolk-sac placenta: An organ in the uterus of some ground sharks (order Carcharhiniformes), formed from the embryonic yolk-sac of the embryo and maternal uterine lining, through which maternal nutriment is passed to the embryo. It is analogous to the placenta of live-bearing mammals. There are several forms of yolk-sac placentas in carcharhinoid sharks, including entire, discoidal, globular, and columnar placentas (see Compagno, 1988).

Yolk-sac viviparity: Live-bearing in which the young are nourished primarily by the yolk in the yolk sacs, which is gradually depleted and the yolk sacs reabsorbed until the young are ready to be born.

2. SYSTEMATIC CATALOGUE – Subclass NEOSELACHII – Cohort BATOIDEA

2.1 Order TORPEDINIFORMES – Electric rays

Order: Order Hypotremi, Suborder Sarcura, (group) suborder Torpedinoidea: Gill, 1893, *Natn. Acad. Sci. (U. S.) Mem.* 6, 6: 130 (group ranked as infraorder or superfamily, exclusively for torpedinoids).

Number of Recognized Deep-sea Indian Ocean Families: 2.

Synonyms: Order Plagiostoma, Suborder Platosomia, “Group” Narcoidei: Garman, 1913 (in part), *Mem. Mus. Comp. Zool. Harvard* 36: 257, 259 (group corresponding to infraorder or superfamily, and exclusively for the torpedinoids). Order Raiae, Suborder Pachyura: Gill, 1872 (in part), *Smithsonian Misc. Colln.* (247): 22, 23 (order for all batoids, suborder for all ‘thick-tailed’ batoids). Order Plagiostomi diplospondyli, Suborder Plagiostomi Tectospondyli, Group 2 Rajae Hasse, 1879 (in part), *Nat. Syst. Elasmobr.* (1): 48 (suborder for batoids, squatinids and pristiophorids, group equivalent to infraorder or superfamily and for rajoids and torpedinoids). Order Euselachii, Suborder Hypotremata, Division Narcobatoidei Regan, 1906, *Proc. Zool. Soc. London* (1906): 723 (division ranking as infraorder or superfamily and exclusive to torpedinoids). Order Narcobatea, Suborder Narcacientes, Superfamily Narcobatoidea: Whitley, 1940, *Fishes Australia. Part I. Aust. Zool. Handbook*: 69 (exclusive for torpedinoids). Order Batoidei, Suborder Sarcura: Jordan and Evermann, 1896 (in part), *Bull. U. S. Nat. Mus.* 47(1): 59, 60 (common group for pristids, rhinobatoids, rajoids, and torpedinoids). Order Batoidei, Suborder Narcacientes: Jordan, 1923, *Stanford Univ. Publ., Univ. Ser., Biol. Sci.*, 3: 103 (exclusive for torpedinoids). Order Rajae, [group] Torpedinoidei Fowler, 1941, *Bull. U. S. Natn. Mus.* (100) 13: 290 (exclusive group equivalent to suborder or superfamily for torpedinoids). Order Rajae Smith, 1949, *Sea fishes Southern Africa*: 37, 62 (common group without subdivisions for all batoids). Order Selachii, Group 2, Division B, Subdivision 2, Suborder Rajiformes, Tribe 2, Group Torpedinoidei: Goodrich, 1909, *In R. Lankester, ed., A treatise on Zoology* (9), Vertebrata Craniata: 161 (tribe equivalent to infraorder, and group equivalent to superfamily and exclusive for torpedinoids). Order Narcobatea, Suborder Narcobatida, Superfamily Narcobatoidea: White, 1936 (in part), *Amer. Mus. Novit.* (837): 5; White, 1937 (in part), *Bull. Amer. Mus. Nat. Hist.* 74: 37, tab. 1 (taxa exclusive to torpedinoids). Order Hypotremata, Suborder Narcobatoidei: Engelhardt, 1913, *Abh. math.-phys. Klasse K. Bayer. Akad. Wiss., Suppl., Beitr. Naturg. Ostasiens*, 4: 101 (suborder exclusive to torpedinoids, order includes all living batoids). Order Torpediniformes: Berg, 1940, *Trudy Zool. Inst. Akad. Nauk SSSR*, 5(2): 139 (exclusive for torpedinoids); Berg and Svedovidov, 1955, *Trudy Zool. Inst. Akad. Nauk SSSR*, 20: 74; Arambourg and Bertin, 1958, *In P.-P. Grasse, ed, Traité de Zoologie*, 13: 2055 (exclusively for torpedinoids); Patterson, 1967, *in W. B. Harland et al., Geol. Soc. London, Spec. Pub.* 2: 673 (exclusively for torpedinoids); Lindberg, 1971, *Fishes of the world* (trans. 1974): 8, 263 (exclusively for torpedinoids); Rass and Lindberg, 1971, *J. Ichthyol.* (trans. *Voprosy Ikhtologii*) 11(3): 305 (exclusively for torpedinoids); Compagno, 1973, *J. Linn. Soc. (Zool.)*, 53, suppl. 1: 27 (exclusively for torpedinoids); Applegate, 1974, *J. Mar. Biol. Ass. India*, 14(2): 743 (exclusively for torpedinoids); Chu and Meng, 1979, *Monogr. Fish. China, Sci. Tech. Press, Shanghai*: 114, tab. 2 (exclusively for torpedinoids); Eschmeyer, 1990, *Cat. gen. Recent fish.*: 437 (exclusively for torpedinoids); McEachran, Dunn and Miyake, 1996, *in Stiassny, Parenti and Johnson, Interrelationships fishes*: 80 (exclusively for torpedinoids); Eschmeyer, 1998, *Cat. Fish.* (exclusively for torpedinoids). Order Torpediniformes, Suborder Torpedinoidea: Chu and Meng, 1979, *Monogr. Fish. China, Sci. Tech. Press, Shanghai*: 114, tab. 2 (suborder exclusively for torpedinoids, including Families Torpedinidae and Narkidae). Order Torpediniformes, Superfamily Torpedinoidea: Compagno, 1973, *J. Linn. Soc. (Zool.)*, 53, suppl. 1: 27 (superfamily for hypnids and torpedinids). Order Torpediniformes, Superfamily Narcinoidea: Compagno, 1973, *J. Linn. Soc. (Zool.)*, 53, suppl. 1: 27 (superfamily for narcinids and narkids). Order Plagiostomi, Suborder Rajiformes or Rayiformes: Lozano y Rey, 1928 (in part), *Fauna Iberica. Peces*. Vol. 1: 281 (suborder for all batoids). Order Rajiformes: Nelson, 1976 (in part), *Fishes of the world*: 40 (order for all batoids; Nelson, *ibid.*: 41, suggests that torpedinoids could be recognized as a suborder Torpedinoidei following Compagno, 1973, but didn’t utilize this taxon in his text or index). Order Rajiformes, Suborder Torpedinoidei: Nelson, 1984, *Fishes of the world*, ed. 2: 60 (suborder exclusively for torpedinoids, order for all batoids); Nishida, 1990, *Mem. Fac. Fish. Hokkaido Univ.* 37(1/2): 11 (suborder exclusively for torpedinoids, order for all batoids); Nelson, 1994, *Fishes of the world*, ed. 3: 58 (suborder exclusively for torpedinoids, order for all batoids). Order Squatinida, Suborder Rajoidei, Superfamily Torpedinoidea: Glikman, 1967 (in part), *in Y. A. Orlov, ed., Fundamentals Paleontology*, 11: 219 (superfamily for torpedinoids, suborder for all batoids, order also including squaloids, orectoloboids, cetorhinids, squatinoids, and pristiophoroids). Order Torpedinida, Suborder Torpedinina: Fowler, 1970, *Q. J. Taiwan Mus.* 23(1–2): 86 (exclusively for torpedinoids). Order Rajida, Suborder Torpedinina: Matsubara, 1955, *Fish morphology hierarchy*, (1): 1–789 (suborder exclusively for torpedinoids, order for all batoids). Order Batoidea: Romer, 1945, *Vert. Paleont.* (ed. 2): 577 (for all batoids). Order Batoidea, Suborder Torpedinoidea: Bigelow and Schroeder, 1953, *Mem. Sears Fnd. Mar. Res.* (1) 2: 14, 80 (suborder exclusively for torpedinoids, order for all batoids); Romer, 1966, *Vert. Paleont.* (ed. 3): 350 (suborder exclusively for torpedinoids, order for all batoids). Order Hypotremata, Suborder Narcobatoidea: Norman, 1966, *draft syn. Recent fishes*: 32 (suborder exclusively for torpedinoids, order includes all batoids). Order Rajiformes: Blot, 1969, *in J. Piveteau, ed. Traité de Paleontologie*. 2: 702–776 (group for all living batoids). Order Batoidea, Suborder Narcobatoidea: Schultz and Stern, 1948, *Ways of Fishes*: 226 (suborder for torpedinoids, order for all living batoids). Order Batoidea, Suborder Torpedinoidea: Carroll, 1988, *Vertebrate paleont. evolut.*: 599 (suborder exclusively for torpedinoids, order for all batoids). Order Torpediniformes: Cappetta, 1987, *Handb. Paleoichthyol.* 3B: 27, 160 (exclusively for torpedinoids). Order Torpediniformes, Superfamily Torpedinoidea: Cappetta, 1987, *Handb. Paleoichthyol.* 3B: 27, 160 (for torpedinids). Order Torpediniformes, Superfamily Narcinoidea: Cappetta, 1987, *Handb. Paleoichthyol.* 3B: 27, 162 (for narcinids). Ordo Plagiostomi, Subordo Rajini: Bleeker, 1859, *Acta Soc. Sci. Indo-Neerl.* 6: xiii (suborder for all batoids, order for all elasmobranchs). Order Selachii, Suborder Tectospondyli: Woodward, 1889 (in part), *Cat. fossil fish.* BM(NH) (1): 30 (suborder for squaloids, squatinoids, pristiophoroids, batoids, psammodonts, petalodonts, and pristodonts, order for other living sharks, fossil neoselachians, hybodonts and cochlodonts). Order Torpediniformes, Suborder Torpedinoidei: McEachran, Dunn and Miyake, 1996, *in Stiassny, Parenti and*

Johnson, *Interrelationships fishes*: 80 (for hypnids and torpedinids). Order Torpediniformes, Suborder Narcinoidei: McEachran, Dunn and Miyake, 1996, in Stiassny, Parenti and Johnson, *Interrelationships fishes*: 80 (for narkids and narcinids). Order Rajiformes, Suborder Rajoidei, Superfamily Torpedinoidea: Shirai, 1996, in Stiassny, Parenti and Johnson, *Interrelationships fishes*: 34 (superfamily exclusively for torpedinoids, suborder also including rajoids and myliobatoids, order for all batoids).

FAO Name: En – Electric rays.

Field Marks: Body disc thick and flabby, oval to roundish, snout short, truncate or rounded, skin soft and loose, without armature of dermal denticles or their modifications, tail section thick, caudal fin well developed (except torpedinid genus *Hypnos*), as well as 0 to 2 dorsal fins.

Diagnostic Features: Disc oval, elliptical, rounded to circular, and with stout tail; snout not formed into a saw. Nostrils close together and close to the mouth, with anterior nasal flaps connected together to form a nasal curtain; nasoral grooves present; pectoral fins large. Teeth small and not fused into crushing plates; tooth counts 8 to 68 upper jaw, 7 to 75 lower jaw. Eyes small to obsolete, with several deepwater species that are blind. A stout to diminutive tail; trunk, head and pectoral fins forming a large disc; two, one or no dorsal fins present, usually large where present; the caudal fin usually large and well developed (tiny in *Hypnos*); skin completely naked; no stinging spine on caudal fin; pectoral electric organs present, but no caudal electric organs; powerful electric organs derived from branchial muscles visible as large bean-shaped contour at both sides of head; the rostrum variable, absent, greatly reduced, or moderately large and wide. These are very large, up to 200 cm long to rather tiny, adults less than 30 cm, batoids. **Colour:** dorsal surface coloration in these batoids can be rather brilliant, with bars or lines, blotches, eye-spots, ocelli, rosettes, and various sized spots, or may be rather drab dark to light black or grey without any mottling or other descriptive patterns.

Distribution: Circumglobal in the Atlantic, Indian and Pacific Oceans.

Habitat: All are bottom dwellers on mostly soft sandy and muddy bottoms; a very few are known to swim pelagically even far offshore into the open ocean (e.g. *Torpedo californica*, *T. nobiliana*). Most members of this order are found in tropical and subtropical waters, with a few species living in cool and warm temperate seas. They occur primarily inshore, on continental shelf waters, but a few species are considered deepwater inhabitants.

Biology: Reproductive mode is yolk-sac viviparous, but very little else is known on the life cycle of most species. The diet consists of a variety of benthic invertebrates and for the larger species also teleost fishes. As electric rays are sluggish swimmers, they usually narcotise their prey by electric shocks to immobilize it prior to feeding.

Interest to Fisheries and Human Impact: Electric rays are unwanted bycatch in inshore and shelf bottom fisheries, and fishermen avoid them carefully fearing their powerful electric shock discharges, and hence discard them promptly resulting in a fair survival rate. Their flesh is flabby, watery and disliked for human consumption.

The conservation status of most species is uncertain and as such many are considered Data Deficient or Least Concern due to a lack of fisheries and poor knowledge of their life history and population status.

Local Names: None.

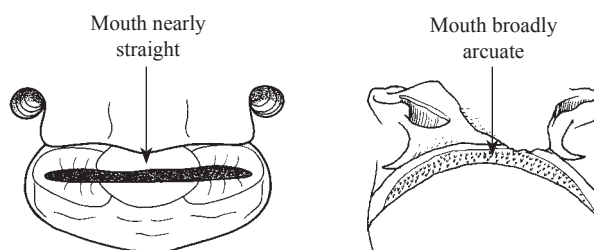
Remarks: Following Aschliman, Claeson and McEachran (2012) the order as restricted here has two families recognized globally, with each family having two subfamilies. The Narcinidae has the Narcininae (Numbfishes) and Narkinae (Sleeper rays), while the Torpedinidae has the subfamilies Torpedininae (Torpedo rays) and Hypninae (Coffin rays). Some classifications recognize as many as four families within this order (Compagno, 2005).

Literature: Compagno (1973, 1977, 2005); Compagno and Last (1999a, b); Compagno *et al.* (1999); Carvalho (1999a, b); McEachran and Aschliman (2004); Nelson (2006); Compagno and Heemstra (2007); Aschliman, Claeson and McEachran (2012); Aschliman *et al.* (2012); L.J.V. Compagno (pers. comm. and unpubl. data).

Key to Deep-sea Indian Ocean Families:

1a. Mouth nearly straight, not distensible, labial cartilages and folds strong at corners of mouth (Fig. 10); two, one, or no dorsal fins, if two present both of similar size . . .
 **family Narcinidae**

1b. Mouth broadly arcuate, distensible, labial cartilages and folds absent at corners of mouth (Fig. 11); two dorsal fins, the first much larger than the second . . .
 **family Torpedinidae**



REGION OF MOUTH AND NOSTRILS

Fig. 10 *Narcine* sp.

Fig. 11 *Torpedo* sp.

2.1.1 **Family NARCINIDAE**

Family: Subfamily Narcininae Gill, 1862 (Family Torpedinoidae or Narcaciontoidea), *Ann. Lyceum Nat. Hist. New York*, 7(32): 387.

Type Genus: *Narcine* Henle, 1834.

Number of Recognized Deep-sea Indian Ocean Genera: 3.

Synonyms: Subfamily Discopyginae Gill, 1895 (Family Narcobatidae), *Proc. U. S. Natn. Mus.* 18: 165. Type genus: *Discopyge* Heckel, 1846.

FAO Name: En – Numbfishes.

Field Marks: Mouth transverse, not distensible, with strong labial cartilages and folds at corners of mouth; two, one, or no dorsal fins present depending on the genus, if two are present these are of similar size, dorsal surface uniformly plain or with rather brilliant colour patterns with spots, blotches, bars, or lines, sometimes forming complex ornate patterns, or with eye-spots on pectoral fins; ventral surface usually light to whitish.

Diagnostic Features: Disc depressed and flattened, not shark-like, oval, rounded to shovel-shaped, with stout shark-like tail; disc and tail about equal in length or tail longer than disc length and disc width. Body entirely naked above and below, without dermal denticles or thorns. Precaudal tail moderately depressed, usually with lateral ridges on sides. Tail abruptly narrower than trunk, with no barbed stinger or stinging spine on its dorsal surface behind dorsal fins and no electric organs. Head broad and depressed; snout moderately elongated, broadly rounded or obtusely rounded-angular, supported by large shovel-shaped rostral cartilage and by anteriorly expanded antorbital cartilages, not formed into a rostral saw and without lateral saw teeth. Five small gill openings on underside of front half of pectoral-fin bases, not visible in lateral view; internal gill slits with no gill sieves or rakers. Eyes small, dorsal on head and just anterior to spiracles. Nostrils just anterior to mouth and separated from it by much less than their own widths, connected with mouth by broad nasoral grooves; anterior nasal flaps usually short but medially expanded and fused into a broad nasal curtain that overlaps mouth. Mouth transverse and straight, with a prominent groove around its periphery, but without prominent knobs and depressions; labial cartilages and folds strong. Oral teeth small, rounded to oval in shape, with a short cusp on their crowns, not laterally expanded and plate-like, and similar in shape; tooth counts from 12 to 33 rows in both upper and lower jaws. Pectoral fins large and forming an oval disc, originating at anterior edges of snout lateral to snout tip, attached to most of head and ending posterior to or opposite pelvic-fin origins; disc not notched and subdivided opposite eyes. Large kidney-shaped electric organs at bases of pectoral fins, these visible through skin. Pelvic fins low, subangular or rounded, not divided into anterior and posterior lobes. Two moderately large equal-sized and widely separated or close-set dorsal fins present, these of similar angular or rounded-angular shape with distinct apices, anterior, posterior and inner margins, and free rear tips, not falcate. First dorsal fin originates behind anterior half of total length, base varying from over rear halves of pelvic-fin bases to behind rear tips of pelvic fins and junction between trunk and tail but well anterior to midlength of tail. Caudal fin large, not shark-like, asymmetrical or symmetrical, with vertebral axis hardly raised above body axis; lower caudal-fin lobe absent. Adults between 15 and 86 cm total length, mostly less than 50 cm. **Colour:** dorsal surface varies from whitish, yellowish, brownish, grey-brown, greenish, reddish or black above, usually white below but black in deep-water species; dorsal surface either unspotted or with small to large dark spots, blotches, bars or lines or white spots and lines, sometimes forming complex eye-shaped spots or ocelli on pectoral fins.

Distribution: Circumglobal with representative species found in most warm temperate and tropical seas.

Habitat: Numbfishes occur mostly inshore on continental shelves, but with a few species occurring along upper continental slopes and insular waters and from the intertidal down to at least 1071 m deep. They are slow-swimming bottom-dwellers, often found on soft mud or sandy bottoms, often off beaches, bays, estuaries, and coral reefs.

Biology: Reproductive mode is viviparous, but very little else known. They feed on invertebrates, which are ingested on the bottom; their jaws and mouths are highly protrusible as a tube that enables them to extract bottom organisms from the substrate.

Interest to Fisheries and Human Impact: Numbfishes are caught as minor bycatch of small local inshore fisheries and in offshore trawl fisheries. They can deliver a strong shock to the unwary when disturbed or captured, but are otherwise inoffensive to people. Utilization of these rays is uncertain.

The conservation status of numbfishes is poorly known, but is of concern because some species occur in areas that are heavily fished by demersal trawlers and many have very limited geographic ranges.

Local names: Electric rays, Torpedo rays, Torpedoes, Torpedo fishes, Numbfishes (English); Pla searn (Thailand); Pari kebas (Malay); Skaty elektricheskie (Russia); Shibire-ei (Japan).

Remarks: The family has 10 recognized genera, with about 43 nominal species, of which four genera and five species are considered to be deep-sea inhabitants; three genera and five species occur in the Indian Ocean deep-sea. The above family account is modified after Carvalho, Compagno and Last (1999). The Key to Deep-sea Genera below is modified after Compagno (1999) and Compagno and Heemstra (2007).

Literature: Carvalho (1999a, b; 2008); Carvalho, Compagno and Last (1999); Compagno and Last (1999a); Carvalho, Compagno and Ebert (2003); Compagno and Heemstra (2007).

List of Deep-sea Species Occurring in the Area:

- *Benthobatis moresbyi* Alcock, 1898
- *Heteronarce garmani* Regan, 1921
- *Heteronarce mollis* (Lloyd, 1907)
- *Narcine lasti* Carvalho and Séret, 2002
- *Narcine tasmaniensis* Richardson, 1841

Key to Deep-sea Indian Ocean Genera:

1a. Snout flexible, soft, with narrow, rod-shaped rostral cartilage; a shallow groove around mouth. *Heteronarce*

1b. Snout firm, stiff, with broad shovel-shaped rostral cartilage, easily felt by palpation of the snout; a deep groove around mouth **2**

2a. Eyes extremely reduced, barely visible as obscure spots anterior to spiracles, and embedded in integument (Fig. 12) . . . *Benthobatis*

2b. Eyes developed, easily visible anterior to spiracles, functional, and not embedded in integument (Fig. 13). *Narcine*

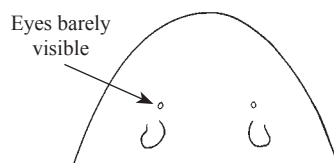


Fig. 12 *Benthobatis* sp.

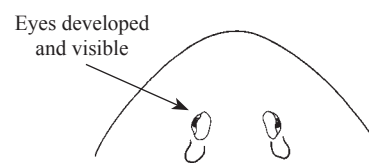


Fig. 13 *Narcine* sp.

***Benthobatis* Alcock, 1898**

Genus: *Benthobatis* Alcock, 1898, *Ann. Mag. Nat. Hist. Ser. 7*, 2(8): 144 (original description, not illustrated).

Type Species: *Benthobatis moresbyi* Alcock, 1898, by monotypy.

Number of Recognized Deep-sea Indian Ocean Species: 1.

Synonyms: None.

Field Marks: Small electric rays with discs rounded to oval-shaped, eyes extremely reduced, embedded and covered by integument, visible only as obscure spots anterior to spiracles, two fleshy dorsal fins, lateral ridges on tail reduced or absent, dorsal coloration dark brown to blackish purple, ventral surface lighter in some species and some with small spots or irregular blotches.

Diagnostic Features: Disc soft, elongate and oval; length noticeably greater than width, 36 to 44% total length. Tail slender, length 51 to 62% disc length. Body smooth, without dermal denticles or thorns above and below; skin loosely attached. Head narrow and depressed, length 27 to 33% total length; snout rounded, length moderate to very elongate; supported internally by expanded anterolateral rostrum. Precaudal tail rounded anteriorly at pelvic fins, narrowing posteriorly to compressed caudal fin section; low lateral ridge-like folds present; no electric organs in tail. Eyes reduced, presumably non-functional, orbits covered with integument and not visible externally; eye positions marked by small pores just anterior to spiracles. Spiracles small, oval-shaped; 5 to 10 pseudobranchial folds present on anterior wall of inner spiracles. Nostrils small, not subdivided into distinct apertures by firm tissue, located just anterior to mouth, with nasoral grooves located in front of mouth; nasal curtain very short, with separate anterior nasal flaps connected by a septum. Mouth very small, somewhat thick, surrounded by moderately shallow circumoral groove; prominent labial folds present at mouth corners; mouth and jaws forming a short tube when protracted and open. Teeth small, in quincunx, medial teeth slightly larger than posteriors, with a short, slender pointed cusp on broad ovate crown base, shape similar in both jaws. Tooth counts 9 to 20 upper jaw, 9 to 22 lower jaw. Gill

openings small, slightly arched, third gill opening largest; no gill sieves or rakers on internal gill slits. Electric organs kidney-shaped, length about 2 to 3 times width, originating at pectoral-fin bases, ventrally visible through semi-transparent skin on outer pectoral fins adjacent to gill openings. Pelvic fins fleshy, not very thick, subangular; origins slightly anterior to pectoral-fin insertions; anterior margins slightly convex; apices narrowly rounded; posterior margins deeply grooved when fins spread; inner margin not distinct. Claspers of mature males elongate, extending two-thirds their length beyond posterior of pelvic fins, calcified, blunt at tip. Dorsal fins small, anterior margins and bases fleshy, similar in shape (less so in females), second dorsal fin slightly larger in size; interdorsal space about equal to dorsal-fin base length. Caudal fin elongate and low, paddle-shaped; origins of upper and lower lobes poorly defined; axis slightly raised above body axis. Vertebral counts: total vertebral counts 110 to 128, monospondylous vertebral counts 13 to 20, precaudal vertebral counts 48 to 73, caudal fin vertebral counts 31 to 46. Spiral valve turn counts: 2 for one species, but unknown for others. Maximum total length is 49 cm for one species, but most species are less than 35 cm total length. **Colour:** in life dorsal surface uniformly dark brown to purplish black, and depending on the species some occasionally with lighter margins on dorsal, pelvic, and caudal fins; ventral surface uniformly creamy white to pinkish brown or dark brown. After preservation colour fades with noticeable lighter and darker patches or streaks on both dorsal and ventral surfaces.

Local Names: Blindrays.

Remarks: This genus of relatively small electric rays has four described species, all of which are deepwater and geographically restricted at distant localities; one species in the western North Atlantic (*Benthobatis marcida*), another in the western South Atlantic (*B. krefftii*), a species in the western North Pacific (*B. yangi*), and a fourth from the Arabian Sea in the western Indian Ocean (*B. moresbyi*). Given the endemic nature of the four known species it would not be surprising that additional species may eventually be recognized.

***Benthobatis moresbyi* Alcock, 1898**

Benthobatis moresbyi Alcock, 1898, *Ann. Mag. Nat. Hist. Ser. 7*, 2(8): 145 (original description, not illustrated); Lectotype: BMNH 1898.7.13.22 [ex ZSI F233/1], designated by Carvalho, 1999a: 237, 351 mm total length, adult male, Laccadive Sea, off Travancore coast, southwestern Indian Ocean, 07° 17.30'N, 76° 54.30'E, collected by RIMS "Investigator" station 232, 19 October 1897, depth 430 fathoms [787 m].

Synonyms: None.

Other Combinations: None.

FAO Name: En – Moresby's blind electric ray.

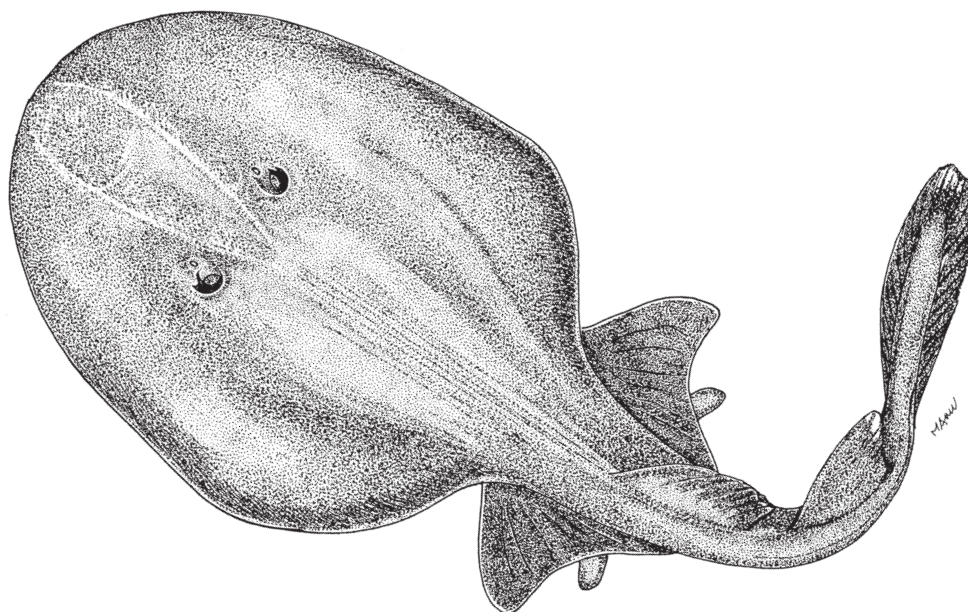


Fig. 14 *Benthobatis moresbyi*

Field Marks: A small electric ray, with eyes concealed by integument and not visible externally, two small dorsal fins, with fleshy anterior portions and bases, and a very elongated, low caudal fin. Colour is a uniform dark brown to purplish dorsally and ventrally, with scattered small white pores.

Diagnostic Features: Disc very soft, elongate and oval, its length 42 to 44% of total length; disc width about two-thirds its length. Body entirely naked, without dermal denticles or thorns above and below; skin loosely attached. Electric organs kidney-shaped, length about 2 to 3 times width, originating at pectoral-fin bases. Precaudal tail rounded anteriorly at pelvic fins level, narrowing posteriorly to compressed caudal fin section; low lateral ridge-like folds weakly present; no electric organs in tail. Head narrow and depressed; snout elongated, rounded, usually more than one-third disc length. Eyes minute, not developed, orbits entirely covered with integument and not visible externally; eye positions marked by small pores just anterior to spiracles. Spiracles small, oval-shaped, wider than long; small pseudobranchial folds present on anterior wall of inner spiracles. Nostrils small, circular, just anterior to mouth corners, with nasoral grooves located in front of mouth; nasal curtain much wider than mouth, extending posteriorly almost to mouth, without pores posterior to nostrils. Mouth very small, somewhat thick, surrounded by moderately shallow circumoral groove; labial folds present at mouth corners; mouth and jaws forming short tube when protracted and open. Teeth small, in quincunx, with a short, slender pointed cusp on broad ovate crown base, shape similar in both jaws. Tooth counts 18 upper jaw, 14 to 19 lower jaw. Gill openings small, slightly arched, first gills located closer to ventral mid-disc length, last gills located at one-fourth posterior disc; space between first gill openings greater than between fifth gill openings; distance between first and fifth gill openings about one-fifth disc length. Pelvic fins fleshy, not very thick, subangular; origins slightly anterior to pectoral-fin insertions; anterior margins slightly convex; apices narrowly rounded; posterior margins deeply grooved when fins spread; inner margin not distinct. Claspers of mature males elongate, extending beyond posterior of pelvic-fin free rear tips, calcified, blunt at tip. Dorsal fins small, anterior margins and bases fleshy, similar in shape and size, about equal in height, but second dorsal fin with longer base. Caudal fin elongate and low, paddle-shaped, origins of upper and lower lobes poorly defined; axis not raised above body axis. Vertebral counts: total vertebral counts 113 to 115, monospondylous vertebral count 19, precaudal vertebral counts 56 to 60, caudal-fin vertebral counts 36 to 38. Spiral valve turn counts not available. Maximum total length to at least 39 cm for adults. **Colour:** dorsal and ventral surfaces after preservation uniformly dark brown with patches of darker brown on both surfaces of disc. In life purplish-brown or purplish-blackish with scattered small white pores; second dorsal-fin tips and caudal fin whitish on some specimens.

Distribution: Western Indian Ocean: southwestern India, Yemen, and Somalia.

Habitat: A little known electric ray from the upper continental slopes from about 787 to 1071 m deep. One specimen was collected on a bottom substrate of green sandy mud and at a bottom temperature of about 8.6 °C (Carvalho, 1999a).

Biology: Nothing known.

Size: Maximum length about 35 cm for an adult male; females to 39 cm, possibly the adult size. Size at birth unknown, but the smallest free-swimming individual measured about 12 cm total length.

Interest to Fisheries and Human Impact: Of no value, this little electric ray may be taken on occasion, as bycatch in deep-sea fisheries, but little is known about it.

The conservation status of this little known electric ray is Data Deficient.

Local Names: Dark blindray.

Remarks: The description of this poorly known blind electric ray is modified after Alcock (1898) and Carvalho (1999a).

Literature: Alcock (1898); Carvalho (1999a, b); Carvalho, Compagno and Last (1999); Carvalho, Compagno and Ebert (2003); Carvalho and McCord (2009); D.A. Ebert (pers. obs.).

Heteronarce Regan, 1921

Genus: *Heteronarce* Regan, 1921, *Ann. Mag. Nat. Hist.*, ser. 9, 7(41): 414.

Type Species: *Heteronarce garmani* Regan, 1921, by subsequent designation of Fowler, 1941, *Bull. U.S. Natn. Mus.* (100)

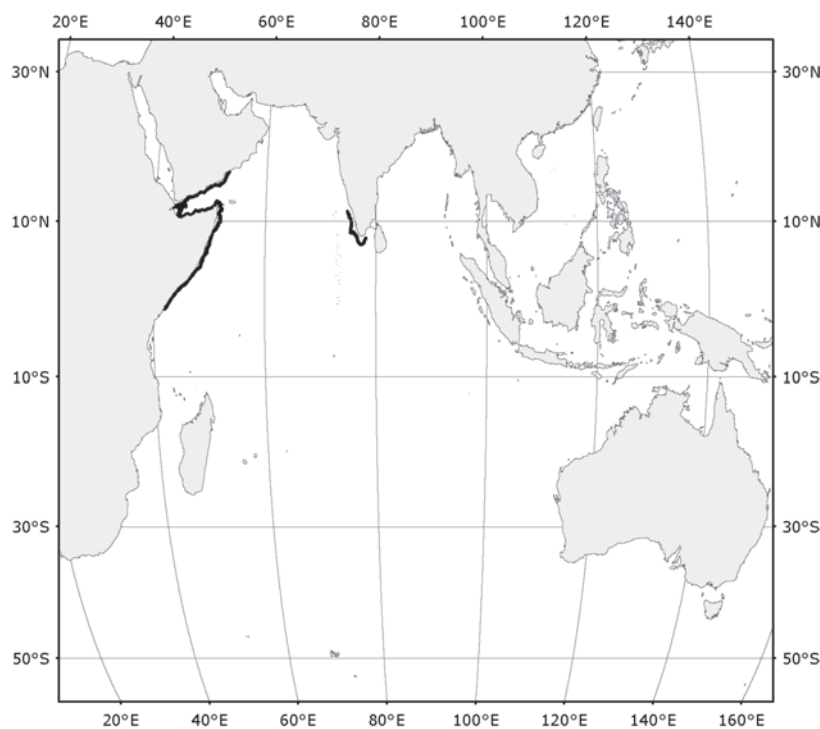


Fig. 15 *Benthobatis moresbyi*

Known distribution

13: 337. Regan had assigned two species, his *H. garmani* and *Narcine mollis* Lloyd, 1907 to *Heteronarce*, without type designation, so that *Heteronarce* was not monotypic as suggested by Fowler, 1941, *ibid*.

Number of Recognized Deep-sea Indian Ocean Species: 2.

Synonyms: None.

Field Marks: A small group of narkids (Subfamily Narkinae) easily distinguished from other members of this group by the combination of two dorsal fins and spiracles without papillae. Coloration is usually a uniform light to dark brown or greyish, with a few large darker blotches on dorsal surface of disc, first dorsal and caudal fins, or without markings; ventral surface may be whitish, grey or grey-brown.

Diagnostic Features: Disc soft, subcircular, slightly longer than wide; head relatively small, anterior margin oval to broadly rounded; snout relatively short. Eyes relatively small, externally visible, and contiguous with spiracles. Spiracles circular, margins with low ridge-like rim, without papillae. Nostril incurrent apertures slit-like, elongated; inter-nasal flap usually without pores, with median groove; posterior edge of flap nearly straight. Mouth small, not forming tube when projected; lower labial lip folds and grooves relatively short. Tooth count 20 to 24 for upper and lower jaws. Claspers of adult males extend slightly beyond pelvic-fin rear tips. Two dorsal fins, usually subequal; first dorsal-fin origin over pelvic-fin rear tips, posterior to pelvic-fin insertions; second dorsal fin usually more rounded at apex than first. Lateral skin folds on tail only moderately broad. Vertebral counts: total vertebral counts 81 to 108, monospondylous vertebral counts 19 to 26, precaudal vertebral counts 71 to 86, caudal-fin vertebral counts 21 to 29. Spiral valve turn counts 8 to 9 for one species, but unknown for others. Maximum total length is 25 cm. **Colour:** dorsal surface uniform pale to dark brown or greyish, brownish or reddish, sometimes with darker blotches, undefined markings or more defined spots; ventral surface usually white, creamy, greyish, or grey-brown.

Local Names: None.

Remarks: Compagno and Heemstra (2007) provide a detailed discussion and overview on the validity of this genus, which they considered to be separable from other narkid (Narkinae) genera. The genus is comprised of three species, all of these occur in the Indian Ocean, but only two of these species are considered to be deep-sea. The Elat electric ray (*Heteronarce bentuviai*) is a relatively shallower occurring species found mostly on continental shelves from about 80 to 200 m deep. The Quilon electric ray (*H. prabhui*) described by Talwar (1981) is not a valid species, but most likely a junior synonymy of the soft electric ray, *H. mollis* (M.R. de Carvalho, pers. comm.).

Key to Deep-sea Indian Ocean Species:

1a. Eye and spiracle diameters similar in size, with spiracles relatively small (interspiracular distance about 3 times spiracle length or width); ventral body surface colour mostly creamy white (Fig. 16) *Heteronarce garmani*

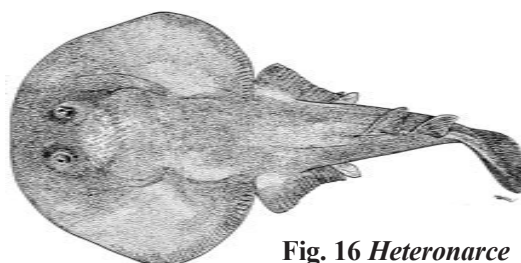


Fig. 16 *Heteronarce garmani*

1b. Eye diameter less than spiracle diameter, with spiracles relatively large (interspiracular distance about 2 times spiracle length or width); ventral body surface colour greyish (Fig. 17) *Heteronarce mollis*

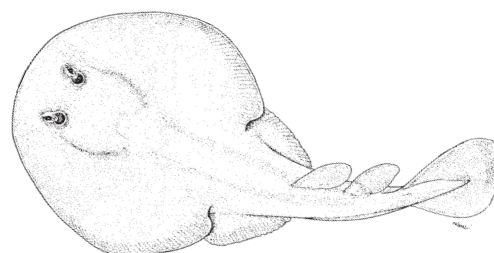


Fig. 17 *Heteronarce mollis*

***Heteronarce garmani* Regan, 1921**

Heteronarce garmani Regan, 1921, *Ann. Mag. Nat. Hist., ser. 9*, 7(41): 414. Holotype: British Museum (Natural History), BMNH 1921.3.1.3, 169 mm total length, adult male, 24–34 km off Umvoti River, Natal, South Africa, 226–238 m.

Synonyms: *Heteronarce regani* von Bonde and Swart, 1923, *Rep. Fish. Mar. Biol. Surv. Union S. Africa*, 3(Spec. Rept. 5): 14, pl. 22, fig. 2. Holotype: 190 mm total length, female specimen (tail damaged), apparently lost, RV *Pickle* sta. 17, 29°49'15"S, 31°18'10"E, southern Natal, 329 m. *Narcine natalensis* Fowler, 1925, *Ann. Natal Mus.* 5(2): 198, fig. 2. Holotype: Academy of Natural Sciences, Philadelphia, ANSP-35010, 260 mm, adult male, East London, South Africa, 73 m.

Other Combinations: None.

FAO Name: En – Natal electric ray.

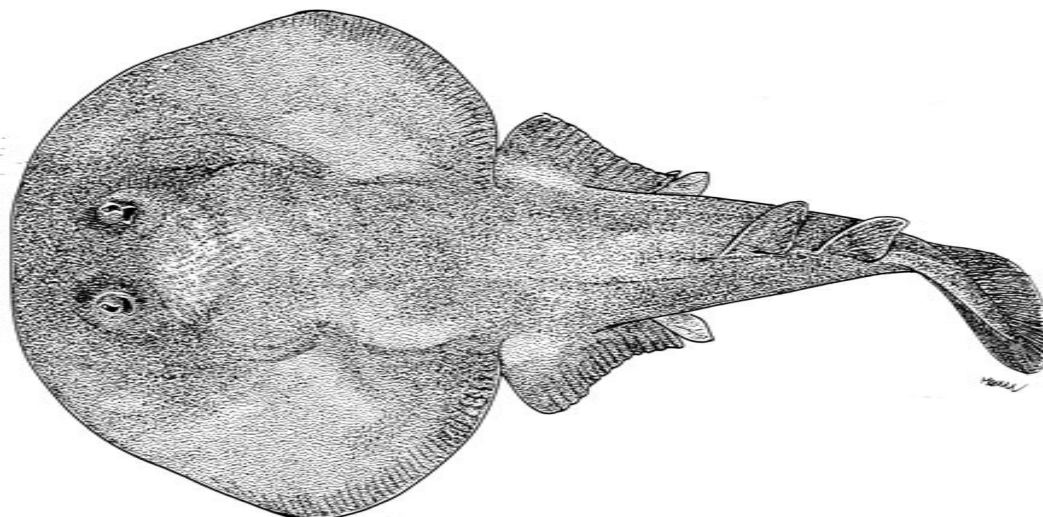


Fig. 18 *Heteronarce garmani*

Field Marks: A small southern African electric ray with an elongated, narrow disc, two dorsal fins, and a small narrow caudal fin. Colour is a plain brown above, white below.

Diagnostic Features: Disc subcircular, slightly longer (1.1 times) than wide. Snout to pre-orbit length more than two times inter-spiracular distance. Eyes and spiracles relatively small, about equal in diameter, and contiguous; spiracles with slender elevated rims and lacking papillae on margins. Nasal curtain about two-thirds as long as wide; internasal width about one-third length of preoral snout length. Mouth very small, slightly undulated, its corners overlapped by nasal curtain. Teeth small, rounded oval, with keels or a single low blunt, broad cusp; concealed when mouth closed. Tooth counts: upper jaw 11, lower jaw 10 to 11. Two dorsal fins, origin of first slightly posterior to base of pelvic fins; second dorsal fin slightly larger than first. Vertebral counts: total vertebral counts 106 to 115, trunk vertebral counts, precaudal vertebral counts 82 to 86, caudal fin vertebral counts 21 to 29. Spiral valve count 8. A small electric ray with a maximum total length of about 29 cm. **Colour:** Dark to pale brown above, sometimes with small darker indistinct markings; creamy white below, with disc margin sometimes brown posteriorly.

Distribution: Southwestern Indian Ocean: from Algoa Bay to KwaZulu–Natal, South Africa, and off southern Mozambique.

Habitat: Continental and upper slope waters from 73 to 329 m deep, it is found in submarine canyons off Sodwana Bay, KwaZulu–Natal.

Biology: Virtually nothing known about its biology.

Size: Maximum total length at least 29 cm; males adult by at least 17 cm in length, female size at maturity uncertain. Size at birth is unknown.

Interest to Fisheries and Human Impact: None, although believed to be taken as bycatch in bottom trawl fisheries, especially for shrimps which use small mesh nets, but it is likely discarded at sea. There is no available information on possible impacts to the population of this electric ray.

The conservation status is Vulnerable due to concerns over the impact intensive bottom trawl fisheries may be having on this species.

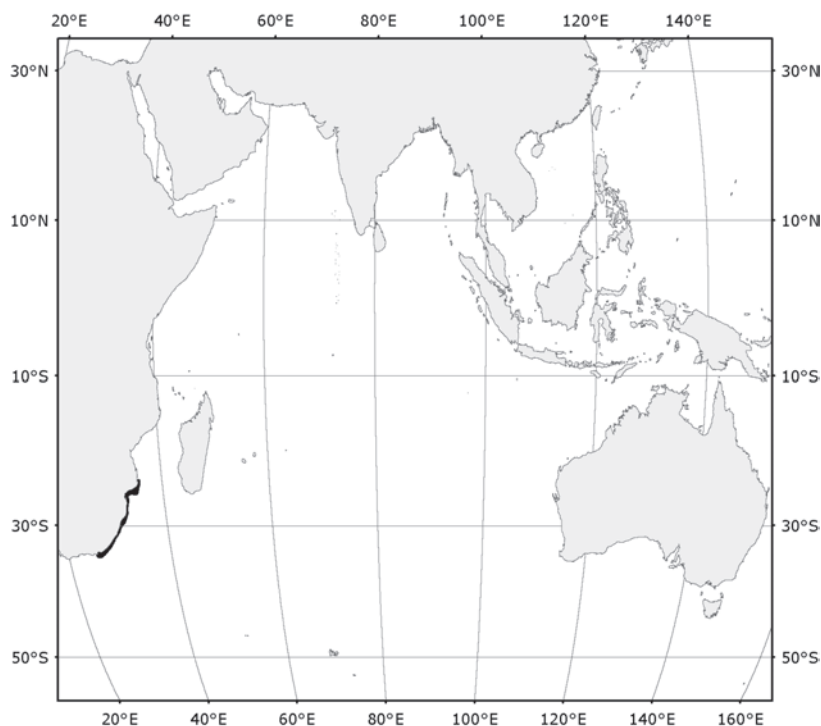


Fig. 19 *Heteronarce garmani*

■ Known distribution

Local Names: Electric ray, Natal electric ray, Drilvis (South Africa).

Literature: Wallace (1967a); Compagno, Ebert and Smale (1989); Heemstra *et al.* (2006); Compagno and Heemstra (2007); Carvalho and McCord (2009); Carvalho (2013).

***Narcine* Henle, 1834**

Genus: *Narcine* Henle, 1834, Ueber *Narcine*, 2: 31.

Type species: *Torpedo brasiliensis* Olfers, 1831, by subsequent restriction of Bonaparte, 1838, *Ann. Soc. Nat. Bologna*, 2: 205.

Number of Recognized Deep-sea Indian Ocean Species: 2.

Synonyms: Genus *Syraxius* Jourdan, in Bonaparte, 1835, 1841, *Fauna Ital. Pesc.*, 3(2), fasc. 13, 1835, Type: *Raja indica* Henle, 1834, 'monotypic' (Fowler, 1941). Genus *Cyclonarce* Gill, 1862, *Ann. Lyceum Nat. Hist. New York*, 7(32): 387. Type: *Narcine timlei* Henle, 1834 by monotypy, equals *Raja timlei* Bloch and Schneider, 1801. Genus *Gonionarce* Gill, 1862, *Ann. Lyceum Nat. Hist. New York*, 7(32): 387. Type: *Narcine indica* Henle, 1834, by monotypy. Genus *Narcina* Jordan and Seale, 1905, *Proc. Davenport Acad. Sci.*, 10: pl. 1. (apparent error for *Narcine*). Genus *Narcinops* Whitley, 1940, *Fish. Aust.* (1): 164. Type species: *Narcine tasmaniensis* Richardson, 1841, by original designation.

Field Marks: Small to medium sized electric rays with well-developed, functional, very visible eyes located anterior to spiracles, not embedded in integument and two equal-sized dorsal fins. Colour may be a uniform brown, reddish brown, or whitish, either plain or with a striking pattern of spots, blotches, or bands; ventral surface mostly white.

Diagnostic Features: Disc oval to shovel-shaped, length greater than width, widest just anterior to pectoral-fin insertions. Skin texture soft, smooth, without any denticles or thorns. Snout rounded to broadly angular; preoral length about one-fourth disc length. Eyes large relative to spiracles, diameter similar to or larger than spiracles; eye spiracle distance minute. Spiracles nearly circular in shape, rims not strongly elevated, usually thick; papillae absent around spiracle. Nostrils small, circular; nasal curtain width greater than length and distance between nostrils. Mouth protrusible, width greater than distance between nostrils. Teeth set in quincunx, cusps not very pronounced. Tooth counts upper jaw 8 to 27, lower jaw 5 to 30. Gill openings small, first to fifth in relatively straight line. Electric organs dorsally extend from anterior of eyes to rear of disc. Pelvic fins width twice as long as length; origins underneath disc. Tail stout at base, tapering slightly from base to second dorsal fin and from second dorsal fin to caudal-fin origin; length much greater than disc length or width; lateral tail folds weakly developed. Dorsal fins similar in size and shape, first dorsal-fin origin slightly posterior to free-rear tips of pelvic fins; distance of interdorsal space and second dorsal caudal space similar. Caudal fin fan-shaped, moderately long and broadly rounded. Vertebral counts: total vertebral counts 100 to 125, trunk vertebral counts 15 to 31, precaudal vertebral counts 58 to 77, caudal fin vertebral counts 20 to 32. Spiral valve turn counts not available. Maximum total length about 50 cm. **Colour:** dorsal surface background uniform light or dark brown, purplish-brown, or reddish, and depending on the species may have light to white spots or ocelli, sometimes darker spots; spots may be medium to relatively large; ventral surface mostly white to creamy, larger specimens may have disc edges lined darker.

Local Names: Small electric rays, Electric rays, Torpedo rays, Crampfishes.

Remarks: The arrangement of the genus *Narcine* follows Carvalho (1999b, 2001, 2008), Carvalho, Compagno and Last (1999), Carvalho, Séret and Compagno (2002) and Carvalho, Stehmann and Manilo (2002).

Key to Deep-sea Indian Ocean Species:

1a. Snout relatively short, length less than five times length of relatively large eye; colour uniformly dark brown above (Fig. 20)
..... *Narcine tasmaniensis*

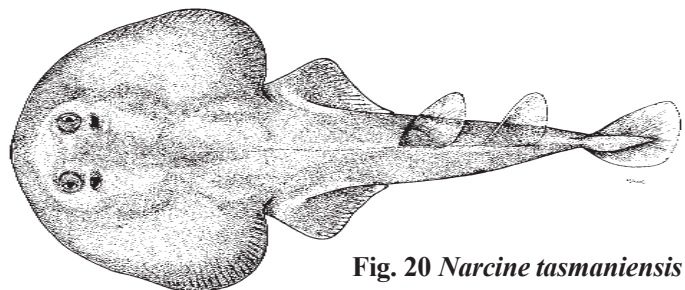


Fig. 20 *Narcine tasmaniensis*

1b. Snout relatively long, length more than five times length of relatively small eye; colour uniformly pale yellow above (Fig. 21)
..... *Narcine lasti*

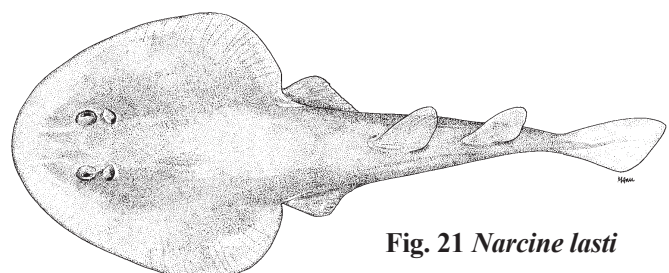


Fig. 21 *Narcine lasti*

Narcine lasti Carvalho and Séret, 2002

Narcine lasti Carvalho and Séret, 2002, *Rec. Aus. Mus.*, 20: 393, figs. 1–7, tabs. 1–2. Holotype: CSIRO H 1036–03, 325 mm total length, adult female, north of Cape Lambert, Western Australia, 19° 06'S, 117° 08'E, 178–183 m, FRV *Soela*, S07–87–129, 12 October 1987.

Synonyms: *Narcine* sp. 1, Gloerfelt–Tarp and Kailola, 1984: 36. *Narcine* sp., Sainsbury, Kailola & Leyland, 1985: 44, 330. *Narcine* sp. B, Last and Stevens, 1994: 376, pl. 66, fig. 39.2; Carvalho, Compagno and Last, 1999: 1441. *Narcine* sp. nov. B, Carvalho, 1999b: 219, figs. 77–81.

Other Combinations: None.

FAO Name: En – Western numbfish.

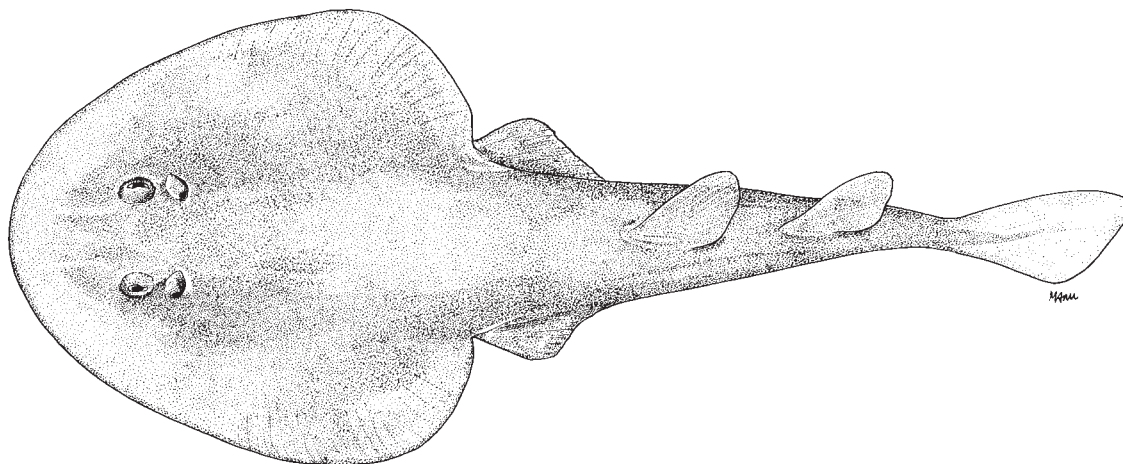


Fig. 22 *Narcine lasti*

Field Marks: A small electric ray only known from northwestern Australia, easily distinguished by its shovel-shaped disc, two dorsal fins, relatively small eyes similar in diameter to spiracles, long tail that is greater in length than disc length or width. The dorsal and ventral coloration is a uniform pale yellow to light brownish without any spots or other distinctive markings.

Diagnostic Features: Disc shovel-shaped, length greater than width, 38.2 to 48.6% total length, disc widest just anterior to pectoral-fin insertions, width 34.1 to 45.2% total length; tail length greater than disc length or width. Electric organs extend dorsally from anterior of eyes to rear of disc, length from 16.7 to 24.0% total length, width 5.0 to 9.4% total length. Skin texture soft, smooth, without any denticles or thorns. Eyes relatively small, length greater than width, similar in diameter to spiracles. Spiracles almost circular in shape, rims not strongly elevated; no papillae around spiracle; pseudobranchial folds present inside anterior spiracle wall; distance from eye to spiracle minute. Nasal curtain width greater than length and distance between nostrils. Mouth slightly wider than distance between nostrils. Teeth set in quincunx, bases diamond-shaped and wider than long; cusps relatively long on inner rows, but more exposed teeth have worn cusps. Tooth counts: upper jaw 8 to 19, lower jaw 15 to 20. Gill openings small, semi-circular, first to fifth in relatively straight line. Pelvic fins width about twice as long as length; origins underneath disc. Tail relatively straight, tapering very little from base to second dorsal fin, but slightly more so from second dorsal fin to caudal-fin origin; lateral tail folds weakly developed, not very discernible. Dorsal fins similar in size and shape, first dorsal-fin origin slightly posterior to free-rear tips of pelvic fins; distance of interdorsal space slightly less than space between second dorsal fin and origin caudal fin. Caudal fin axis low, moderately long, 13 to 14% total length with relatively straight posterior margin. Vertebral counts: total vertebral counts 112 to 119, trunk vertebral counts 16 to 17, precaudal vertebral counts 71 to 76, caudal fin vertebral counts 25 to 31. Spiral valve turn counts not available. Maximum total length 37 cm. **Colour:** a uniform pale yellowish to light tan usually with a white edged disc margin; ventral surface also a uniform pale white to cream, without any distinctive markings.

Distribution: Eastern Indian Ocean: northwestern Australia, from Melville Island (Northern Territory) to Lancelin (Western Australia).

Habitat: Outer continental shelf and upper slope from 170 to 350 m deep.

Biology: Viviparous, with litters of at least two, but little else known about its biology.

Size: Maximum total length 37 cm; males and females mature at about 25 cm total length. Size at birth is about 8 cm.

Interest to Fisheries and Human Impact: Of no interest, although this species may be taken as bycatch on occasion; current bottom trawl fisheries practices are minimal throughout its current known range.

The conservation status of this species is Least Concern.

Local Names: None.

Remarks: The above description is modified from Carvalho and Séret (2002).

Literature: Last and Stevens (1994, 2009); Carvalho (1999b); Carvalho, Compagno and Last (1999); Carvalho and Séret (2002); Carvalho, McCord and Stevens (2009).

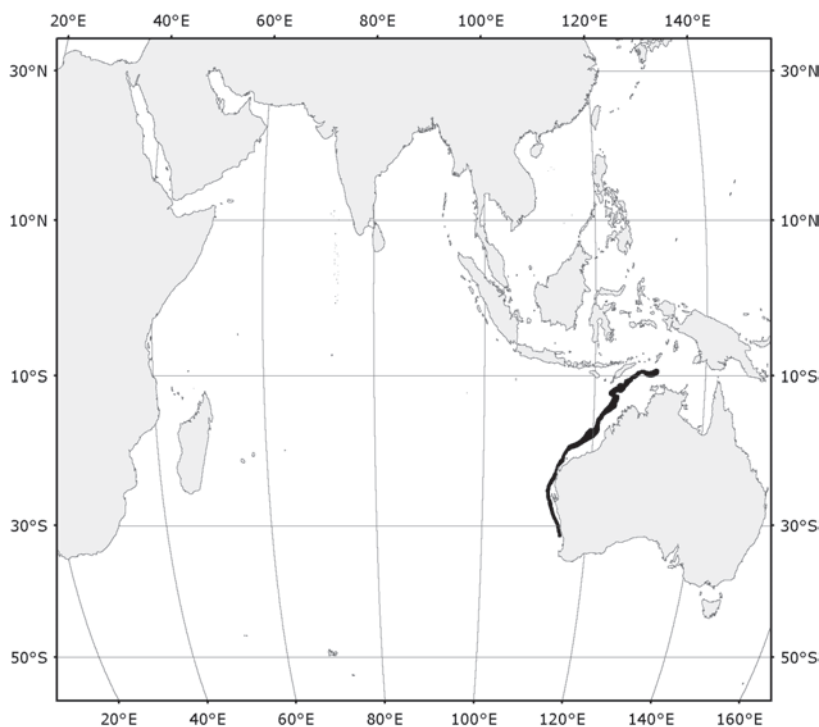


Fig. 23 *Narcine lasti*

Known distribution

2.1.2 Family TORPEDINIDAE

Family: Subfamily Torpedinini Bonaparte, 1838, *Nuov. Ann. Sci. Nat., Bologna, ser. 1, 2*: 130 (Family Rajidae). Also as Family Torpedinoidea Gill, 1862, *Ann. Lyceum Nat. Hist. New York*, 7(32): 386.

Type Genus: *Torpedo* Duméril, 1806, *Zoologie analytique, ou méthode naturelle de classification des animaux*. Paris, 102, 343.

Number of Recognized Deep-sea Indian Ocean Genera: 1.

Synonyms: Family Narcaciontoidea Gill, 1862, *Ann. Lyceum Nat. Hist. New York*, 7(32): 386, also Subfamily Narcaciontinae Gill, 1862, *ibid.*, 387. Type genus: *Narcacion* Gill, 1862, a revival of *Narcacion* Klein, 1776, 1777. Family Narcobatidae Gill, 1895, *Proc. U. S. Nat. Mus.* 18(1050): 163. Type genus: Subgenus *Narcobatus* Blainville, 1816 (Genus *Raia* Scopoli, 1777). Also as subfamily Narcobatinae Gill, 1895, *ibid.*, 164. Subfamily Torpedinae Fowler, 1934, *Proc. Acad. Nat. Sci. Philadelphia*, 85: 240 (Family Torpedinidae). Erroneous spelling.

FAO Names: **En** – Electric rays; **Fr** – Torpilles, raies électriq.; **Sp** – Tremielgas, torpedos.

Field Marks: Mouth broadly arched, distensible, without labial cartilages and folds at corners of mouth, two subequal sized dorsal fins, with the first much larger than the second. Colour of dorsal surface uniformly plain, sometimes with small spots or variegated with blotches or marbling, sometimes with eyespots on pectoral fins; ventral surface of most species creamy to white.

Diagnostic Features: Small to moderately large (maximum total length to about 180 cm, but most species less than 100 cm in length), heavy-bodied batoids with short stout shark-like tails; body depressed and dorso-ventrally flattened, typically soft and flabby, and entirely naked above and below, without dermal denticles or thorns (except in one eastern Central Atlantic species). Head, trunk and the broadly expanded pectoral fins forming a more or less circular disc. Anterior contour of disc conspicuously truncate or emarginate, snout extremely short. Two large powerful kidney-shaped electric organs at bases of pectoral fins, these visible through skin. Tail distinctly shorter than and marked off from body disc, with narrow dermal fold along either lower edge; tail abruptly narrower than trunk, no barbed sting (stinger or stinging spine) on dorsal surface of tail, and no electric organs in tail. Rostral cartilage absent or reduced. Eyes and spiracles small and close-set on top of head; posterior margins of spiracles either smooth, or set with knobs or tentacles. Nostrils transverse and relatively large, closer to mouth than to snout edge, their inner margins broadly expanded rearward and fused as a transverse nasal curtain, smooth free rear margin of which nearly overlaps upper jaw. Mouth broadly arched and broad, without prominent knobs and depressions and with labial furrows absent; strong grooves at distal ends of mouth but not around its periphery. Oral teeth small, with flat bases and a prominent cusp, not laterally expanded and plate-like, similar in shape and in 20 to 75 rows in upper and lower

jaws. Five small gill openings on underside of front half of pectoral-fin bases, not visible in lateral view; no gill sieves or rakers on internal gill slits. Pectoral fins large, very thick toward their margins, completely fused to sides of head, and expanded rearward to, or slightly beyond origin of the single-lobed pelvic fins. Pelvic fins low, broadly rounded and not divided into anterior and posterior lobes. Two relatively large dorsal fins, the first much larger than the second and close to it; rounded-angular in shape with apices, anterior, posterior and inner margins, and free rear tips more or less confluent, not falcate. First dorsal fin originates far behind anterior half of total length, origin over or just behind rear fourth of pelvic-fin bases and well anterior to midlength of tail. Caudal fin large, subtriangular, paddle-shaped, much larger than dorsal fins and about size of pelvic fins or larger, not shark-like, nearly symmetrical, with vertebral axis hardly raised above body axis; lower caudal-fin lobe absent. Spiral valve turn counts: 9 to 13. Adults between 20 and 180 cm total length. **Colour:** variably plain or variegated above, from greyish or brownish to black, dark and light spots, blotches or marbling, variably present or absent, sometimes with eyelike spots (ocelli); usually lighter below, often uniformly white or with a dark margin to the pectoral and pelvic fins.

Distribution: Circumglobal, occurring from high latitude seas to the tropics and in most oceans, except for polar seas.

Habitat: Electric rays inhabit tropical to temperate shelf waters from inshore to about 100 m depth, but some have been reported from as deep as 1100 m. A few species are semi-pelagic, while others such as the Pacific electric ray (*Tetronarce* [= *Torpedo*] *californica*) have been observed swimming offshore at about 10 m below the surface in waters over 3000 m deep. A few species (e.g. *T. nobiliana*) are highly migratory, with the adults swimming pelagically. Electric rays usually lie quietly on the bottom during the day, often buried on soft bottoms in sand or mud and will appear sluggish when swimming, but become quite active at night and will swim off the bottom in search of prey items.

Biology: All species are yolk-sac viviparous, but in addition adult females produce by villi and folds on their uterus walls a secretion commonly called "uterine milk", which the embryos take up, depending on their development stage, through their external gills, or through the ectoderm of the yolk-sac and its stalk.

Electric rays feed mainly on bottom living small to large fishes and invertebrates; their jaws and mouths are highly distensible to allow them to swallow very large prey. At least some species will deliberately shock potential fish victims with their powerful electric organs to stun them, and then use their flexible pectoral discs as manipulators to guide the prey into their mouths. The electric organs are also defensive, and can successfully protect these rays against predators such as sharks and octopuses.

Interest to Fisheries and Human Impact: Electric rays may locally be quite abundant in some areas, but there is no targeted fisheries for them or any use for human consumption; this is mainly due to the flabby consistency of their bodies and because a large part of the pectoral fins is occupied by the electric organs of gelatinous texture. In some areas, such as southern California (U.S.A.) these rays are taken in small numbers for biological and medical research.

Fishermen are wary of these rays because of their discharge of strong electric shocks, so discard them quickly. Although there are no confirmed fatalities from these rays, there are several suspicious, unexplained fatal scuba diving accidents that may have involved these rays; whereby divers possibly after being 'shocked' by these rays may have subsequently drowned. The conservation status of these electric rays is poorly known due to a lack of life history data and information on population trends.

Local names: Torpedo rays.

Remarks: The family consists of two subfamilies (Torpedininae and Hypninae), three genera, *Hypnos*, *Tetronarce*, and *Torpedo*, and about 25 nominal species. The genus *Torpedo* until recently consisted on two subgenera, *Tetronarce* and *Torpedo*, but Carvalho (2013) resurrected *Tetronarce* Gill, 1862 to full generic status. All three genera are primarily shelf dwelling species, but at least four *Tetronarce* species occur mainly on the upper slopes.

Literature: Compagno and Last (1999b); Carvalho, Stehmann, and Manilo (2002); Ebert (2003); Haas and Ebert (2006); Welter-Schultes and Feuerstein (2008); Carvalho (2013); L.J.V. Compagno (pers. comm.).

List of Deep-sea Species Occurring in the Area::



Tetronarce macneilli (Whitley, 1932)
Tetronarce tokionis Tanaka, 1908

***Tetronarce* Gill, 1862**

Genus: *Tetronarce* Gill, 1862, *Ann. Lyceum Nat. Hist. New York*, 7: 387.

Type species: *Torpedo occidentalis* Storer, 1843, by monotypy, a junior synonym of *Torpedo nobiliana* Bonaparte, 1835. According to Gill, 1895, *Proc. U. S. Nat. Mus.* 18(1050): 163, the spelling *Tetronarce* was a printer's error.

Number of Recognized Deep-sea Indian Ocean Species: 2.

Synonyms: Genus *Gymnotorpedo* Fritsch, 1886, *Arch. Anat. Phys. Leipsig*: 365. Genus *Tetronarcine* Tanaka, 1908,

Journ. Coll. Sci. Tokyo, 23: 2. Type species: *Tetronarcline tokionis* Tanaka, 1908, by monotypy according to Fowler, 1941. Genus *Notastrape* Whitley, 1932, *Rec. Australian Mus.*, 18(6): 327.

Field Marks: Similar to family account above, except that members of the genus *Tetronarce* are generally uniformly coloured of a dark to light black, grey, or dark purplish above (some species with small dark spots, and white below), and have smooth-edged spiracles without knobs or papillae.

Diagnostic Features: Disc subcircular, soft and flabby, and naked above and below, without dermal denticles or thorns; anterior disc margin conspicuously truncate or emarginate, snout extremely short; rostral cartilage absent or reduced. Tail short, stout, distinctly marked off from disc, with narrow dermal fold along either lower edge; abruptly tapering posteriorly from disc; electric organs absent in tail. Eyes relatively small, but fully developed. Spiracles small, moderately oblique, with smooth posterior margins, and no papillae; inner anterior margin with 8 to 14 pseudobranchial folds. Nostrils relatively large, oblique, closer to mouth than to snout edge; their inner margins broadly expanded rearward and fused as a transverse nasal curtain, smooth free rear margin of which nearly overlaps upper jaw. Mouth broadly arched and broad, without prominent knobs and depressions and with labial furrows absent; strong grooves at distal ends of mouth but not around its periphery. Teeth small, with flat bases and a prominent cusp, not laterally expanded and plate-like, similar in shape. Tooth counts 18 to 66 upper jaw, 19 to 61 lower jaw. Gill openings small, first and fifth slightly smaller than third and fourth openings. Electric organs kidney-shaped, length about one-half disc length, these visible through skin. Pelvic fins low, broadly rounded, not divided into anterior and posterior lobes. Dorsal fins relatively large, first much larger than second and close to it; rounded-angular in shape with apices, anterior, posterior and inner margins, and free rear tips more or less confluent, not falcate. Caudal fin large, subtriangular paddle-shaped, much larger than dorsal fins, similar in size to pelvic fins or slightly larger; lower caudal-fin lobe absent. Vertebral counts: total vertebral counts 95 to 97, monospondylous vertebral counts 25 to 33, precaudal vertebral counts 68 to 77, caudal fin vertebral counts 20 to 24. Spiral valve turn counts: 9 to 14. Adults up to 180 cm total length. **Colour:** dorsal surface variably plain, from purplish to grayish or brownish to black, some species with darker inconspicuous spots; usually lighter below, often uniformly white or with a dark margin along the pectoral and pelvic fins.

Local Names: Torpedo rays.

Remarks: This genus until recently has been considered a subgenus of *Torpedo*, but Carvalho (2013) recently resurrected *Tetronarce* to full generic status. Members of the genus *Tetronarce* can be distinguished from the genus *Torpedo* by their uniformly drab, often dark black, purplish-black to brown dorsal coloration, and smooth margined spiracles that lack knobs or papillae. *Torpedo* species by contrast are usually ornately coloured on their dorsal surface, and have knobs or papillae around their spiracle margins.

The genus *Tetronarce* has about 11 nominal species, but many are poorly described. Most species occur along continental shelves, but at least four species are considered deep-sea inhabitants of upper continental and insular slopes.

The conservation status of most members of this group is poorly known.

Key to Deep-sea Indian Ocean Species:

1a. Tail relatively short, distance from free rear tip of pelvic fins to caudal-fin lower lobe less than three-fourths caudal fin height and less than one-half width of pelvic-fin span (Fig. 24) *Tetronarce macneilli*

1b. Tail relatively long, distance from free rear tip of pelvic fins to caudal-fin lower lobe more than three-fourths caudal fin height and more than one-half width of pelvic-fin span (Fig. 25). *Tetronarce tokionis*

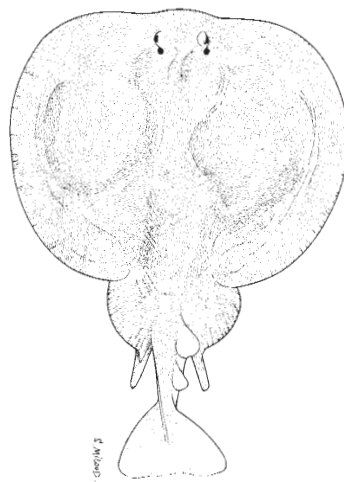


Fig. 24 *Tetronarce macneilli*

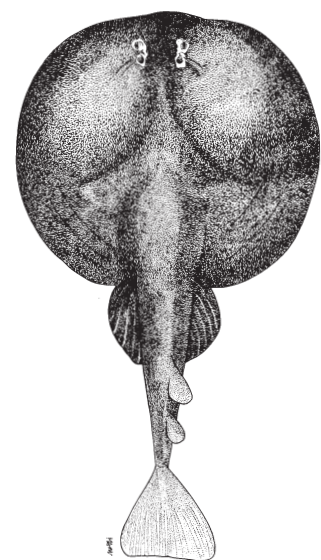


Fig. 25 *Tetronarce tokionis*

***Tetronarce tokionis* Tanaka, 1908**

Tetronarcine tokionis Tanaka, 1908, *Journal College Sci. Tokyo*, 23: 2, fig. Holotype: ZUMT 917 (lost), Tokyo fish market.

Synonyms: *Torpedo* sp. A: Last and Stevens 1994; Compagno and Last (1999b).

Other Combinations: None.

FAO Name: En – Trapezoid torpedo.

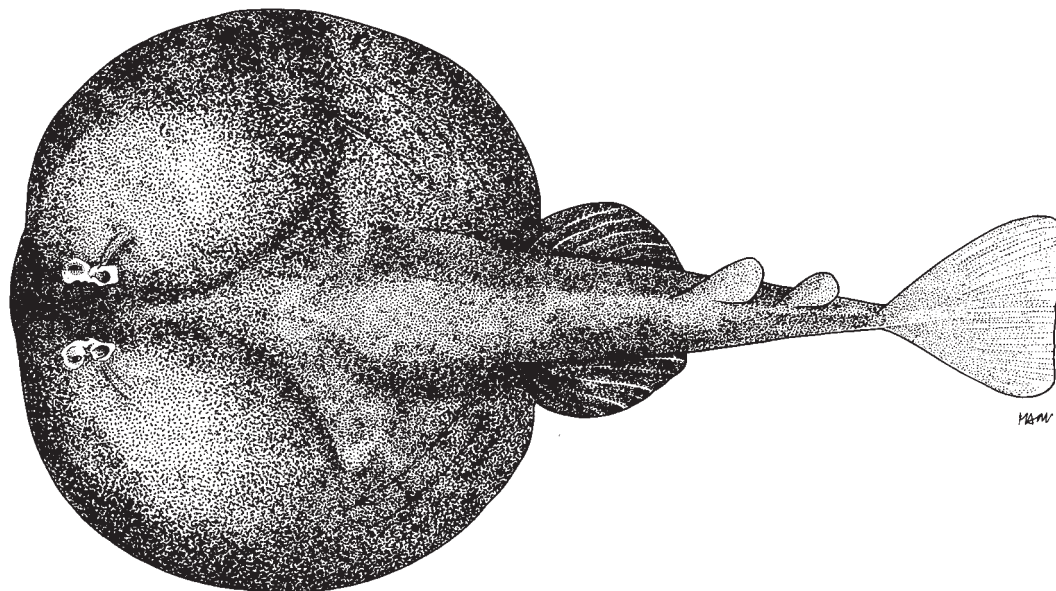


Fig. 26 *Tetronarce tokionis*

Field Marks: A moderate sized electric ray, with a nearly circular disc, width slightly greater than length, a relatively long tail, a first dorsal fin originating anterior to pelvic-fin insertion, and a large paddle-like caudal fin. Colour is a uniform blackish to grey or purplish black dorsally, without any spots or blotches; ventral surface white with darker margins on disc.

Diagnostic Features: Disc rather circular, width slightly greater than length, anterior disc margin truncated, and with very short snout. Eyes and spiracles nearly equal in size, both very small; spiracles without knobs or papillae; pseudobranchial folds 13 to 14. Nostrils relatively large, transverse, close-set to mouth; inner margins posteriorly expanded, forming a transverse nasal curtain that reaches about to upper jaw. Mouth broadly arched, with labial furrows absent; grooves at distal ends of mouth but not around its periphery. Teeth small, with a prominent cusp, no lateral cusplets, base not laterally expanded and plate-like, uppers and lowers similar in shape. Tooth counts 18 to 35 upper jaw, 23 to 32 lower jaw. Gills openings similar sized. Electric organs elliptical-shaped, extending from head anterior along base of pectoral fins about two-thirds length of pectoral-fin base, more visible on ventral surface than on dorsal surface. Tail distinctly marked off disc, relatively long, tapering posteriorly, with distinct lateral dermal ridge-like folds; precaudal tail length from pelvic free-rear tips to lower caudal-fin origin more than 0.7 times height of caudal fin and over one-half pelvic-fin span across fin apices. Dorsal fins subequal in size, first dorsal fin more than twice the size of second; first dorsal fin originating anterior to pelvic-fin insertion; second dorsal fin originates posterior to pelvic-fin free-rear tip. Caudal fin large, posterior margin nearly straight to slightly convex. Vertebral counts not available. Spiral valve turn counts: 9 to 10. Adults to about 114 cm total length. **Colour:** uniformly blackish to grey-black above, without any spots or blotches; ventral surface white except for prominent black margins on pectoral disc, pelvic fins, and caudal peduncle regions; claspers of adult males are black laterally and at tips.

Distribution: Eastern Indian Ocean: off Western Australia from Shark Bay to Rowley Shoals. Western Pacific Ocean: northern Japan to the East China Sea, Ryukyu Islands, Taiwan (Province of China), and tropical eastern Australia from Queensland to New South Wales.

Habitat: An uncommon electric ray that occurs mostly along outer continental slopes from about 200 to 1100 m deep, and is usually found over rocky, cobble, sand, or mud substrates.

Biology: Viviparous, but nothing else known about its biology.

Size: Maximum total length is 113.6 cm; males are adult at 67.5 cm, females at a larger size. Size at birth is about 20 cm in length.

Interest to Fisheries and Human

Impact: Of no interest, this species is usually discarded when taken as bycatch in fisheries. It may be used as fishmeal on occasion, but its flabby flesh and poor quality meat is not desirable for human consumption.

The conservation status of this uncommon and little known electric ray is Data Deficient.

Local Names: Yamato-shibire-ei (Japan).

Remarks: *Tetronarce tokionis* has a rather disjunct distribution, occurring in the western North Pacific around Japan and Taiwan (Province of China), and in northern Australian waters. It may be that the Australian form is a different species. Therefore, further morphological comparison together with molecular information will be required to determine whether this species is wider ranging than previously thought, or may represent different species.

Literature: Tanaka (1908); Nakaya and Shirai (1992); Last and Stevens (1994, 2009); Compagno and Last (1999b); Hatooka (2002); Nakabo (2002) Haas and Ebert (2006); Haas *et al.* (2009); D.A. Ebert (unpubl. data).

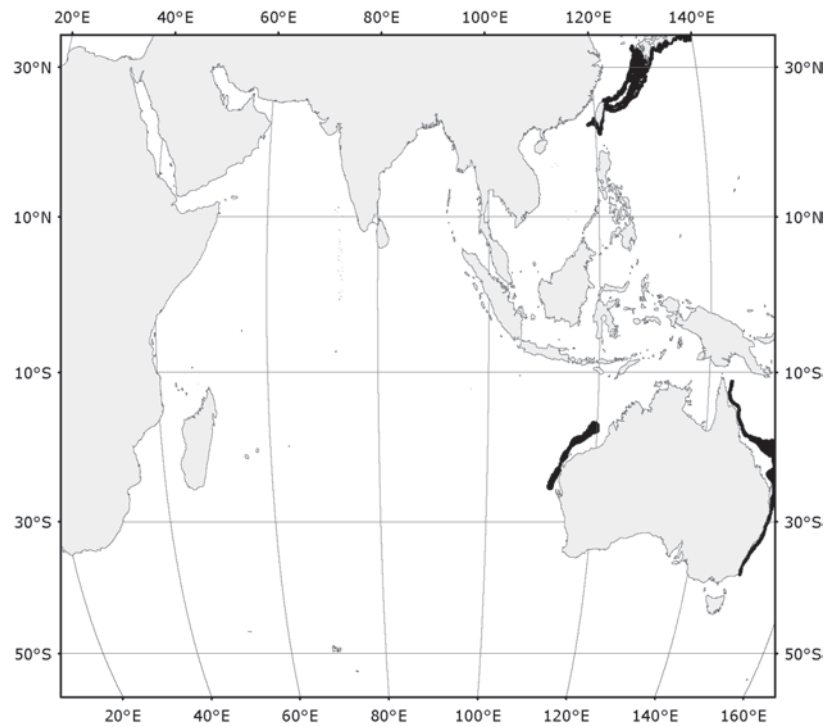


Fig. 27 *Tetronarce tokionis*

■ Known distribution

2.2 Order RAJIFORMES – Skates

Order: Rajae: Müller & Henle, 1841, *Syst. Besch. Plagiost.* [Part] 2, (3): 103 (group equivalent to order for batoids).

Number of Recognized Deep-sea Indian Ocean Families: 3.

Synonyms: Batoidei, Batoidea, Batoidimorpha (*partim*)

Field Marks: Guitarfishes (Rhinobatidae) have an elongated, shark-like appearance and size, but gill slits are on underside of head. They are entirely and densely covered with small placoid scales and have a long, massive tail section not distinct from the body with two large separated dorsal fins and a large, uni-lobed caudal fin. Skates (Rajidae and Arhynchobatidae) have a completely dorsoventrally flattened body and greatly extended pectoral fins forming a disc, a slender tail sharply distinct from the disc, small dorsal fins, a caudal fin rudimentary or absent and body and tail never completely covered by overlapping, very densely set placoid scales.

Diagnostic Features: Rhinobatidae: only head and body with pectoral and pelvic fins dorsoventrally flattened to form a rather narrow and short body disc. Snout wedge-shaped, with a broad, solid rostral cartilage to snout tip. Pelvic fins uni-lobed. Rajidae and Arhynchobatidae: shape of disc varying from almost circular to inverse heart-shaped and subrhombic, with snout ranging from very short and blunt to very elongated and pointed; snout either supported by a firm rostral cartilage extending to snout tip, or by forward extension of anterior pectoral radials and their basal skeletal elements almost to snout tip because of lacking, incomplete or very delicate rostral cartilage; tail from moderately slender in most species to very thin thread-like, usually not much longer than disc; two dorsal fins small, or absent; caudal fin rudimentary or absent; pelvic fins with two lobes in majority of species; most species with a distinct upper side pattern of conspicuous thorns set in small patches on certain areas of head, and in longitudinal rows along back of trunk and tail; thorns on disc reduced in some genera, mostly so in arhynchobatid genus *Bathyraja*; mature males with a patch of malar thorns on cheeks, and across wing tips with a field of sharp, claw-like alar thorns being either retractable in dermal pockets, or permanently erect; very low powered electric organs along entire, or only part of tail length, which derived from lateral caudal musculature. Sizes ranges from pygmy to more than 200 cm total length. **Colour:** dorsal surface varying from whitish to pale, to darker colours, from reddish, brown, grey, purplish to black, with either plain surface or with blotches, reticulations, spots, ocelli, and lighter to darker variations; ventral surface mostly lighter, but some species darker coloured or with blotches.

Distribution: Circumglobal in the Atlantic, Indian and Pacific Oceans, including Arctic and Antarctic waters (except for Rhinobatidae).

Habitat: Members of the family Rhinobatidae are mostly nearshore to outer continental shelf species, except for one deep-sea species found in the eastern Indian Ocean. The skates (families Arhynchobatidae and Rajidae) by contrast are mostly marine inhabitants, except for one uniquely endemic species found in estuarine waters, and are found in all oceans from tropical to polar latitudes and from shallow inshore waters down to the deep sea abyssal plains (to a depth over 4,000 m). The majority of species are demersal on subtropical to polar shelves and upper slopes, where they can be locally rather abundant; a few large species mainly in deep-water are also benthopelagic and may migrate over long distances.

Biology: The rhinobatids are viviparous with a yolk-sac, while all skate species are oviparous, with some species producing relatively large numbers of eggs that are encapsulated in rather large, rectangular horny capsules with a pair of slender horns at both ends. The females deposit these egg capsules individually on the sea floor, where the embryos develop over many months to possibly years, until they hatch from capsules. The life span of these batoids may range from about 10 years to nearly 40 years or possibly more. All species feed primarily on benthic invertebrates, but larger size species also feed on small fishes; some of the larger sized deep-water species are active hunters on larger benthopelagic fishes, including other chondrichthyans.

Interest to Fisheries and Human Impact: There is a long tradition in many Asian and European countries of fishing for skates for human consumption. Modern trawler fisheries have overfished skate stocks in many places; catch quotas have been introduced slowly only in some areas, often only quite recently, because intensive fishing has led to severe depletion of stocks due to the slow growth, late maturity and low reproductive rate of skates. The same holds true for guitarfishes with their more restricted shelf habitat in tropical and subtropical waters, where they are targeted these days for their large dorsal fins in addition to their flesh that is used for human consumption.

In the Indian Ocean deep-sea, skates are mostly taken as bycatch, but very little information is available on catch rates, while the mostly nearshore guitarfishes are targeted in many countries for their fins which are quite valuable. However, catch estimates are poorly known throughout most of the Indian Ocean. The only deep-sea guitarfish (*Acroteriobatus variegatus*) is known only from a very few specimens.

The conservation status of most guitarfishes is Near Threatened or higher, while many skates, especially the deep-sea species are Data Deficient.

Local Names: Skates, Rays, Guitarfishes, Softnose skates.

Remarks: The order Rajiformes is still largely unresolved with morphological and molecular data being strongly at odds regarding the relationship of the skates to other extant batoids (Aschliman, Claeson and McEachran, 2012; Aschliman *et al.*, 2012). Nelson (2006) combined four families of very different morphological appearance, Rhinidae, Rhynchobatidae, Rhinobatidae, Rajidae, into a single order, the Rajiformes, following McEachran and Konstantinou (1996), and McEachran and Aschliman (2004), who considered two rhinid genera *incertae sedis*. Compagno (2005) placed Rhinidae and Rhynchobatidae in two suborders under the Rajiformes. The order as currently restricted is composed of five families, more than 30 genera, and over 350 species. Three families occur in the Indian Ocean deep-sea.

Literature: McEachran and Konstantinou (1996); McEachran and Aschliman (2004); Compagno (2005); Nelson (2006); Aschliman, Claeson and McEachran (2012); Aschliman *et al.* (2012).

Key to Deep-sea Indian Ocean Families:

1a. Body rather shark-like, except gill slits on underside of head; tail long, its section massive, bearing two large, widely separated dorsal fins and a large caudal fin; pectoral fins dorsoventrally flattened, elongated to form a rather narrow body disc (Fig. 28) **family Rhinobatidae**

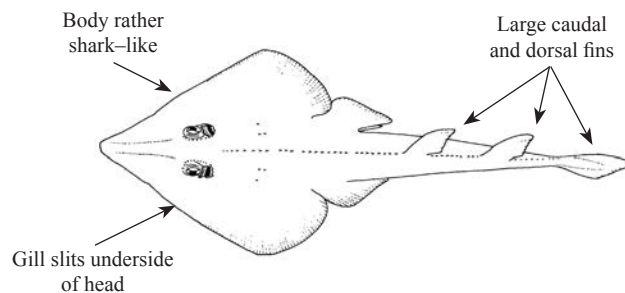


Fig. 28 Rhinobatidae

1b. Body greatly flattened dorsoventrally to form a large disc, not shark-like; tail rather slender, distinctly marked off from body disc and, if present, dorsal fin(s) and caudal fin very small to rudimentary; pectoral fins greatly flattened dorsoventrally, angular to rounded at apices to form a rhomboidal-shaped disc. **2**

2a. Flexible, delicate rostral cartilage extended to snout tip, or being incomplete to not reach rostral node in snout tip; anterior pectoral-fin radials and their basal elements extended forward to close to, or being in touch with snout tip (can be checked by touch or against translucent light) (Fig. 29) **family Arhynchobatidae**

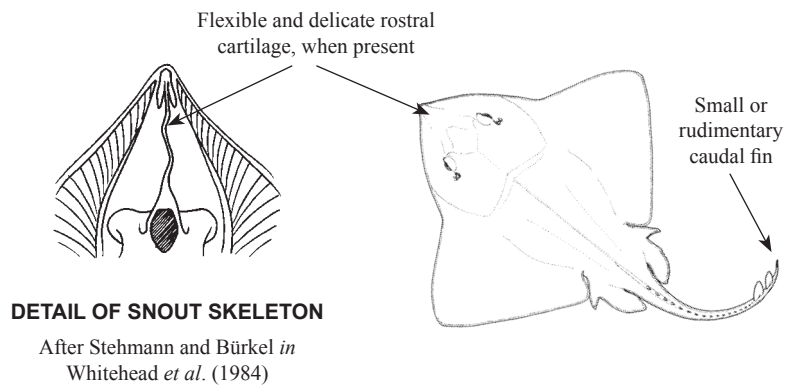


Fig. 29 Arhynchobatidae

2b. Stiff rostral cartilage extended to snout tip; anterior pectoral-fin radials and their basal elements (depending on the genus) approach, abut, or fall short of snout tip (can be checked by touch or against translucent light) (Fig. 30) **family Rajidae**

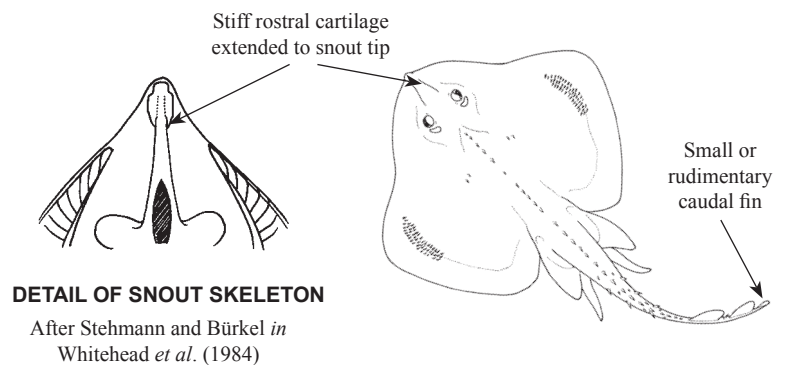


Fig. 30 Rajidae

2.2.1 **Family RHINOBATIDAE**

Family: Rhinobatidae Müller and Henle, 1837, *Ber. K. Preuss. Akad. Wiss. Berlin*, 2: 116. 1837, *Arch. Naturg.* 3: 399.

Type Genus: *Rhinobatos* Linck, 1790.

Number of Recognized Deep-sea Indian Ocean Genera: 1.

Synonyms: None.

FAO Names: **En** – Guitarfishes; **Fr** – Guitares; **Sp** – Guitarras.

Field Marks: Body rather shark-like, but gill slits on underside of head; long, massive tail not clearly marked off from body and bearing two large, separated dorsal fins and a large, uni-lobed caudal fin.

Diagnostic Features: Only head and body with pectoral and pelvic fins dorsoventrally flattened to form a rather narrow and short body disc. Snout wedge-shaped, with a broad, solid rostral cartilage to snout tip. Entire body and fins (like in sharks) densely covered with small placoid scales; dorsally, additional thornlets and thorns at orbits, between spiracles, on nape and shoulder and along midline of body and tail. **Colour:** above uniformly in shades of brown, with or without various light, dark or ocellar pattern components; underside usually white, but greyish fin margins and/or a dark blotch on snout tip may occur.

Distribution: Tropical to warm temperate latitudes of all oceans, but not reported from the numerous islands of the western Pacific.

Habitat: Guitarfishes are sluggish, bottom-living shark-like rays on sandy and muddy bottoms mostly on shelf waters from inshore to about 110 m depth, also entering estuaries and freshwater. However, one species (*Acroteriobatus variegatus*) is considered to be a deep-sea inhabitant.

Biology: Yolk-sac viviparous, with litters of about 4 to 15 young once or twice a year. Guitarfishes feed on small fishes and various kinds of bottom-living invertebrates. They swim slowly over the bottom in a shark-like mode by undulating their stout tails, but often rest buried in the substrate.

Interest to Fisheries and Human Impact: Guitarfishes were locally and regionally rather abundant but have become overfished in many places. Their flesh is said to be of mediocre quality but is used mostly dried salted for human consumption. In recent years, guitarfishes have been more intensively targeted in fisheries due to an increasing Asian markets demand for their large dorsal fins. As a consequence and due mostly to a lack of management and conservation measures, many stocks have become much depleted.

The conservation status of most guitarfishes is Near Threatened or higher due to increasing demand for their fins, which are highly valued in the international fin trade market.

Local names: None.

Remarks: Compagno (1999) introduced *Glaucostegus* as a subgenus of *Rhinobatos* without providing a rationale or specifying any diagnostic features. Furthermore, Compagno (2005) elevated *Glaucostegus* to generic rank, again without specifying any rationale or specifying any diagnostic features. Recently, Séret and de Carvalho (2013) formally elevated the subgenera *Acroteriobatus* and *Glaucostegus* to full generic status along with the genus *Rhinobatos*; these three genera can be separated by development of their nasal flaps head shape (Séret and de Carvalho, 2013). The family mostly inhabits shallow waters, but one species that occurs in the Indian Ocean is considered deep-sea.

Literature: McEachan and Capapé, *in*: Whitehead *et al.* (1984); Compagno (1999, 2005); Séret and de Carvalho (2013).

List of Deep-sea Species Occurring in the Area:

 *Acroteriobatus variegatus* (Nair and Lal Mohan, 1973)

***Acroteriobatus* Giltay, 1928**

Genus: *Acroteriobatus* (subgenus of *Rinobatos*) Giltay, 1928, *Ann. Soc. Roy. Zool. De Belgique*, 59: 26.

Type Species: *Rhinobatus (Syrhina) annulatus* Müller and Henle, 1841. Type by subsequent designation. Type apparently designated by Fowler, 1969, *Quarterly J. Taiwan Museum (Taipei)*, 22(3/4): 141, according to Eschmeyer (2012).

Number of Recognized Deep-sea Indian Ocean Species: 1.

Synonyms: None.

Field Marks: The genus *Acroteriobatus* can be distinguished from the other guitarfish genera by the dorsal and ventral-view outline of their snout, which is broadly acute anteriorly, widely spaced rostral cartilages with a weak constriction at mid-length, anterior nasal flaps well-developed, inner nostril margins extending well onto internasal space, with both nasal flaps almost joining at the midline of snout. Colour is plain dorsally with blotches and spots on some species.

Diagnostic Features: Disc wedge-shaped, tapering posteriorly, snout elongated, tip broadly pointed. Nostril flaps extending to excurrent aperture, nearly meeting at midline of internarial space. Mouth transverse; teeth close-set, short, with bluntly rounded cusps. Dorsal fins about equal in height, similar in shape. Size to at least 140 cm total length. **Colour:** dorsal surface plain or with blotches and spots depending on species; ventral surface mostly pale without markings except for pigmented snout tip in some species.

***Acroteriobatus variegatus* (Nair and Lal Mohan, 1973)**

Rhinobatos variegatus Nair and Lal Mohan, 1973, *Senckenbergiana Biologica*, 54(1/3): 77, fig. 4. Holotype (unique): FMRI F.176, 645 mm total length, female, Gulf of Mannar, off Mandapam, India, ca. 79° 55'E, 8° 51'N, 366 m.

Synonyms: None.

Other Combinations: None.

FAO Name: En – Stripenose guitarfish.

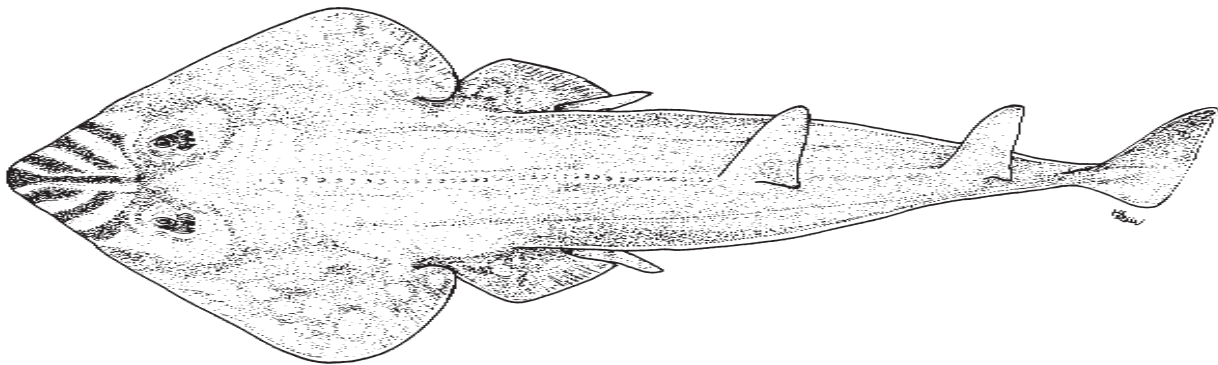


Fig. 31 *Acroteriobatus variegatus*

Field Marks: Shark-like in appearance, with long thick tail, two similar-sized, widely spaced dorsal fins and anterior nasal flap extending beyond posterior nasal margin and laterally beyond inner corner of nostrils. Coloration is grey dorsally, lighter ventrally; snout with one medial and three broad lateral brown bands on dorsal surface.

Diagnostic Features: Disc wedge-shaped anteriorly, snout elongated, tip subacutely pointed, anterior disc margin relatively straight, posterior disc margin broadly rounded, and slightly overlapping pelvic-fin origins. Rostral cartilage interspace narrow anteriorly, but widening posteriorly. Eye diameter 81% of interorbital space; interorbital space 25.3% of preorbital length. Spiracle length 25.8% of interspiracle width; interspiracle width 37.3% of preorbital length. Nostrils oblique, width about equal to the distance between inner margins; anterior margin with well developed inner nasal flap extending beyond posterior nostril margin and extends laterally to internarial space past inner corner of nostrils; outer nasal flap greatly reduced, posterior margins with two well developed flaps. Mouth nearly transverse, moderately large, its width 41.7% of preoral length; teeth close-set, rhombic, broad based with short bluntly rounded cusp; tooth count from a single specimen 64 upper jaw, 72 lower jaw. Dermal denticles close-set, with a short pedicel, tricuspidate with central cusp longer than laterals; tubercles along midline of back, numbering 36, and extending from nuchal region to first dorsal fin; texture relatively smooth. Dorsal fins about equal in height, subtriangular, similar in shape, first dorsal-fin base slightly shorter than second; first dorsal-fin origin behind pelvic-fin free rear tips by a distance slightly more than preoral length; inter-dorsal space about 2.7 times first dorsal-fin base. Vertebral and spiral valve counts not available. Size to at least 65 cm total length. **Colour:** dorsal surface a pale grey with three broad darker brown bands and one medial band on snout; pectoral and pelvic fins with blue variegated markings; ventral surface pale without marking except for pigmented snout tip.

Distribution: Eastern Indian Ocean: Gulf of Mannar, India.

Habitat: A deep-water guitarfish known from the upper continental slope to at least 366 m deep.

Biology: Nothing known, presumed to be viviparous with a yolk-sac like other members of this family.

Size: Maximum total length to at least 65 cm for a female, but nothing else known.

Interest to Fisheries and Human

Impact: Nothing known regarding possible fishing impacts on this guitarfish, although the Gulf of Mannar, where this species is only known to occur, was established as a marine reserve by the Indian government in 1989 and was the first such protected area in south and southeast Asia. However, the depth at which this species occurs may not be fully covered.

The conservation status of this rare guitarfish is Data Deficient.

Local Names: Variegated shovelnose guitarfish.

Remarks: Research on the distribution and life history of this species, and possible fisheries impacts, should be a priority to determine whether adequate management practices are in place for this species.

Literature: Nair and Lal Mohan (1973); McCormack (2009).



Fig. 32 *Acroteriobatus variegatus*

Known distribution

2.2.2 Family ARHYNCHOBATIDAE

Family: Subfamily Arhynchobatinae Fowler, 1934, *Proc. Acad. Nat. Sci. Philad.*, 85: 240.

Type Genus: *Arhynchobatis* Waite, 1909

Number of Recognized Deep-sea Indian Ocean Genera: 4.

Synonyms: Family Pseudorajidae Bigelow and Schroeder, 1954, *Breviora Mus. Comp. Zool. Harvard*, (24): 2. Type genus: *Pseudoraja* Bigelow and Schroeder, 1954. Tribe Pavorajini McEachran, 1984, *Copeia*, 1984(1): 55. Type genus: *Pavoraja* Whitley, 1939. Subfamily Arhynchobatidinae Steyskal, 1980, *Proc. Biol. Soc. Washington*, 93(1): 170, suggested emendation of Arhynchobatinae Fowler, 1934 according to the case of a basonym (batis) ending in -is for correct orthography.

FAO Name: En – Softnose skates.

Field Marks: Rostral cartilage flexible, delicate and extending to snout tip, or being incomplete not reaching rostral node in snout tip, or rostral cartilage basally segmented or separated from neurocranium, or limited to distal section of snout, anterior pectoral-fin radials and their basal elements extended forward to close to, or being in touch with snout tip. Snout characteristics can be checked by touch, or against strong light.

Diagnostic Features: Disc large, broad, and flat rhomboidal to heart-shaped, with a tail narrow and slender, slightly shorter to nearly twice as long as pectoral disc; dorsal disc either smooth or covered with small dermal denticles; more or less enlarged, sharp hooked denticles or thorns usually present on dorsal surface, on the midline of the tail and often on the midline of the disc, on the snout, orbits, and shoulders. Trunk depressed and flattened, not shark-like. Precaudal tail cylindrical or moderately depressed but not whip-like, with lateral ridges or folds on sides; tail abruptly narrower than trunk, no barbed sting (stinger or stinging spine) on dorsal surface of tail behind dorsal fins, electric organs present in tail. Head broad and depressed; snout short to long and bluntly to acutely angular or rounded-angular, supported by a more or less reduced, soft, slender rostral cartilage. Five small gill openings on underside of front half of pectoral-fin bases, not visible in lateral view. Eyes dorsolateral on head and just anterior to spiracles. Mouth transverse and straight to moderately arched, without prominent knobs and depressions. Nostrils just anterior to mouth and separated from it by less than half their own widths, connected by broad nasoral grooves with mouth; anterior nasal flaps elongated, posteriorly expanded and reaching mouth, but separate medially and not forming a nasal curtain. Teeth small, rounded-oval in shape, with or without cusps on their crowns, and not laterally expanded and plate-like, similar in shape and in over 20 rows in either jaw. Pectoral fins large, originating in front of mouth and reaching snout tip or not, attached to sides of head and forming a large pectoral disc with free

rear tips ending posterior to pelvic-fin origins; disc not subdivided by a notch at eyes. No electric organs at bases of pectoral fins. Pelvic fins high, rounded-angular or angular, and distinctly bilobed (except in *Pseudoraja*) through deep incision in joint outer margin. Claspers of mature males slender to relatively stout, and elongated, nearly extending to first dorsal fin in some species, and with the glans short and only slightly widened; external clasper glans components relatively few and very similar for most species. Alar thorns of mature males sharp, hooked, permanently erect, not retractable into dermal pockets. Usually two small, subequal and close to widely separated dorsal fins present, these of similar rounded or rounded-angular shapes with margins more or less confluent, not falcate; only one dorsal fin or none in some species. First dorsal fin when present originates far behind anterior half of total length, base far behind rear tips of pelvic fins and junction between trunk and tail, and well behind midlength of tail. Caudal fin small to rudimentary, and vertebral axis parallel to body axis; lower caudal-fin lobe absent. Maximum total length between 30 and 175 cm, with most species less than 100 cm. **Colour:** dorsal surface varying from whitish to dark brown, purplish, or black, either unmarked or with light or dark spots, blotches, or basal ocelli on pectoral fins; usually white below but often dark or blotched along midbody in dark-bellied species, or faint grey edging of disc and pelvic fins in light-bellied species.

Distribution: Worldwide in all oceans from continental shelves down to the continental slopes and deep-sea abyssal plains. Absent in tropical shelf waters.

Habitat: This skate family occurs from close inshore to outer continental shelves and upper continental slopes, down to abyssal plains at more than 4000 m deep. It is mostly found at high latitudes, where some species may occur at shallower depths, but at lower latitudes they occur mostly in the deep-sea below 200 m depth.

Biology: Oviparous, with long embryonic development due to low temperatures of environment. Egg capsules rectangular, with two pairs of long horns at both ends. Some deep-sea members of this family are very long lived and do not mature until over 20 years in age. Diet includes various bottom living invertebrates and fishes; larger species tend to consume more bony fishes.

Interest to Fisheries and Human Impact: Most members of this family are deep-sea species and are generally taken as bycatch rather than as targeted species. However, where these skates are caught there generally is very little species-specific information available on catch rates. This is especially true for the Indian Ocean where there is virtually no fishery information on this skate family.

The conservation status of these skates in the Indian Ocean is mostly Data Deficient to Least Concern, although *Pavoraja nitida* has been assessed as Near Threatened.

Local names: None.

Remarks: The family Arhynchobatidae is considered a subfamily (Arhynchobatinae) by some authors (McEachran and Aschliman, 2004; Nelson, 2006; Aschliman, Claeson and McEachran, 2012; Aschliman *et al.*, 2012), but given full family status by others (Compagno, 1999, 2005; Last and Compagno, 1999; Ebert and Compagno, 2007). The family Arhynchobatidae is retained here pending further resolution. The above account is modified after Last and Compagno (1999) and Ebert and Stehmann (2013).

The family has 12 or 13 genera and about 102 species, of which four genera and about 12 species occur in the Indian Ocean deep-sea; this does not include several nominal undescribed species currently under investigation.

Literature: Stehmann (1986); McEachran and Miyake (1990); McEachran, Dunn and Miyake (1996); McEachran and Dunn (1998); Compagno (1999, 2005); Last and Compagno (1999); Compagno and Ebert (2007); Ebert and Compagno (2007); Aschliman, Claeson and McEachran (2012); Aschliman *et al.* (2012); Ebert and Stehmann (2013); Aschliman and Ebert (2013a).

List of Deep-sea Species Occurring in the Area:

- Bathyraja ishiharai* Stehmann, 2005
- Bathyraja richardsoni* (Garrick, 1961)
- *Bathyraja smithii* (Müller and Henle, 1841)
- Bathyraja tunae* Stehmann, 2005
- *Insentiraja subtilispinosa* (Stehmann, 1989)
- *Notoraja azurea* McEachran and Last, 2008
- Notoraja hirticauda* Last and McEachran, 2006
- Notoraja lira* McEachran and Last, 2008
- Notoraja sticta* McEachran and Last, 2008
- Pavoraja alleni* McEachran and Fechhelm, 1982
- Pavoraja arenaria* Last, Mallick, and Yearsley, 2008
- *Pavoraja nitida* (Günther, 1880)

Key to Deep-sea Indian Ocean Genera:

1a. Disc rhomboidal (quadrangular); tail length less than maximum disc width (Fig. 33) *Bathyraja*

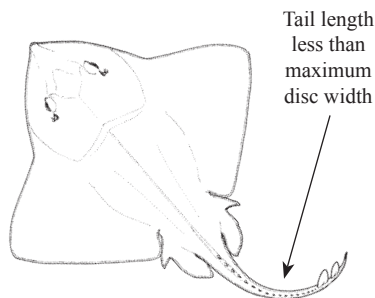
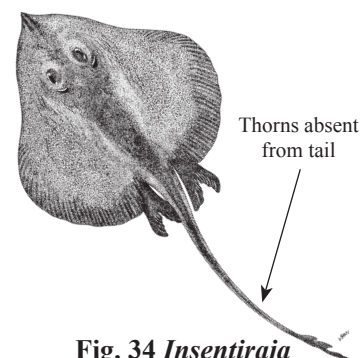
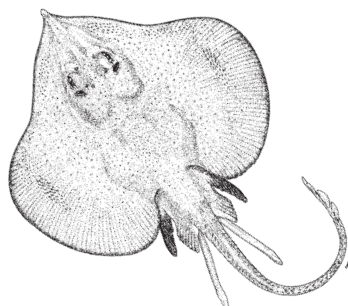
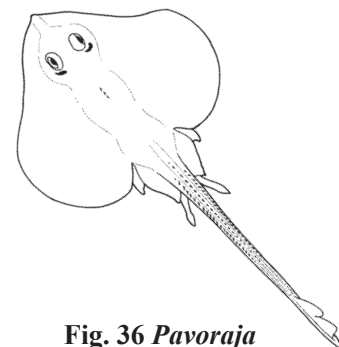
1b. Disc circular to heart-shaped, not rhomboidal (quadrangular); tail length greater than maximum disc width **2**

2a. Thorns absent from tail; tail velvety to touch; skin flabby on both dorsal and ventral surfaces (Fig. 34). *Insentiraja*

2b. Thorns present on tail; tail not velvety to touch; skin not flabby on dorsal and ventral surfaces (looser ventrally) **3**

3a. Rostral cartilage present, flexible, rod-like or slender (Fig. 35) *Notoraja*

3b. No rostral cartilage (Fig. 36) *Pavoraja*

Fig. 33 *Bathyraja*Fig. 34 *Insentiraja*Fig. 35 *Notoraja*Fig. 36 *Pavoraja****Bathyraja* Ishiyama, 1958**

Genus: *Bathyraja* Ishiyama, 1958: 325 (subgenus of *Breviraja* Bigelow and Schroeder, 1948), *J. Shimonoseki Coll. Fish.* 7 (2/3): 193–394; elevated to generic level by Ishiyama and Hubbs (1968) in context with a revision of genus *Breviraja*, *Copeia* 1968(2): 407–410.

Type Species: *Raja isotrachys* Günther, 1877, by original designation.

Number of Recognized Deep-sea Indian Ocean Species: 4.

Synonyms: “Pseudogenus” (=subgenus) *Zetaraia* Leigh–Sharpe, 1924 (Genus *Raja* Linnaeus, 1758), *J. Morph.* 39: 568, 575. Type species: *Raja brachyura* Günther, 1880, by original designation, = *Raja brachyurops* Fowler, 1910. “Pseudogenus” (= subgenus) *Thetaraia* Leigh–Sharpe, 1924 (Genus *Raja* Linnaeus, 1758), *J. Morph.* 39: 568, 577. Type species: *Raja eatoni* Günther, 1876, by original designation. Subgenus *Arctoraja* Ishiyama, 1958 (Genus *Breviraja* Bigelow and Schroeder, 1948), *J. Shimonoseki Coll. Fish.* 7(2–3): 337. Type species: *Raja smirnovi* Soldatov and Pavlenko, 1915, by original designation. Subgenus *Actoraja* Stehmann, 1990 (Genus *Breviraja* Bigelow and Schroeder, 1948), in J.–C. Quero *et al.*, eds., 1990, CLOFETA. *Check-list fish. E. trop. Atlantic*, 1: 29. Apparent error for *Arctoraja* Ishiyama, 1958.

FAO Names: **En** – Bathyraja rays; **Fr** – Raies Bathyraja; **Sp** – Rayas Bathyraja.

Field Marks: Large soft-nosed skates, with soft flexible, slender, uncalcified, rostral cartilage, sub-rhomboidal disc, with a broadly triangular, blunt pointed snout, pectoral tips angular or broadly rounded, tail length mostly shorter than disc width, disc dorsal surface depending on species without thorns or may have nuchal, midback, or scapular thorns present. Colour above uniform or with blotches or spots on some species; ventral surface mostly uniform except for disc edges may be darker in some species.

Diagnostic Features: Disc rhombic-shaped, rather broad, width usually greater than disc length, with lateral corners angular or broadly rounded at tips. Snout flabby, flexible, and soft. Mouth small to relatively wide, and slightly arched; teeth with single large cusp, arranged in quincunx. Tooth counts upper and lower jaws 22 to 36. Anterior pelvic-fin lobes of moderate length, not extending to posterior margin of posterior lobe. Tail relatively short, its length equal to or less than disc width. Dorsal fins usually two, subequal, similar in shape. Skin smooth or with roughly textured on dorsal and ventral surfaces. Thorns on dorsal surface, if present, usually on nuchal, scapular, and midback areas; predorsal tail thorns mostly in single midline row; inter-dorsal thorns present or absent; ventral surface usually without thorns. Vertebral counts: trunk vertebral counts 31 to 39, predorsal vertebral counts 68 to 122. Spiral valve counts 8 to 15. Maximum total length is about 175 cm. **Colour:** dorsal surface varying from whitish to dark brown, purplish, or black; dorsal surface either unmarked or with blotches or spots on pectoral fins; ventral surface usually white but may have dark blotches between gills or on abdomen, or grey edging of disc and pelvic fins.

Remarks: Globally about 45 nominal valid species have been described and named, but several additional mostly deep-water species remain to be described; this genus is one of the most diverse of elasmobranchs. In the Indian Ocean deep-sea, four species are known to occur.

Key to Deep-sea Indian Ocean Species:

1a. Preoral length more than 1.4 times mouth width. Tail length 48% or more of total length (Fig. 37). *Bathyraja ishiharai*

1b. Preoral length less than 1.4 times mouth width. Tail length less than 48% of total length **2**

2a. Disc dorsal surface uniformly grey to whitish grey above, sometimes with white spots; ventral surface white to cream coloured, with darker edges around disc and dark grey blotches around the gills and cloaca (Fig. 38) *Bathyraja smithii*

2b. Disc dorsal surface uniformly pale grey to chocolate brown, darker at edges; ventral surface similar in colour but darker and with pale patches around mouth, gills and cloaca. **3**

3a. Pre-orbital snout length 1.2 to 1.3 times inter-orbital width; inter-spiracular width 1.0 to 1.1 times inter-orbital width; uniformly dark greyish above, sometimes with lighter flecks and small spots, darker grey below (Fig. 39) *Bathyraja richardsoni*

3b. Pre-orbital snout length 2.1 to 2.5 times inter-orbital width; inter-spiracular width 1.8 to 1.9 times inter-orbital width; uniformly dark greyish-brown above and below (Fig. 40) *Bathyraja tunae*

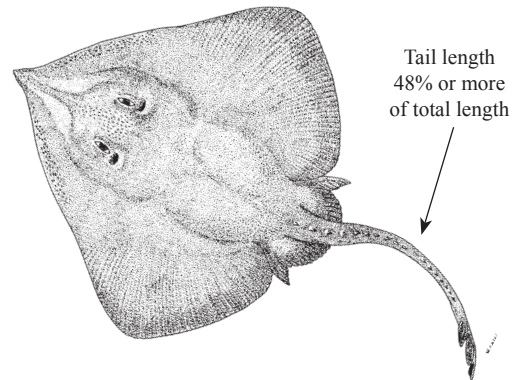


Fig. 37 *Bathyraja ishiharai*

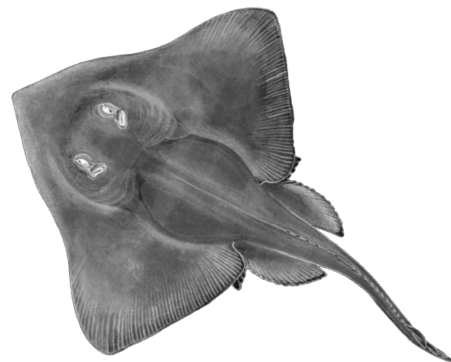


Fig. 38 *Bathyraja smithii*

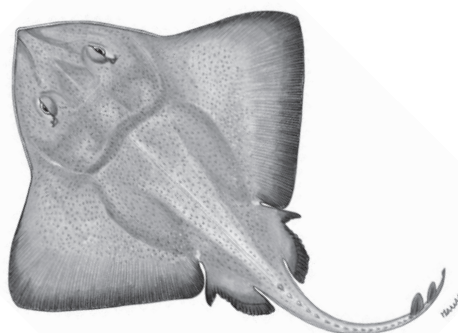


Fig. 39 *Bathyraja richardsoni*

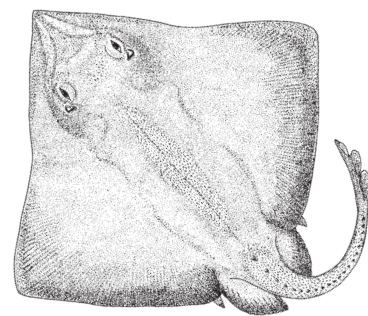


Fig. 40 *Bathyraja tunae*

***Bathyraja smithii* (Müller and Henle, 1841)**

Raja smithii Müller and Henle, 1841, *Systematische Beschreibung der Plagiostomen*. Veit und Comp., Berlin, 150, pl. 49. Syntypes: (2) BMNH 1953.8.10.1 (skin), South Africa; MNHN 0000–1594 (1), Bosphorus, likely not this species. Type catalogue: Bertin, 1939: 84, Séret and McEachran, 1986: 17, with MNHN specimen as paratype.

Synonyms: *Raja smithii* Müller and Henle, 1841: 150, pl. 49, fig. 1 (South Africa); Gray, 1851: 112; Bleeker, 1860: 58; Duméril, 1865: 553; Günther, 1870: 467; Gilchrist, 1902: 168; Thompson, 1914: 159. *Raia smithii* Garman, 1913: 366; von Bonde and Swart, 1923: 5. *Raia smithi* Barnard, 1925: 66, fig. 4, pl. 4. *Raja smithi* Norman, 1935: 41; Fowler, 1941: 364. *Breviraja smithii*: Hulley, 1970: 213; 1972a: 2.

Other Combinations: None.

FAO Names: **En** – African softnose skate;
Fr – Raie de Smith; **Sp** – Raya de Smith.

Field Marks: A large soft-bodied skate, with a broadly triangular, bluntly pointed snout, pectoral tips angular, tail shorter than disc length, disc dorsal surface without thorns, but tail with a single row of large thorns, young with single row of mid-back thorns, but these are lost with growth. Colour a uniform light grey, without any prominent pattern; ventral surface whitish–grey.

Diagnostic Features: Disc rhombic-shaped, rather broad, width about 1.2 to 1.4 times disc length, with lateral corners broadly rounded at tips; snout length about 12% total length, moderately produced, obtuse; snout angle in front of spiracles about 90° to 100°. Total pectoral radial counts not available. Nasal curtain not fringed. Mouth broad and slightly arched; teeth with a single large cusp, arranged in quincunx; sexual dimorphism present, anterior most teeth of adult males more erect, robust, than found in adult females and juveniles. Tooth counts 24 to 28 upper jaw, not available for lower jaw. Anterior pelvic-fin lobes not extending to posterior pelvic-fin lobe tips; anterior lobe length about 66 to 75% of posterior pelvic-fin lobe length. Tail relatively short, its length about 1.3 to 1.6 times in distance from tip of snout to posterior margin of cloaca. Dorsal fins medium-sized, similar in shape with rounded apices and size. Skin mostly smooth, with fine, widely spaced, spicules on upper disc surface; ventral surface mostly smooth. Thorn pattern on dorsal surface (adult): rostrum, orbital, nuchal, scapular, and midback thorns absent. Predorsal tail thorns in single midline row and number 14 to 19; inter-dorsal thorns 0 to 1; juveniles with 3 small orbital thorns, 2 nuchal thorns, and 3 to 4 scapular thorns, followed by a row of about 30 midback thorns from nuchal region to first dorsal fin origin, and 1 interdorsal thorn; all dorsal surface thorns except predorsal tail thorns and presumably interdorsal thorn disappear with growth. Ventral surface usually without thorns at all stages. Vertebral counts: predorsal vertebral counts 68 to 71. Spiral valve counts not available. Maximum total length is about 120 cm. **Colour:** uniform light to medium grey above, sometimes with small white spots; underside white to cream with darker edges around disc and blotches between gills and around vent.

Distribution: Central and southeastern Atlantic and western Indian Ocean: from off Mauritania to off the west coast of South Africa, with its range extending to the Eastern Cape, South Africa.

Habitat: Benthic in deep-water along upper continental slopes between 295 and 1040 m depth, but mostly below 600 m; neonates usually below 700 m.



Fig. 41 *Bathyraja smithii*

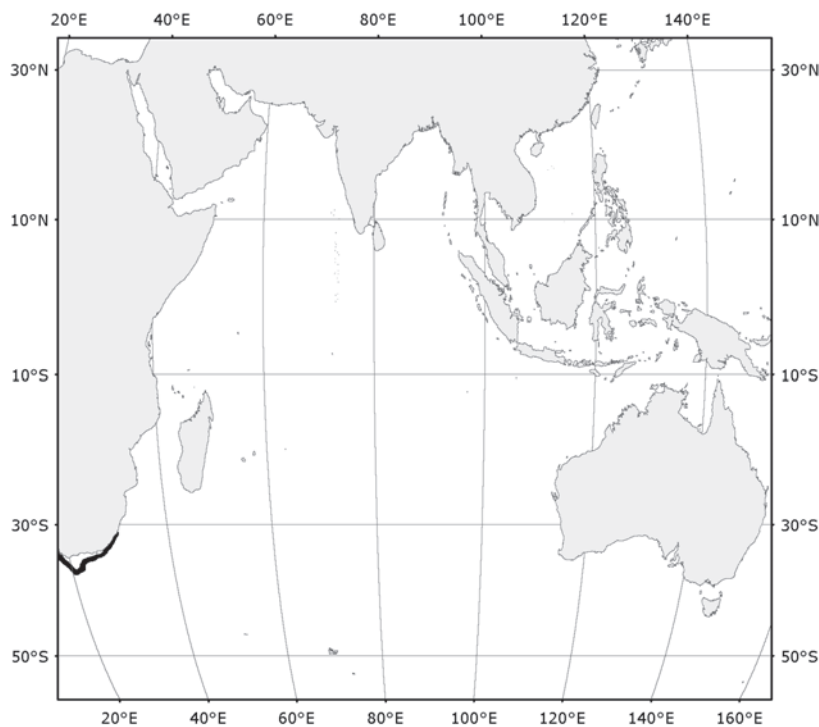


Fig. 42 *Bathyraja smithii*

Known distribution

Biology: Oviparous, with very large egg cases and very long horns. Nothing is known about the reproductive cycle for this species. The diet consists of invertebrates including crustaceans and cephalopods, but larger individuals prefer bony fishes including hake; this skate species appears to be a very formidable predator in its habitat.

Size: Maximum total length about 120 cm. Males mature between 95 to 100 cm, and females mature at about 87.5 cm. Size at hatching is about 12 cm total length based on smallest free-swimming neonate.

Interest to Fisheries and Human Impact: This deep-water skate is taken mostly in small numbers as bycatch by bottom trawlers targeting hake (*Merluccius* spp.) around southern Africa.

Conservation status is Data Deficient.

Local Names: None.

Remarks: Although not uncommon at depth, the life history of this deep-sea skate is relatively unknown. It is the only member of this genus known to occur off the southern African coast.

Literature: Hulley (1970, 1972a, 1986); Compagno, Ebert and Smale (1989); Compagno, Ebert and Cowley (1991); Ebert, Cowley and Compagno (1991); Stehmann (1995); Compagno and Ebert (2007); Ebert, Compagno and Cowley (2008).

Insentiraja Yearsley and Last, 1992

Genus: *Insentiraja* Yearsley and Last, 1992: 840 (subgenus of *Pavoraja* Whitley, 1939), *Copeia*, 3: 839–850.

Type Species: *Pavoraja (Insentiraja) laxipella* Yearsley and Last, 1992. Type by original designation (also monotypic).

Number of Recognized Deep-sea Indian Ocean Species: 1.

Synonyms: None.

Field Marks: Dorsal fins occasionally absent; thorns absent from mid-back and tail; tail very elongated, length greater than disc width, very narrow, velvety to touch; skin flabby.

Diagnostic Features: Disc subcircular, heart-shaped in adult males, width slightly greater than length. Pelvic fins deeply incised, anterior lobes slender, tapering posteriorly, length about as long or longer than posterior length. Tail elongated, slender, tapering posteriorly, moderately depressed, length about equal to or slightly longer than disc length from tip of snout to margin of cloaca; lateral tail folds distinct, extending from pelvic-fin bases to past dorsal fins. Eyes moderately large, diameter about equal to or slightly greater than inter-orbital space. Spiracles length about one-half eye diameter. Nasal curtain convex, apices broadly rounded, with thin or no fringe along distal margin. Mouth slightly arched; teeth arranged in quincunx. Tooth counts upper and lower jaws 35 to 43. Dorsal fins absent or if present two, dissimilar in size, overlapping, interdorsal space minimal. Caudal fin present. Disc dorsal surface covered with dense fine prickles, giving it a velvety texture; ventral surface mostly smooth except for tail covered with fine prickles; skin very flabby. Thorns mostly absent, except for a pair of small preorbital thorns, no other thorns on dorsal or ventral surfaces. Vertebral counts: trunk vertebral counts 24 to 26, precaudal vertebral counts 66 to 95. Spiral valve counts not available. Maximum total length is about 57 cm. **Colour:** dorsal surface uniformly pale to dark bluish with irregular dark or light patches or flecks; anterior margins of disc and snout tip may or may not be lighter than remainder of disc; ventral surface similar to dorsal, except skin transparent.

Remarks: This little known genus, originally described as a subgenus of *Pavoraja*, has two species, one of which occurs in the eastern Indian Ocean off northwestern Australia and eastern Indonesia.

Insentiraja subtilispinosa (Stehmann, 1989)

Notoraja subtilispinosa Stehmann, 1989, *Mem. Mus. Natn. Hist. Nat., Paris, Ser. A, Zool.*, 143: 249, fig. 1–4, 6–7. Holotype: MNHN-1985-134, 415 mm TL, 192 mm DW adolescent male, South China Sea off NW Philippines, 13°53.7'N, 119°56.3'E, 970 m.

Synonyms: *Pavoraja* sp. B Last and Stevens, 1994, *Sharks and Rays of Australia*, CSIRO Publishing: 315, ill. Pl. 49.

Other Combinations: None.

FAO Name: En – Velvet skate.

Field Marks: A small, flabby, softnose skate, with a subcircular to heart-shaped disc, its width greater than length, a very long, thin tail, two dorsal fins, and a long, low upper caudal-fin lobe; a pair of orbital thorns, but lacking any other thorns except for alar thorns in adult males. Colour is a uniform dark bluish above and below.

Diagnostic Features: Disc subcircular, heart-shaped in adult males, 1.1 times as wide as long; disc width 46.3% total length; maximum disc width 66% disc length; outer corners of disc broadly rounded; snout 11.6% total length, tip with small fleshy process; preorbital length about 3.5 times inter-orbital width; snout angle in front of spiracles about 94°. Total pectoral radial counts 73 to 74. Pelvic fins deeply incised, anterior pelvic-fin lobes slender, tapering posteriorly, length about as long or longer than posterior lobes. Tail very long, slender, tapering posteriorly, moderately depressed, length about equal to or slightly longer than disc length from tip of snout to margin of cloaca; lateral tail folds distinct, extending from pelvic-fin base to past dorsal fins. Orbits moderately large, diameter about 1.0 to 1.1 times in inter-orbital width. Spiracles length about one-half diameter of orbit. Nasal curtain weakly convex, apices broadly rounded, with thin or no fringe along distal margin. Mouth slightly arched; teeth arranged in quincunx, sexual dimorphism not reported; median teeth with single short cusp, angled posteriorly. Tooth count for upper and lower jaws 35. Dorsal fins small, dissimilar in size, overlapping, interdorsal space minimal; upper caudal fin low, base about equal to first dorsal-fin base. Disc dorsal surface densely covered with fine prickles, giving it a velvety texture; ventral surface mostly smooth except for tail covered with fine prickles; skin very flabby. Thorn pattern on dorsal surface: only a pair of small thorns on anterior of orbits, no other thorns on dorsal or ventral surfaces. Vertebral counts and spiral valve counts not available. Maximum total length is about 57 cm. **Colour:** dorsal surface uniformly medium to dark blue with irregular speckles; pelvic-fin posterior margins and tail bluish brown; ventral surface similar to dorsal, except skin somewhat transparent.

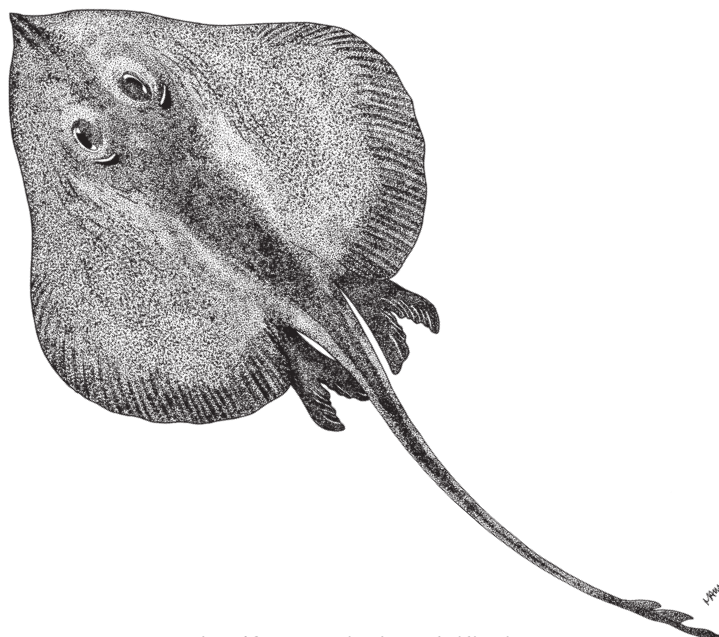


Fig. 43 *Insentiraja subtilispinosa*

Distribution: Indo–Western Pacific: off northwestern Australia, Indonesia, and the Philippine Islands; may be more widespread.

Habitat: A small relatively common deep-water skate on upper continental slopes from 320 to at least 1460 m deep, but most common between 900 and 1100 m.

Biology: Oviparous, but little else known.

Size: Maximum total length 57 cm; females and males mature at 40 to 45 cm. Size at birth unknown.

Interest to Fisheries and Human Impact: This little known skate is often caught as bycatch in bottom trawl fisheries in northern Australian waters, but has no commercial value.

The conservation status of this little known skate is Least Concern.

Local Names: Western looseskin skate (Australia).

Remarks: Populations of this skate off Indonesia may include additional species.

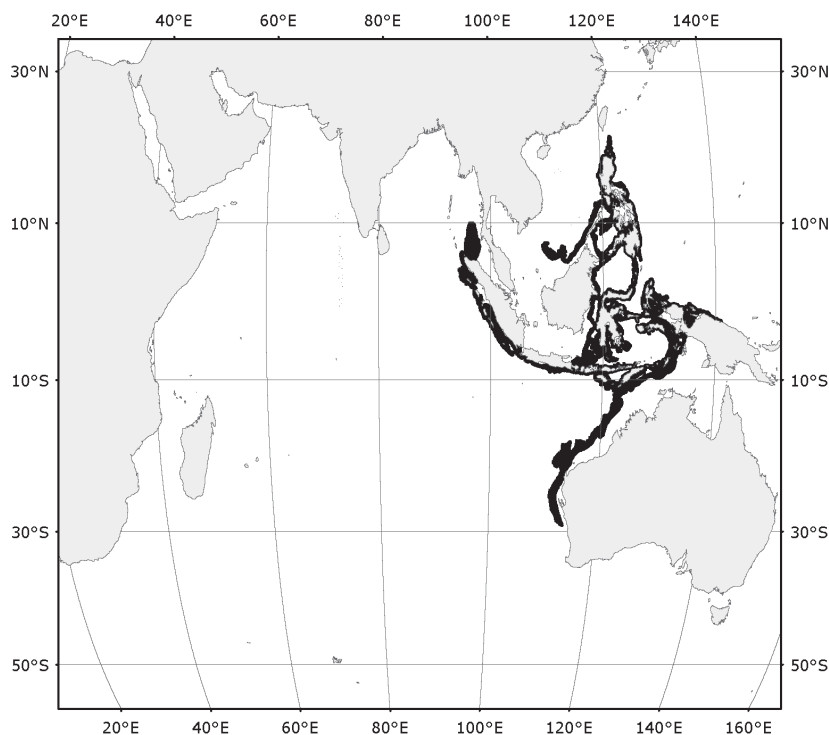


Fig. 44 *Insentiraja subtilispinosa*

Known distribution

Literature: Stehmann (1989); Ishihara and Stehmann (1990); Last and Stevens (1994, 2009); Last and Compagno (1999); Huveneers, Stehmann and Last (2009).

Notoraja Ishiyama, 1958

Genus: Subgenus *Notoraja* Ishiyama, 1958, *J. Shimonoseki Coll. Fish.* 7(2–3): 322 (Genus *Breviraja* Bigelow and Schroeder, 1948).

Type species: *Raja tobitukai* Hiyama, 1940, by original designation (also monotypic). Raised to genus level by Stehmann 1989, *Mem. Mus. Natn. Hist. Nat., Paris, Ser. A, Zool.*, 143: 258.

Number of Recognized Deep-sea Indian Ocean Species: 4.

Synonyms: None.

Field Marks: Small softnose skates, with heart-shaped disc, width greater than its length, tail length greater than disc width and nuchal and scapular thorns absent. Colour is a uniform bluish above, darker below, with pale patches around mouth and gills.

Diagnostic Features: Disc heart-shaped, width greater than length; snout length relatively short, flexible, tip produced. Pelvic fins deeply incised, anterior pelvic-fin lobes narrow at base, tapering to blunt tip. Tail slender at base, moderately depressed, tapering posteriorly, length greater than disc length to cloaca. Eyes moderately large, diameter more than inter-orbital width. Spiracles less than eye diameter. Mouth small, slightly arched; teeth arranged in quincunx. Tooth counts upper and lower jaws 32 to 50. Dorsal fins similar in shape and size, relatively short. Caudal-fin upper lobe low, base longer than first dorsal-fin base. Thorn pattern on dorsal surface includes pre- and post-orbital thorns; tail with rows of irregular thorns on either side of midline, a single row of midline thorns along posterior half of tail; nuchal, scapular, and midback thorns absent; interdorsal thorns mostly absent; ventral surface smooth, without thorns. Vertebral counts: trunk vertebral counts 24 to 32, predorsal vertebral counts 95 to 119. Spiral valve counts 5 to 6. Maximum total length is about 65 cm. **Colour:** dorsal surface uniform pale to dark, sometimes with small spots or mottling; ventral surface light, except darker on disc margins and tail on some species.

Remarks: Formerly a subgenus of *Breviraja*, but raised to full generic status by Stehmann (1989). The genus has 11 species, four of which occur in the Indian Ocean.

Key to Deep-sea Indian Ocean Species:

1a. Disc width relatively broad, 57% or more of total length; preorbital snout relatively long, about 15% or more of total length; tail length less than 55% total length (Fig. 45) *Notoraja lira*

1b. Disc width broad, but 57% or less of total length; preorbital snout shorter, 15% or less of total length; tail length greater than 55% total length **2**

2a. Colour uniformly pale above and below (Fig. 46) *Notoraja hirticauda*

2b. Colour not uniformly pale above and below. **3**

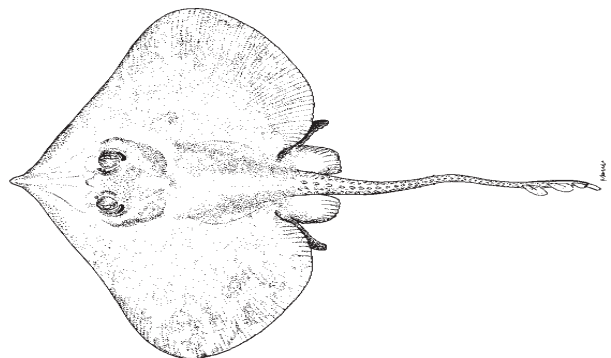


Fig. 45 *Notoraja lira*

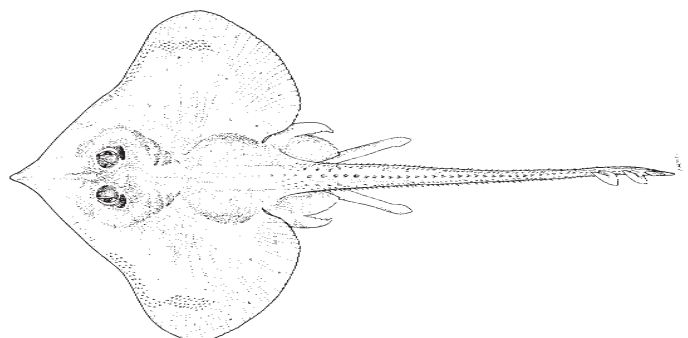


Fig. 46 *Notoraja hirticauda*

3a. Disc dorsal surface uniformly bluish or with bluish mottling, ventral surface mostly darkly coloured (Fig. 47) *Notoraja azurea*

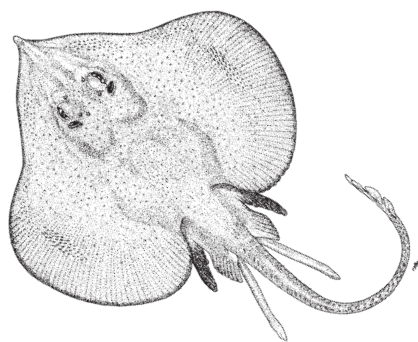


Fig. 47 *Notoraja azurea*

3b. Disc dorsal and ventral surfaces uniformly white with prominent greyish brown blotches and patches (Fig. 48) *Notoraja sticta*

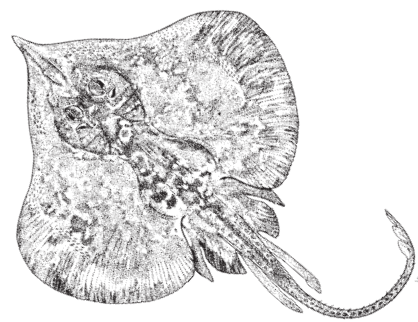


Fig. 48 *Notoraja sticta*

Notoraja azurea McEachran and Last, 2008

Notoraja azurea McEachran and Last, 2008, *CSIRO Marine and Atmospheric Research Paper*, 21: 156, figs. 1–6. Holotype: CSIRO H 170–01, 621 mm total length, adult male, east of Seymour, Tasmania, 41°43'S, 148°38'E, 877 to 950 m deep, 27 July 1982.

Synonyms: *Notoraja* sp. A Last and Stevens, 1994, *Sharks and rays of Australia*, CSIRO Publishing: 304, 309–310, fig. 34.4, Pl. 50.

Other Combinations: None.

FAO Name: En – Blue skate.

Field Marks: A small softnose skate, with a heart-shaped disc, its length shorter than width, disc surface smooth in adults, but coarsely prickled in juveniles, a pair of pre-orbital and post-orbital thorns, and 2 to 3 irregular rows of pre-dorsal tail thorns. Colour is a uniform bluish above, darker below, with pale patches around mouth and gills.

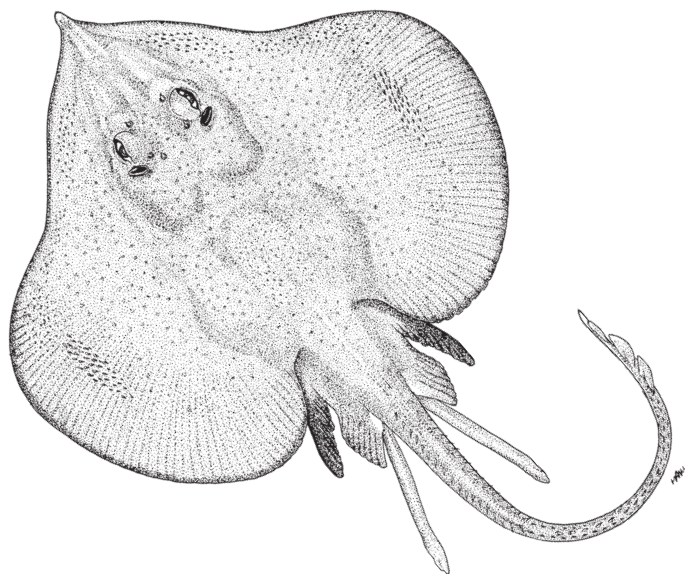


Fig. 49 *Notoraja azurea*

Diagnostic Features: Disc heart-shaped, 1.1 to 1.2 times as wide as long; preorbital snout short, length 11.1 to 14.5% total length, flexible, 3.2 to 4.3 times orbital diameter, and 4.5 to 5.7 times interorbital width; tip produced, angle in front of spiracles about 108° to 112° in females and juveniles, 84° to 85° in adult males. Disc anterior margin slightly concave from snout tip to anterior extension of propterygium, slightly convex to anterior margin of orbit, becoming concave to level of spiracles, broadly rounded at pectoral outer corners, with posterior margins being moderately convex. Total radial counts: pectoral radial counts 66 to 69, pelvic radial counts 1 + 16 to 19. Pelvic fins deeply incised, anterior pelvic-fin lobes narrow at base, tapering to blunt tip, length about 81 to 101% of posterior lobe length. Tail slender at base, moderately depressed, tapering posteriorly, length about 1.3 to 1.6 times disc length to cloaca. Orbits moderately large, diameter about 1.2 to 1.4 times inter-orbital width. Spiracles about one-half to three-quarters as orbital length. Nasal curtain well developed, broadly rounded and roughly fringed along posterior margin; posterior nasal curtain poorly developed and smooth edged. Mouth weakly arched; teeth arranged in quincunx; adult males with acutely pointed cusps, arranged in diagonal rows; adult females and juveniles with short plate-like cusps arranged in quincunx. Tooth counts 32 to 43 upper jaw, 32 to 39 lower jaw. Dorsal fins similar in shape and size, relatively short, moderate in height, anterior margin evenly convex, posterior margin straight or slightly convex, with apex being acutely rounded or pointed; interdorsal space short to moderate, 1.3 to 4.4 times first dorsal-fin base. Caudal fin upper lobe low, base longer than first dorsal-fin base. Skin mostly smooth in adults, except along disc margin at level of orbits and spiracles, and along mid-back of disc; juveniles with dermal denticles along anterior disc margin, head, and mid-back of disc. Thorn pattern on dorsal surface: a pair of pre- and post-orbital thorns; nuchal, scapular, and mid-back thorns absent; tail with 2 rows of irregular thorns on either side of midline, a single row of midline thorns along posterior half of tail; interdorsal thorns mostly absent, but smaller irregularly arranged thornlets present; adult males with small, erect, moderately recurved, broad-based malar thorns; alar thorns with very elongated bases and slightly recurved crowns, arranged in 3 to 5 longitudinal rows, and with about 5 to 7 columns; ventral surface smooth, without

adult males with small, erect, moderately recurved, broad-based malar thorns; alar thorns with very elongated bases and slightly recurved crowns, arranged in 3 to 5 longitudinal rows, and with about 5 to 7 columns; ventral surface smooth, without

denticles. Vertebral counts: total vertebral counts 133 to 136, trunk vertebral counts 25 to 27, predorsal caudal vertebral counts 76 to 80, predorsal vertebral counts 103 to 104, interdorsal vertebral counts between dorsal-fin origins 7 to 8, diplospondylous vertebral counts 107 to 111. Spiral valve counts not available. Maximum length is about 65 cm. **Colour:** uniform pale blue–grey to dark blue above, sometimes with small black spots or light bluish grey mottling; underside medium brown, except darker blue to black on disc margins and tail; pale around gill openings, mouth, and ventral tip of anterior pelvic fins; pores sometimes pale.

Distribution: Southern Australia from the Solitary Islands, New South Wales, to Perth, Western Australia, and including Tasmania.

Habitat: A relatively common, but little known species along upper continental slopes from 765 to 1440 m deep.

Biology: Oviparous, nothing else known.

Size: Maximum length about 65 cm; males mature at about 53 cm. Size at birth unknown, but smallest free-swimming specimen was 19.3 cm long.

Interest to Fisheries and Human Impact: None.

The conservation status of the blue skate is Least Concern. It is protected by a ban on fishing below 750 m within its known range. Its geographic distribution overlaps several marine protected areas in southern Australia including the Great Australian Bight Marine Park.



Fig. 50 *Notoraja azurea*

Local Names: None.

 Known distribution

Remarks: Last and Stevens (2009) noted that this wide-ranging southern Australian skate has several regional forms that exhibit colour, morphological, and meristic differences suggesting that additional species may be involved.

Literature: Last and Stevens (1994, 2009); McEachran and Last (2008); James and Ebert (2011).

Pavoraja Whitley, 1939

Genus: *Pavoraja* Whitley, 1939, *Australian Zool.* 9(3): 251.

Type species: *Raja nitida* Günther, 1880, by original designation.

Number of Recognized Deep-sea Indian Ocean Species: 3.

Synonyms: None.

Field Marks: Disc circular to heart-shaped, tail length greater than disc width, thorns present on tail, usually in 3 longitudinal rows, tail not velvety to the touch, dermal denticles on tail mostly reduced, skin flabby on dorsal and ventral surfaces. Colour yellowish to brown, with or without spots or blotches; ventral surface mostly white or creamy.

Diagnostic Features: Disc heart-shaped, subcircular, width greater than length; snout short, flexible, tip produced; anterior margin undulate, outer corners broadly rounded, posterior margins convex. Pelvic fins relatively small, deeply incised, anterior lobes not extending to posterior margin of posterior lobes. Tail slender, rounded to slightly depressed, length about equal to or slightly longer than disc length from tip of snout to margin of cloaca. Eyes moderately large; spiracles about one-half eye diameter. Nasal curtain broadly lobed, with dermal fringe absent. Mouth transverse, rather narrow; teeth arranged in quincunx. Tooth counts: upper jaw not available, lower jaws 31 to 47. Dorsal fins small, similar in size and shape; interdorsal space about one-half first dorsal-fin base. Caudal-fin upper lobe low, short, base equal to or less than first dorsal-fin base, connected to second dorsal-fin base. Disc surfaces covered with coarse dermal denticles giving it sandpaper texture. Thorn pattern on dorsal surface: orbital thorns prominent, range from 2 to 8; nuchal thorns 1 to 6; scapular thorns if present, small; midback thorns absent; tail thorns large, arranged in 3 longitudinal rows; ventral surface smooth, without thorns. Vertebral counts: trunk vertebral counts 26 to 29, predorsal caudal vertebral counts 62 to 83. Spiral valve counts not available. Maximum total length is about 37 cm. **Colour:** dorsal surface yellowish to dark brown, plain or with distinctive pattern of irregular spots arranged in clusters,

sometimes with irregular patterns light and dark blotches; ventral surface usually white or cream, occasionally out disc margins yellowish, light brown or greyish.

Remarks: This genus has 6 species, of which three occur in the Indian Ocean.

Key to Deep-sea Indian Ocean Species:

1a. Disc dorsal surface with a distinctive pattern of irregular spots arranged in clusters (Fig. 51) *Pavoraja nitida*

1b. Disc dorsal surface is mostly plain, occasionally with faint dusky blotches **2**

2a. Orbital (2 to 8) and nuchal (1 to 6) thorns prominent. Tail long and relatively flattened in cross-section, with median tail thorns immediately in front of first dorsal fin distinctly smaller than anterior tail thorns (Fig. 52) *Pavoraja alleni*

2b. Orbital (2 to 4) and nuchal (2 to 3) thorns relatively small. Tail long and relatively rounded in cross-section, with median tail thorns immediately in front of first dorsal fin similar in size to anterior tail thorns (Fig. 53) *Pavoraja arenaria*

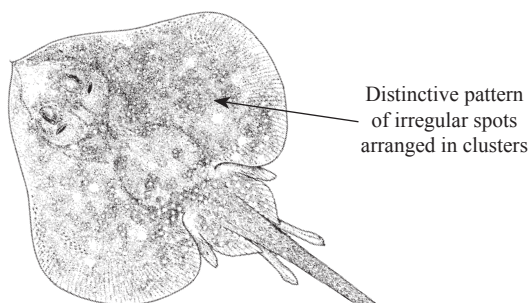


Fig. 51 *Pavoraja nitida*

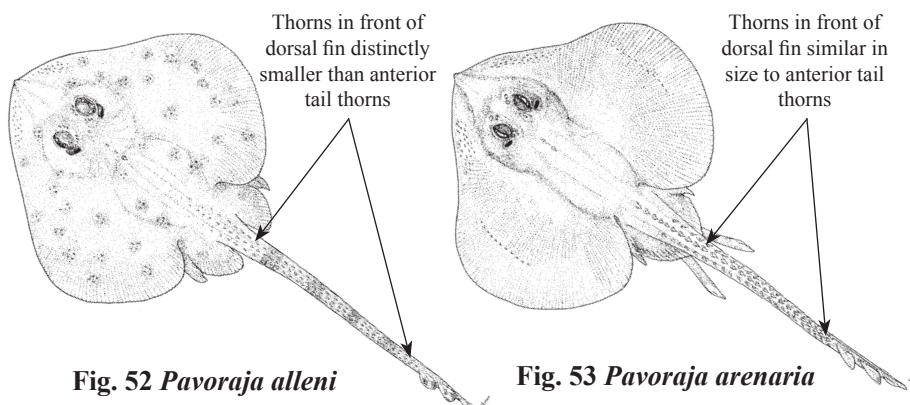


Fig. 52 *Pavoraja alleni*

Fig. 53 *Pavoraja arenaria*

***Pavoraja nitida* (Günther, 1880)**

Raja nitida Günther, 1880, Report on the shore fishes procured during the voyage of the *H.M.S Challenger*, 1873–76, *Zool.* 1(6): 27, pl. 14A. Holotype: British Museum (Natural History), BMNH-1879.5.14.417, 209 mm total length, immature male, Two Fold Bay, Australia, estimated at ca. 37°4.3'S, 150°28'E, 220 m.

Synonyms: None.

Other Combinations: None.

FAO Name: En – Peacock skate.

Field Marks: A small softnose skate, with a heart-shaped disc, a moderately long, slender tail, orbital and nuchal thorns present, and tail thorns in 3 prominent rows. Colour is a dark brown above, with clusters of small white spots, some forming ocelli.

Diagnostic Features: Disc heart-shaped (adult males), subcircular in juveniles and adult females, wider than long; snout short, flexible, tip produced. Disc anterior margin undulate, broadly rounded at pectoral-fin outer corners, with posterior margins being convex. Radial fin counts: pectoral-fin radial counts 62 to 73, pelvic-fin radial counts 1 + 19 to 20. Pelvic fins small, deeply incised, anterior pelvic-fin lobes not extending to posterior pelvic-fin lobe tips; anterior lobe length 1.4 to 1.8 in posterior pelvic-fin lobe length. Tail slender, slightly depressed, length about

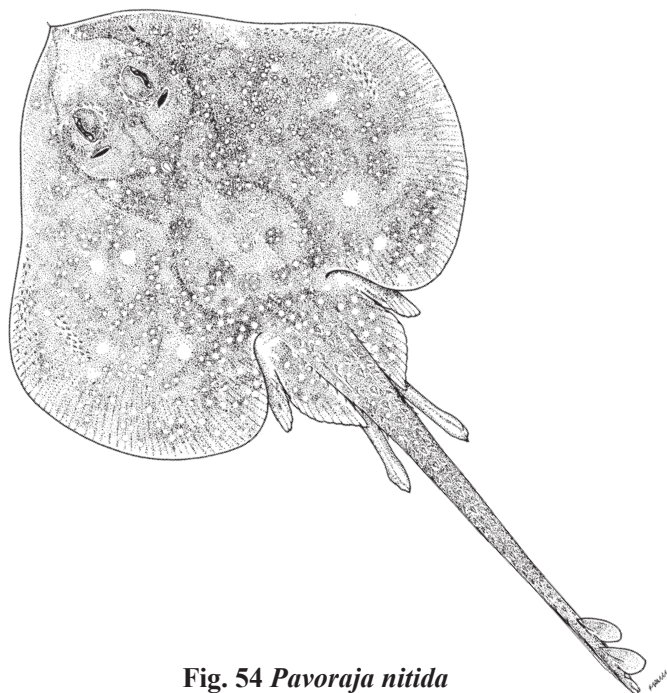


Fig. 54 *Pavoraja nitida*

equal to or slightly longer than disc length from tip of snout to margin of cloaca; lateral tail folds well developed posteriorly. Orbits moderately large, diameter about 1.5 to 1.8 in inter-orbital width. Spiracles about one-half as long as orbits. Nasal curtain broadly lobed, with dermal fringes absent. Mouth nearly straight, rather narrow; teeth arranged in quincunx, sexual dimorphism not reported; teeth with single cusp, slightly arched posteriorly. Tooth counts: upper jaw 31 to 36, lower jaw 31 to 36. Dorsal fins small, similar in size and shape; interdorsal space about one-half first dorsal-fin base. Caudal-fin upper lobe low, short, its base less than first dorsal-fin base, connected to second dorsal-fin base. Disc surfaces coarsely covered with dermal denticles giving it sandpaper texture, except for anterior pelvic-fin lobes which are smooth. Thorn pattern on dorsal surface: orbital thorns prominent, arranged as pre-orbital 2 to 3, mid-orbital 0 to 1, and post-orbital 2 to 3 thorns; nuchal thorns 1 to 5; interspiracular thorns usually present in adults; scapular thorns if present, small; mid-back thorns absent; tail thorns large, arranged in 3 widely spaced longitudinal rows (tail base may have additional lateral rows); adult males with small alar thorns in 3 longitudinal rows; malar thorns small, arranged along anterior disc margin lateral to alar thorns; ventral surface smooth, without thorns. Vertebral counts: predorsal caudal vertebral counts 66 to 72, trunk vertebral counts 26 to 29. Spiral valve counts not available. Maximum total length is about 37 cm. **Colour:** dorsal surface medium to dark brown with conspicuous white spots, some forming ocelli, sometimes with irregular patterns of light and dark blotches; ventral surface usually white or cream, out edges of pectoral fins occasionally light brown or yellowish.

Distribution: Southeastern Australia from Clarence River, New South Wales to Eyre, Great Australian Bight, and including Tasmania.

Habitat: One of the most abundant skates occurring on the continental shelf and upper slopes from 30 to 450 m deep.

Biology: Nothing known other than it feeds mainly on shrimps. Egg cases have been described as very small, dorsal and ventral surfaces with fine fibroids, attachment fibres along lateral edges and lateral keels absent; posterior horns very long, more than 5 cm, and tapering to fine threads; anterior horns shorter, curving inwards at tips.

Size: Maximum total length about 37 cm; females and males mature between 30 and 33 cm. Size at birth about 8 cm.

Interest to Fisheries and Human Impact: A small skate often taken as bycatch in bottom trawl and shark fisheries, but of little value and frequently discarded. Between 1992 and 2003 this skate made up 19% of the skate by-catch in the Australian southeast trawl fishery.

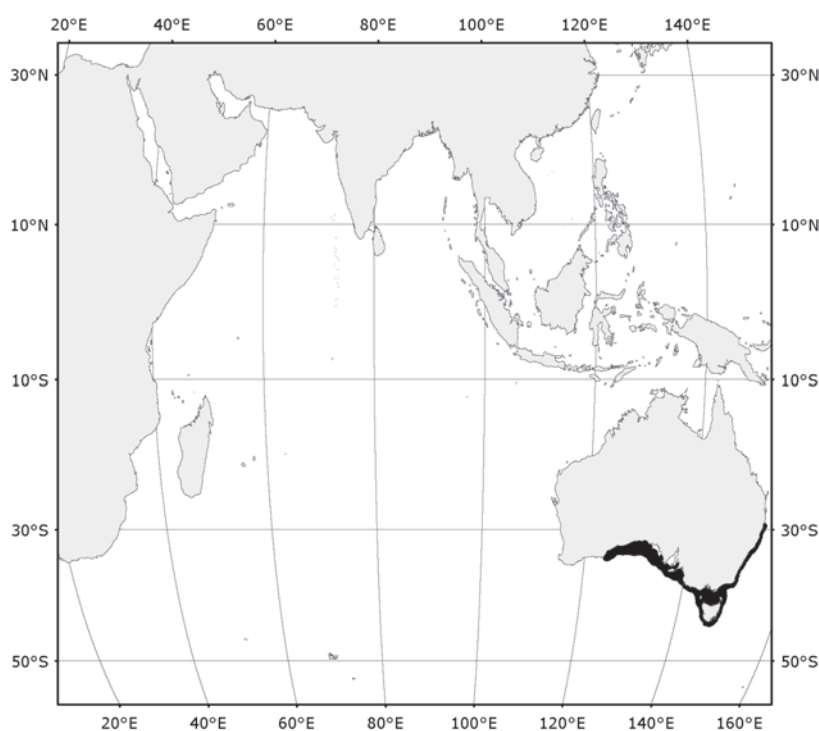


Fig. 55 *Pavoraja nitida*

Known distribution

The conservation status is Near Threatened since this skate is caught often as bycatch and mostly discarded and nothing is known about its population structure or status.

Local Names: Graceful skate, Roughback skate, Shining skate (Australia).

Literature: Günther (1880); McEachran and Fehhelm (1982); Last and Stevens (1994, 2009); Treloar, Laurenson and Stevenson (2006); Treloar (2009b).

2.2.3 Family RAJIDAE

Family: Genus or Family Raia Blainville, 1816, *Bull. Sci. Soc. Philomat.* Paris, (8).

Type Genus: *Raja* Linnaeus, 1758.

Number of Recognized Deep-sea Indian Ocean Genera: 10.

Synonyms: None.

FAO Names: En – Rays and skates; Fr – Rajidés; Sp – Rayidos.

Field Marks: Rostral cartilages solid and stiff to snout tip, anterior pectoral-fin radials and their basal elements distinctly falling short of snout tip. Snout skeleton characters can be checked by touch, or against strong light.

Diagnostic Features: Disc shape from nearly circular to subrhombic or subquadrate, with snout from very short and bluntly angled to very long and pointed. Pectoral fins large, originating in front of mouth and reaching snout tip or not, attached to sides of head and forming a large pectoral disc with free rear tips ending posterior to pelvic-fin origins; disc not subdivided by a notch at eyes. Eyes dorsolateral on head and just anterior to spiracles. Mouth transverse and straight to strongly arched, without prominent knobs and depressions. Nostrils just anterior to mouth and separated from it by less than half their own widths, connected by broad nasoral grooves with mouth; anterior nasal flaps elongated, posteriorly expanded and reaching mouth. Oral teeth small, rounded-oval in shape and with or without cusps on their crowns, not laterally expanded and plate-like, similar in shape and in 30 to 70 rows in either jaw. Pelvic fins high, rounded-angular or angular, and subdivided (except for *Gurgesiella*) into anterior narrow lobes, and posterior broad lobes with a connecting web (except in the genera *Anacanthobatis*, *Cruriraja* and *Sinobatis*). Mature male claspers from very long, nearly reaching first dorsal fin, to rather short about as long as one third tail length, and solid, with the glans elongated to at least one third of clasper length and widened; sharp, hooked male alar thorns not permanently erect, but retractable into dermal pockets. Tail solid, sharply marked off from disc, somewhat shorter than, to about as long as, or slightly longer than disc and gradually tapering to tip (in *Anacanthobatis* and *Sinobatis* tail is very slender), with two small, subequal, close to widely separated dorsal fins at rear and a rudimentary upper caudal fin. Upper and lower disc may be completely covered by rough dermal denticles, or partly or entirely smooth. Thorns on upper disc usually present (except lacking for the genera *Anacanthobatis* and *Sinobatis*), at least in juveniles, and arranged typically in pattern of orbital, nuchal, scapular and mid-dorsal thorns along trunk and tail in at least one median row, but mostly also parallel rows of thorns and often lateral thorns along tail do occur. Interdorsal thorns present or absent. Adults range between 20 and 250 cm total length. **Colour:** dorsal surface varying from whitish to dark brown or black, usually white below but often dark or blotched; dorsal surface either unmarked or with light or dark spots, blotches, or basal ocelli on pectoral fins; ventral surface white with dark edging and blotching, or dark with white markings, or totally dark.

Distribution: Worldwide in all oceans from inshore on continental shelves to upper slopes and to deep-sea plains, also at distant offshore islands and on submarine elevations; absent from shallow tropical shelf waters, but present in Arctic and Antarctic waters.

Habitat: Demersal from enclosed bays and estuaries, to coastal waters in boreal and cold temperate to subtropical latitudes down the continental slopes and far offshore islands and on submarine elevations to deep-sea plains to more than 4000 m depth. Larger deep-water species may be benthopelagic.

Biology: Oviparous, with embryonic development taking from a few months to possibly years depending on temperatures of environment. Egg capsule mostly rectangular, with two pairs of long horns at both ends. Feed on a variety of bottom living invertebrates and fishes.

Interest to Fisheries and Human Impact: Skates have been the subjects of target and non-target fisheries worldwide, mostly in temperate seas.

The conservation status of skates is variable as many are listed as Data Deficient, while others have largely been extirpated on a local scale. A problem in many regions where skates are caught is that species specific identification has been lacking.

Local names: Rays and skates in numerous, more or less specific combinations.

Remarks: All rays and skates at one time were grouped in the family Rajidae, with just one genus *Raja* for all species, but over the past couple decades there have been considerable taxonomic changes with about 26 genera and nearly 200 species recognized. The above family account is modified after Last and Compagno (1999) and Ebert and Stehmann (2013).

Literature: Stehmann and Bürkel, *In*: Whitehead *et al.* (1984); McEachran and Dunn (1998).

List of Deep-sea Species Occurring in the Area:

- *Amblyraja hyperborea* (Collett, 1879)
- *Amblyraja reversa* (Lloyd, 1906)
- *Anacanthobatis marmoratus* (von Bonde and Swart, 1923)
- *Anacanthobatis ori* (Wallace, 1967)
- *Cruriraja andamanica* (Lloyd, 1909)
- *Cruriraja hulleyi* Aschliman, Ebert, and Compagno, 2010
- *Cruriraja parcomaculata* (von Bonde and Swart, 1923)
- *Dipturus acrobelus* Last, White, and Pogonoski, 2008
- *Dipturus campbelli* (Wallace, 1967)
- *Dipturus canutus* Last, 2008
- *Dipturus crosnieri* (Séret, 1989)
- *Dipturus doutrei* (Cadenat, 1960)
- *Dipturus gudgeri* (Whitley, 1940)
- *Dipturus healdi* Last, White, and Pogonoski, 2008
- *Dipturus johannisdavisi* (Alcock, 1899)
- *Dipturus lanceorostratus* (Wallace, 1967)

- Dipturus oculus* Last, 2008
- Dipturus pullopunctatus* (Smith, 1964)
- Dipturus springeri* (Wallace, 1967)
- Dipturus stenorhynchus* (Wallace, 1967)
- Dipturus wengi* Séret and Last, 2008

- *Fenestraja maceachrani* (Séret, 1989)
- Fenestraja mamillidens* (Alcock, 1889)
- Leucoraja compagno* (Stehmann, 1995)
- Leucoraja pristispina* Last, Stehmann, and Séret, 2008
- *Leucoraja wallacei* (Hulley, 1970)
- *Neoraja stehmanni* (Hulley, 1972)
- *Okamejei arafurensis* Last and Gledhill, 2008
- Okamejei heemstrai* (McEachran and Fechhelm, 1982)
- Okamejei leptoura* Last and Gledhill, 2008
- Rajella barnardi* (Norman, 1935)
- *Rajella caudaspinosa* (von Bonde and Swart, 1923)
- Rajella challenger* Last and Stehmann, 2008
- Rajella dissimilis* (Hulley, 1970)
- Rajella leopardus* (von Bonde and Swart, 1923)
- Rajella ravidula* (Hulley, 1970)
- *Sinobatis bulbicauda* Last and Séret, 2008
- Sinobatis caerulea* Last and Séret, 2008

Key to Deep-sea Indian Ocean Genera:

1a. Anterior pelvic-fin lobes not limb-like, separated by notch from posterior lobes along outer fin margin (Fig. 56) . 2

1b. Anterior pelvic-fin lobes limb-like, separated externally from posterior fin-like lobes (Fig. 57). 8

2a. Snout distinctly elongated, pointed; anterior disc margins deeply concave; internarial width usually less than 70% of distance from nostril to snout tip (Fig. 58) . *Dipturus*

2b. Snout moderately long to relatively short; anterior disc margins somewhat convex, slightly concave or undulated; internarial width usually more than 70% of distance from nostril to snout tip. 3

3a. Dorsal disc surface and tail finely covered with dense dermal denticles giving it a velvet-like texture; ventral surface of tail partially to completely covered with dermal denticles. Median row of tail thorns decreasing rearwards in size and disappearing completely on posterior third of tail among dense dermal denticles (Fig. 59). *Neoraja*

3b. Dorsal disc surface and tail partially to completely covered with less dense, but very coarse dermal denticles, giving it a rough texture; ventral surface of tail usually smooth. Median row of tail thorns may somewhat reduce in size rearwards, but are distinctly continuous to origin of first dorsal fin. 4

4a. Tail short, stout, length about equal to or shorter than precaudal length; scapular thorns 2 to 3 on each shoulder; median row of enlarged thorns extending from nuchal area to first dorsal fin may be incomplete or interrupted, but always present (Fig. 60) *Amblyraja*

4b. Tail length about equal to or usually longer than precaudal length 5

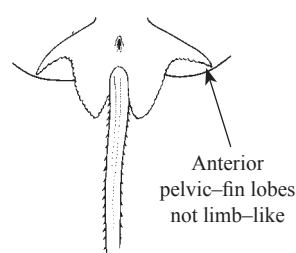


Fig. 56 *Dipturus* sp.

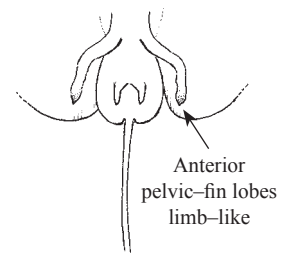


Fig. 57 *Anacanthobatis* sp.

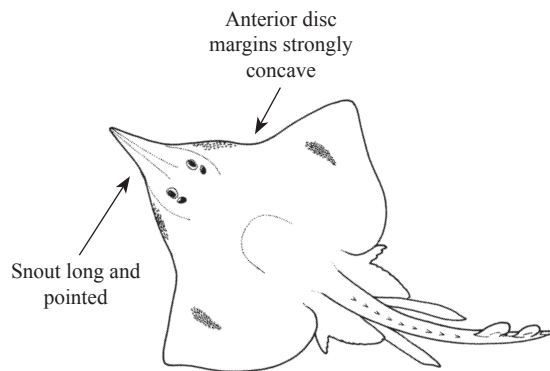


Fig. 58 *Dipturus*

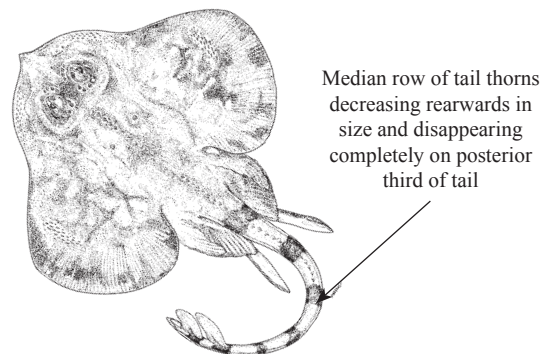


Fig. 59 *Neoraja*

5a. Disc with prominent triangular patch of thorns over nuchal and scapular region; median thorns extending from nuchal area to first dorsal fin either reduced in size or disappearing with growth (Fig. 61). **6**

5b. Disc without prominent triangular patch of thorns over nuchal and scapular region; nuchal thorns in a single median row or absent **7**

6a. Multiple rows of median thorns along mid-back of disc and tail, with mid-row smaller than lateral row(s); absent in large juvenile and adult specimens (Fig. 61) **Leucoraja**

6b. One to several rows of similar sized thorns along mid-back of disc and tail in juvenile and adult specimens (Fig. 62) **Rajella**

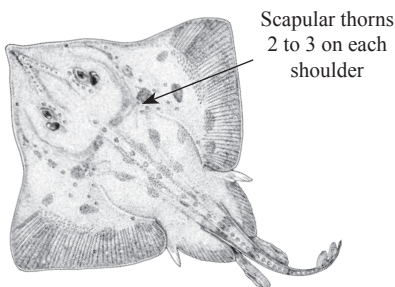


Fig. 60 *Amblyraja*

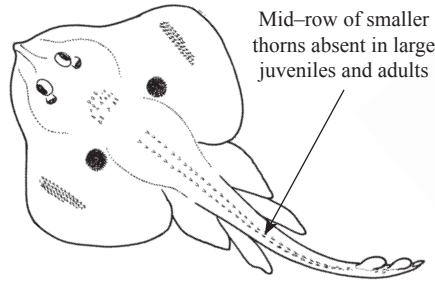


Fig. 61 *Leucoraja*

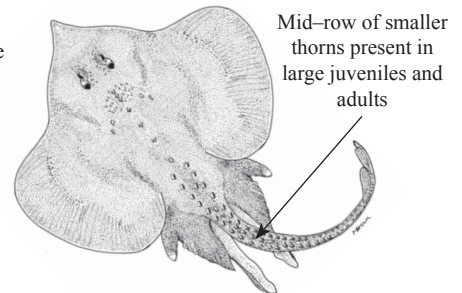


Fig. 62 *Rajella*

7a. Disc heart-shaped, narrow, usually less than 55% total length; pectorals narrow to broadly rounded at outer corners; snout short, less than 11% total length, with tip slightly produced as a small triangular process; tail very long, more than 60% total length (Fig. 63) **Fenestraja**

7b. Disc rhombic-shaped, moderately broad, usually more than 55 to 65% total length; pectorals sharply rounded at outer corners; snout acutely angled, moderately long, usually 13 to 17% total length, with tip slightly to moderately produced beyond anterior margin of disc; tail moderately long, 44 to 56% total length (Fig. 64) **Okamejei**

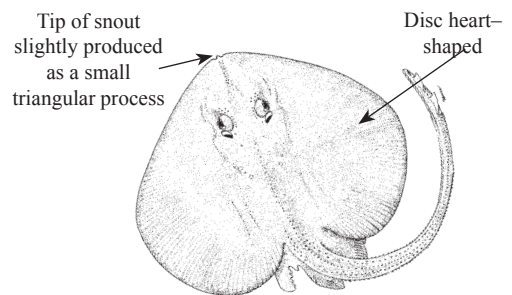


Fig. 63 *Fenestraja*

8a. Legskates lacking a terminal filament on snout; tail stout at base, not whip-like, with two dorsal fins (Fig. 65). **Cruriraja**

8b. Legskates with a terminal filament extending from a small, rounded projection at the snout tip; tail slender at base, whip-like, without dorsal fins **9**

9a. Pelvic fins completely fused along entire length with base of tail (the relationship between this genus and *Sinobatis* below is not fully resolved) (Fig. 66) **Anacanthobatis**

9b. Pelvic fins not completely fused along entire length with base of tail (Fig. 67) **Sinobatis**

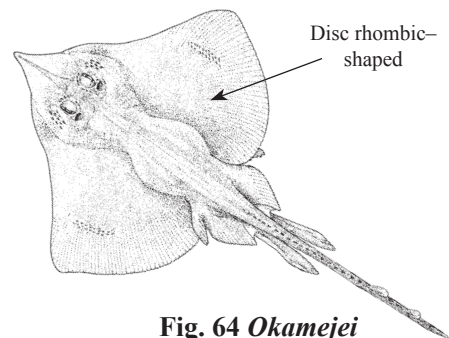


Fig. 64 *Okamejei*

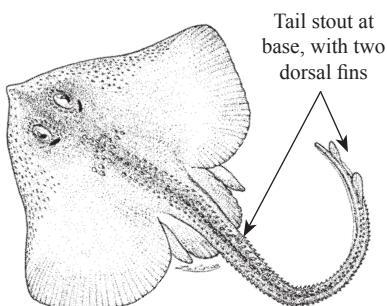


Fig. 65 *Cruriraja*

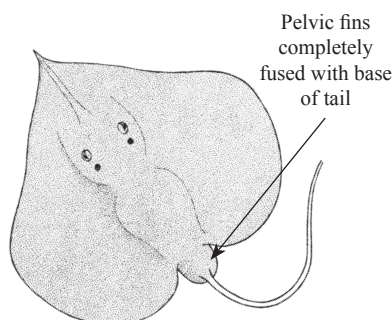


Fig. 66 *Anacanthobatis*

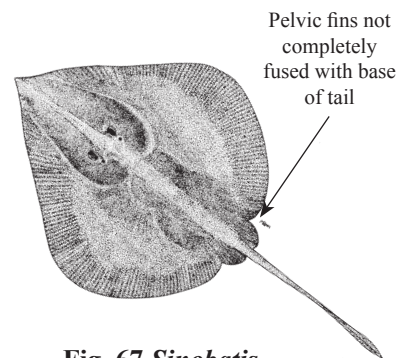


Fig. 67 *Sinobatis*

***Amblyraja* Malm, 1877**

Genus: *Amblyraja* Malm, 1877, *Göteborgs och Bohusläns Fauna*: 607–608.

Type Species: *Raja radiata* Donovan, 1808 by subsequent designation of Jordan (1919).

Number of Recognized Deep-sea Indian Ocean Species: 2.

Synonyms: *Raja* (*Amblyraja*), subgenus (Stehmann, 1970).

Field Marks: Thick bodied skates with outer disc corners angular, a relatively short, stout tail usually less than the disc length, reduced thorns on snout, but conspicuous around eye orbits, nuchal, shoulder region, and midback and tail. Colour above greyish brown to dark brown or reddish, strikingly mottled with light blotches and spots in some species in life; creamy to white below.

Diagnostic Features: Disc shape subquadrate to subrhombic, outer corners angular. Tail rather massive along anterior one-half and shorter than precaudal length. Thorns on head set individually at orbits, on nape and shoulders; median row of relatively few conspicuously large thorns from nape to first dorsal fin always present; all thorns and thornlets with typically ribbed basal cone. Claspers of mature males massive, with club-shaped, widened glans. **Colour:** dorsal surface plain medium to dark brown or greyish-brown, without patterning or with obscure dark blotching or with rather lively pattern of dark and light blotches and spots, but also plain whitish; ventral surface white, but in deep-water species only in young becoming with growth increasingly dark blotched and finally almost totally dark, with only few white markings remaining along midbody.

Remarks: The genus comprises about 10 nominal species circumglobally, but the validity of some in deep-water is uncertain. Two species are recognized as occurring in the Indian Ocean. However, *Amblyraja reversa* is known only from a single specimen (Holotype) collected from the Arabian Sea off the coast of Pakistan; any *Amblyraja* species taken from this area should be retained for further study. The genus account follows Ebert and Stehmann (2013).

Key to Deep-sea Indian Ocean Species:

1a. Disc dorsal surface dark grey or brown, with large indistinct dark blotches and lighter spots; pelvic fins slightly darker; ventral surface mostly white in juveniles, becoming darker, similar in colour to dorsal surface, with growth (Fig. 68) *Amblyraja hyperborea*

1b. Disc dorsal surface white, becoming greyish at disc margins; pelvic fins greyish on upper surface; ventral surface is purplish-black (Fig. 69) *Amblyraja reversa*

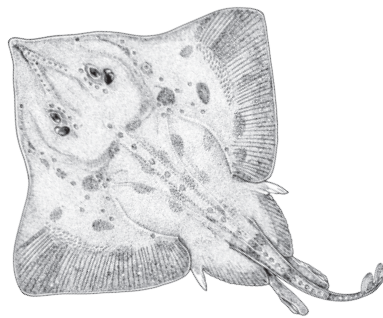


Fig. 68 *Amblyraja hyperborea*

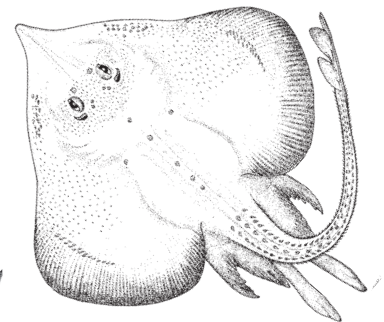


Fig. 69 *Amblyraja reversa*

***Amblyraja hyperborea* (Collett, 1879)**

Raja hyperborea Collett, 1879, *Forh. VidenskSelsk. Christ.* 1878 (publ. 1879), 14: 7–12. Holotype: ZMO 13134.

Synonyms: *Raja* (*Amblyraja*) *hyperborea*, subgenus (Stehmann, 1970).

FAO Names: **En** – Arctic skate; **Fr** – Raie arctique; **Sp** – Raya ártica.

Field Marks: Disc subrhombic, with angular outer corners; tail short, tapering posteriorly. Snout moderately elongate, bluntly angled, and with stiff rostrum. Distinct enlarged thorns around orbits, mid-back, and scapular region; ventral surface smooth. Colour above dark grey or brown, occasionally with indistinct light spots and dark blotches; underside largely white only in juveniles, whereas dark speckling along midbody and along disc margins increasing with age and size with underside becoming predominantly dark.

Diagnostic Features: Body disc of large specimens thick and somewhat flabby. Disc subrhombic, with

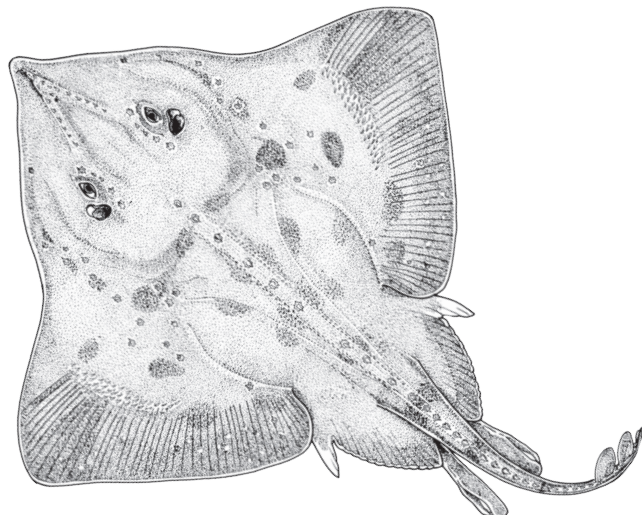


Fig. 70 *Amblyraja hyperborea*

anterior margins strongly undulated in mature males, and angular outer corners; tail short, stout at base, tapering posteriorly, with two small dorsal fins separated, or rarely confluent. Snout moderately elongate, bluntly angled, and vertically not flexible due to stiff rostrum to snout tip. Upper thorns distinct, set in largely constant pattern of separate orbital and suprspiracular thorns, a single one each on mid–nape and mid–shoulder, 2 to 3 on each shoulder, and a very regular median row of 25 to 32 thorns from anterior trunk to first dorsal fin; 0 to 2 thorns between dorsal fins, if these separated. All upper thorns large, their bases typically ribbed and with stellate margins, as well as those of thornlets; entire upper disc rough through large thorns, many thornlets scattered over snout and pectoral wings and coarse dermal denticles over most of disc and tail, but large specimens may lack thorns on pectoral wings and on trunk except for median thorn row; larger specimens may show rows of thornlets from anterior trunk onto anterior tail along each side of median thorn row; underside smooth. Tooth rows in upper jaw 35 to 48, teeth of larger specimens long and pointed and set in parallel rows. **Colour:** above dark grey or brown, occasionally with indistinct light spots and dark blotches; underside largely white only in juveniles, whereas dark speckling along midbody and along disc margins increasing with age and size, so that underside becomes predominantly dark.

Distribution: Indian Ocean: Tasmania and Victoria, Australia. Western Pacific: New Zealand and Japan.

Habitat: A moderately common benthic and benthopelagic skate on and over various bottom substrates from coastal waters in polar regions to deeper cold temperate regions down the slopes and on submarine seamounts from 300 to 1500 m depth (single records down to about 2500 m); largely restricted to Arctic water masses in temperatures from -1 to $+1.5$ °C, but usually less than $+4$ °C. Off Australia and New Zealand from 980 to 2000 m deep.

Biology: Oviparous, with egg capsules measuring 81 to 125 mm by 54 to 77 mm, excluding the horns; surfaces are rather smooth in texture; egg case size varies with size of the female, as well as number of capsules laid.

Depending on its size, this skate feeds on a variety of benthic animals, including Arctic prawns, crabs and cephalopods, pelagic amphipods, with larger specimens also feeding on small Arctic bottom fish.

Size: Maximum total length is about 107 cm; males mature at about 94 cm in length, females at about the same size. The size at birth is about 16 to 18 cm total length.

Interest to Fisheries and Human Impact: Taken on occasion as bycatch in deep–water bottom trawls and by longlining, they are mostly discarded, except for large specimens that may be landed. In the southern hemisphere this skate appears to be relatively rare, whereas it appears to be more common in the Arctic region of the North Atlantic.

The conservation status of this skate is Least Concern.

Local Names: Boreal skate; Mitsuboshi–kasube (Japan).

Remarks: It has been suggested that *Amblyraja hyperborea* may have a global distribution and that several nominal species may in fact be conspecific with it. Stehmann (unpubl. data; Ebert and Stehmann, 2012) has been investigating the various nominal species within this genus and has suggested that many of the species–specific differences within the *Amblyraja* fall within the range of natural variation within a single species. Therefore, there is a strong possibility that *A. hyperborea* (as the oldest valid name) may well have a worldwide distribution in deep, cold waters. Last and Stevens (2009) have tentatively accepted Stehmann's hypothesis, in that they assigned specimens from deep–water off southern Australia and around New Zealand to *A. hyperborea*. However, genetic studies are still lacking to back, or disprove this conclusion, and adequate genetic samples will be very difficult to get from most of these very rare deep–water species.

Literature: Stehmann and Bürkel, in: Whitehead *et al.*, (1984); Last and Stevens (1994, 2009); Dolgov, Drevetnyak and Gusev (2005); Dolgov *et al.* (2005); Kulka *et al.* (2007); Williams (2008); Ebert and Stehmann (2013).

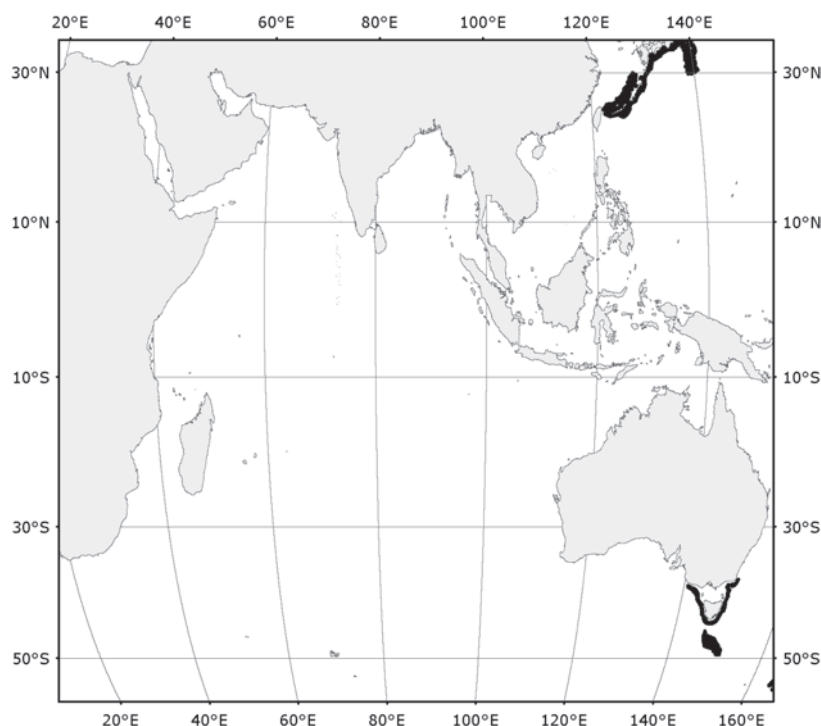


Fig. 71 *Amblyraja hyperborea*

Known distribution

***Anacanthobatis* von Bonde and Swart, 1923**

Genus: *Anacanthobatis* von Bonde and Swart, 1923, *Report Fisheries and Marine Biological Survey, Union of South Africa Rep. 3* (art. 5): errata [18], pl. 18. Appeared as *Leiobatis* but this original name was preoccupied; name therefore corrected in printed errata sheet (affixed to separates) to *Anacanthobatis*.

Type Species: Type by subsequent designation; two species included.

Number of Recognized Deep-sea Indian Ocean Species: 2.

Synonyms: *Leiobatis* von Bonde and Swart, 1923: 18, pl. 23, original name preoccupied; name therefore corrected in printed errata sheet (affixed to separates) to *Anacanthobatis*. Subgenus (of *Anacanthobatis*) *Sinobatis* Hulley, 1973: 153. Type by original designation (also monotypic).

Field Marks: Small heart-shaped legskates with a terminal filament extending from a small, rounded projection at the snout tip, tail slender, with small upper and lower caudal fins, lacking dorsal fins, caudal fin very weakly developed but with hypocaudal lobe present and smaller than epicaudal lobe, posterior lobes of pelvic fins fused to base of tail along length and dorsal and ventral surfaces of disc lacking dermal denticles.

Diagnostic Features: Disc heart-shaped, width slightly greater than disc length; snout tip short, slender, filamentous; disc anterior margins to spiracles nearly straight with short concavity near snout tip, weakly concave from spiracles to rounded apices of pectoral fins, becoming more convex on posterior margins; snout angle in front of spiracles 93° to 102° . Total pectoral radial counts 67 to 73. Eyes small to moderate sized. Spiracles small. Nostrils small, with nasal curtain variably overlapping or not overlapping, depending on species, the mouth corners. Mouth nearly transverse, with teeth arranged in quincunx. Tooth counts 20 to 35 upper jaw, 18 to 23 lower jaw. Pelvic-fin anterior lobes slender, leg-like, distinctly separated from posterior lobes. Total pelvic radial counts 12 to 17. Tail very slender, almost whip-like, its length greater than disc length; dorsal fins and lateral tail folds absent; upper and lower caudal fins very small, membranous; lower caudal-fin lobe about two-thirds length of upper caudal-fin lobe. Skin smooth on upper and lower surfaces; no thorns on dorsal or ventral surfaces. Vertebral counts: trunk vertebral counts 23 to 28. Spiral valve counts not available. Maximum total length is about 42 cm. **Colour:** dorsal surface uniform grey-black or brownish, either plain or mottled with lighter patches and scattered ocelli; ventral surface uniform pale to greyish black.

Remarks: The genus comprises globally eight described species, of which two occur in the Indian Ocean. Generic account modified after Aschliman and Ebert (2013c).

Key to Deep-sea Indian Ocean Species:

1a. Nasal curtain overhangs corners of mouth; tail length less than disc length from snout tip to posterior end of cloaca; 29 to 35 rows of teeth in upper jaw (Fig. 72) *Anacanthobatis marmoratus*

1b. Nasal curtain does not overhang corners of mouth; tail length greater than disc length from snout tip to posterior end of cloaca; 20 to 24 rows of teeth in upper jaw (Fig. 73) *Anacanthobatis ori*

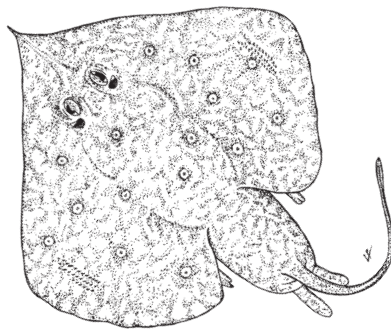


Fig. 72 *Anacanthobatis marmoratus*

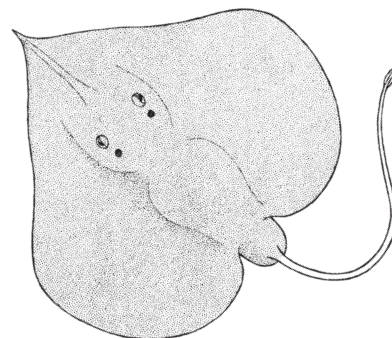


Fig. 73 *Anacanthobatis ori*

***Anacanthobatis ori* (Wallace, 1967)**

Springeria ori Wallace, 1967b, *S. African Assn. Mar. Biol. Res., Oceanogr. Res. Inst., Invest. Rept.* (17): 46, fig. 24. Holotype: SAIAB [formerly RUSI] 8343, 206 mm total length, female, east of Bazaruto Is., Mozambique, $21^\circ 18'S$, $36^\circ 18'E$, 1510 to 1602 m.

Synonyms: None.

Other Combinations: None.

FAO Name: En – Black legskate.

Field Marks: A dark smooth-skinned legskate with a long, slender tail greater than its body length, and no dorsal fins, snout angular with broad-based filament, pectoral disc with rounded corners and no large thorns or denticles and pelvic-fin anterior lobes slender, leg-like and separate from posterior lobes. Colour is a uniform grey-black or brownish above, lighter below.

Diagnostic Features: Disc broad, flat, “heart-shaped”, width slightly greater than disc length; snout tip short, slender, filamentous; disc anterior margins to spiracles nearly straight with short concavity near snout tip, weakly concave from spiracles to rounded apices of pectoral fins, becoming more convex on posterior margins; snout angle in front of spiracles 93° to 99° . Total pectoral radial counts 70 to 73. Eyes small, diameter less than inter-orbital space. Spiracles very small, diameter about one-half eye length. Nostril small, anterior lobes slightly fringed along margin, posterior nasal curtain with fine lobes not quite overlapping the corners of the mouth. Mouth nearly transverse; teeth arranged in quincunx, with a single, short cusp posteriorly directed, on a triangular to oval base. Tooth counts 20 to 24 upper jaw, 18 to 23 lower jaw. Anterior pelvic-fin lobes slender, “leg-like” and separated from posterior lobes. Pelvic-fin posterior lobes well developed, fused to pectoral fins for more than one-half its length; inner margin fused to side of tail for entire length. Total pelvic-fin radial counts 13 to 17. Tail very slender, cylindrical, its length greater than disc length; upper and lower caudal fins very small, membranous; lower caudal-fin lobe about two-thirds length of upper caudal-fin lobe. No dorsal fins or lateral tail folds. Skin smooth on upper and lower surfaces; upper surface with short row of mucous pores in front of orbits and a lateral row extending from scapular region to base of tail. No thorns on dorsal or ventral surfaces. Vertebral counts: trunk vertebral counts 23 to 26. Spiral valve counts not available. Maximum known total length is about 21 cm for an immature female. **Colour:** uniform grey-black or brownish above and below; snout translucent, orbits dark brown, and tail a creamy white; no distinctive markings on dorsal or ventral surfaces.

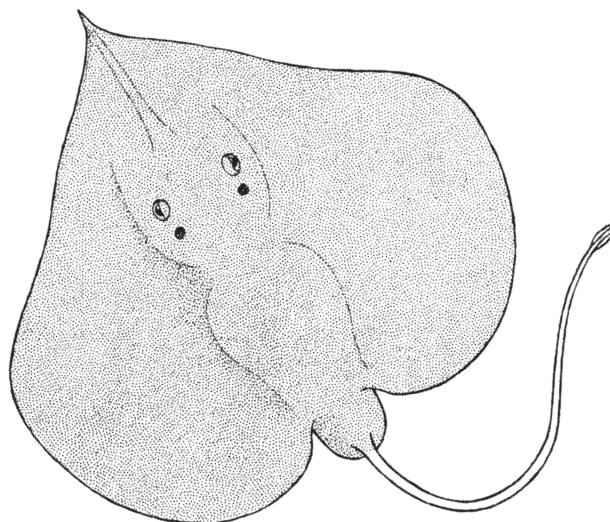


Fig. 74 *Anacanthobatis ori*

Distribution: Southwestern Indian Ocean: known only from off Bazaruto Island, Mozambique and off Madagascar.

Habitat: Known only from continental and insular slopes from 1000 to 1725 m deep. Two specimens taken off Madagascar were collected on calcareous mud bottoms.

Biology: Nothing known of its biology.

Size: Maximum length at least 21 cm. Size and maturity or birth unknown.

Interest to Fisheries and Human Impact: None, rarely taken by deep-sea research vessels.

The conservation status of this skate is Data Deficient.

Local Names: Black legskate (South Africa), Raia preta (Mozambique).

Remarks: This rare deep-water species is known from only four immature specimens. As this catalogue was going to press Weigmann, Stehmann, and Thiel (2014) published a description of a new legskate genus, *Indobatis*, and assigned *Anacanthobatis ori* as the type species for their new genus.

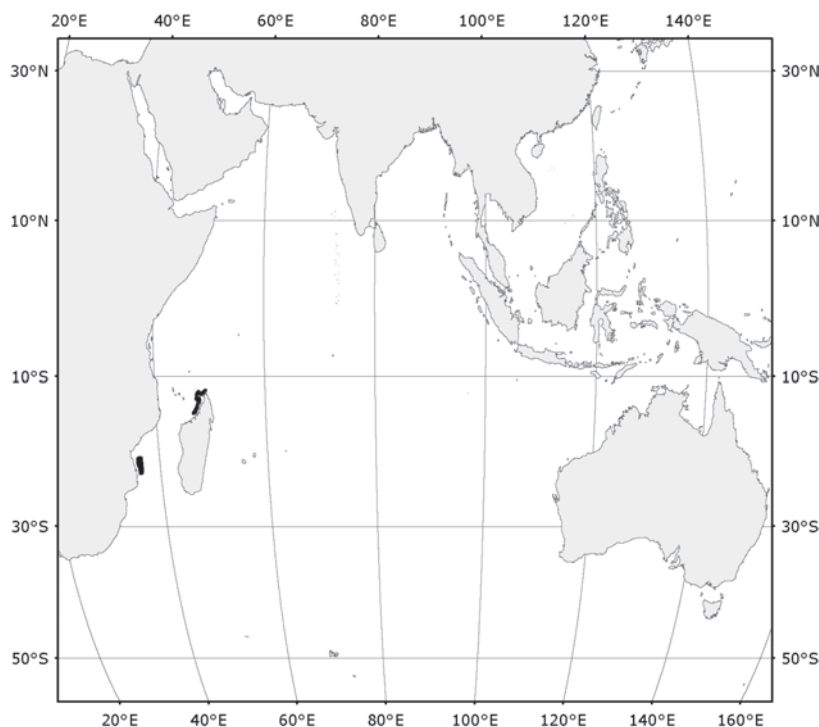


Fig. 75 *Anacanthobatis ori*

Known distribution

Literature: Wallace (1967b); Hulley (1973); Séret (1986); Compagno, Ebert and Smale (1989); Smale (2004a); Compagno and Ebert (2007); Aschliman and Ebert (2013c); Weigmann, Stehmann, and Thiel (2014).

Cruriraja Bigelow and Schroeder, 1948

Genus: *Cruriraja* Bigelow and Schroeder, 1948, *Journal of Marine Research*, 7: 549.

Type Species: *Cruriraja atlantis* Bigelow and Schroeder, 1948. Type by original designation.

Number of Recognized Deep-sea Indian Ocean Species: 3.

Synonyms: None.

Field Marks: Small legskates lacking a terminal filament on the snout, with deeply incised pelvic fins, tail stout at base, two dorsal fins, lateral tail fold, and weakly developed caudal fin with a very weakly developed or absent hypocaudal lobe. Disc ventral surface and tail smooth. Colour uniformly brownish to tan or yellowish above, whitish to yellow below.

Diagnostic Features: Disc quadrangular, width 1.3 times disc length; snout pointed, lacking distal process or filament; disc anterior margins to spiracles weakly convex with short concavity near snout tip, weakly concave from spiracles to rounded apices of pectoral fins (more concave in adult males), becoming more convex on posterior margins; snout angle about 80° to 100°. Eye diameter about equal to or slightly greater than inter-orbital distance. Spiracle small, diameter less than eye length. Nostril sub-circular to oval, anterior flap forming a posterolaterally directed tube, mostly obscured by nasal curtain; posterior lobes well developed meeting medially to form nasal curtain; distal ends sub-rectangular with fringe on posterior margin. Mouth slightly arched, teeth arranged in quincunx. Tooth counts 37 to 50 upper jaw, 38 to 48 lower jaw. Pelvic fins large, deeply incised separating anterior from posterior lobes. Tail broad anteriorly, tapering posteriorly to first dorsal fin; width at pelvic-fin insertions about two times width at first dorsal-fin origin; tail moderately long, length greater than disc length; lateral tail folds long and well developed. Two dorsal fins, medium-sized, similar in size and shape with rounded apices. Skin with fine denticles on upper surface; ventral surface mostly smooth. Thorn pattern on dorsal surface (adult): 0 to 5 rostral thorns; 7 to 12 regularly spaced orbital thorns arranged in semi-circular pattern from pre-orbit to anterior margin of spiracle; post-orbital thorns 1 to 2; nuchal thorns 1 to 3; scapular thorns in close-set irregular patches, and numbering from 2 to 9; midback thorns arranged in 1 to 9 linear rows followed by tail thorns usually in 3 to 5 linear rows; predorsal thorns 39 to 47; inter-dorsal thorns 2 to 6; adult males with malar thorns ranging from 1 to 8 (at greatest distance) rows of short strongly recurved thorns and alar thorns ranging from 1 to 5 rows in 16 to 20 columns; ventral surface without thorns. Vertebral counts: predorsal vertebral counts 66 to 70. Spiral valve counts: 6 to 7 for one species. Maximum total length is about 60 cm. **Colour:** dorsal surface uniformly pale brown to tan, reddish, or yellowish; conspicuous dark brown blotches and spots in juveniles; ventral creamy to white or yellowish.

Remarks: The genus comprises eight described species globally, three of which occur in the Indian Ocean. Generic account and Key to Indian Ocean species (below) modified after Aschliman, Ebert and Compagno (2010) and Aschliman and Ebert (2013c).

Key to Deep-sea Indian Ocean Species:

1a. Snout with about 15 rostral thorns (Fig. 76) . . . *Cruriraja andamanica*

1b. Snout with 3 to 7 rostral thorns . . . 2

2a. Thorns present on mid-back, in continuous row, above anterior half of abdominal region; pelvic-fin anterior lobe tips spatulate (Fig. 77) *Cruriraja hulleyi*

2b. Thorns absent on mid-back above anterior half of abdominal region; pelvic-fin anterior lobe tips pointed (Fig. 78) *Cruriraja parcomaculata*

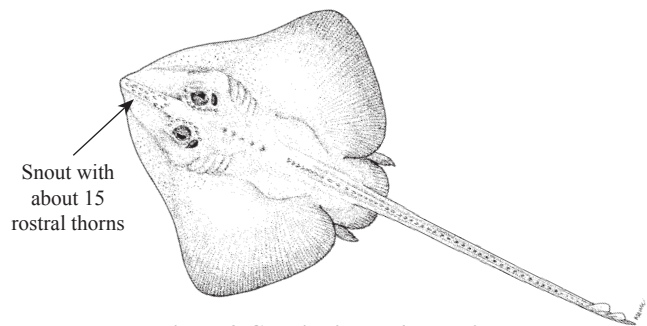


Fig. 76 *Cruriraja andamanica*

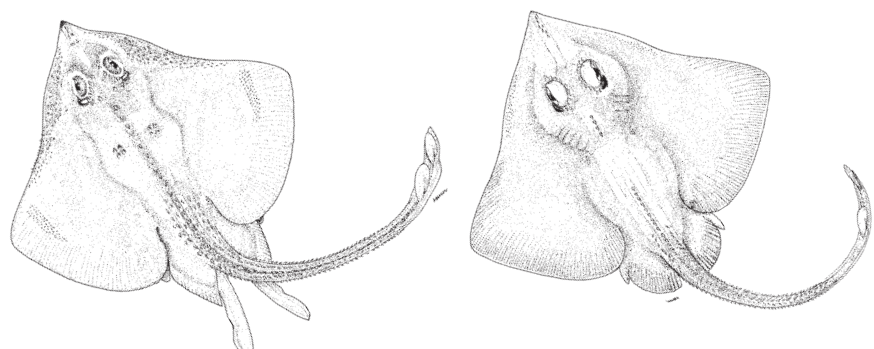


Fig. 77 *Cruriraja hulleyi*

Fig. 78 *Cruriraja parcomaculata*

***Cruriraja hulleyi* Aschliman, Ebert, and Compagno, 2010**

Cruriraja hulleyi Aschliman, Ebert, and Compagno, 2010, *Copeia*, 2010 (3): 364, figs. 1, 2a–b, 3a–b, tab. 1. Holotype: SAM 37618, 514 mm total length, mature male, R/V *Africana* cruise 122, south coast hake biomass survey, station A16438 122 083 3640, South Africa, 34° 29.6'S, 25° 28.3'E, 308 m, 1 July 1994.

Synonyms: *Raia parcomaculata* von Bonde and Swart, 1923: 9, Pl. 21, fig. 2. *Raia miraletus* Barnard, 1925: 68; types of *Cruriraja parcomaculata* Fowler, 1941: 375; KwaZulu–Natal, South Africa, also including *Raia parcomaculata* von Bonde and Swart, 1923, in synonymy. *Raja caudaspinosa* Norman, 1935: 43, west of Cape Town, South Africa. *Raja parcomaculata* Norman, 1935: 46, KwaZulu–Natal, South Africa, doubtful species. *Cruriraja parcomaculata*, Bigelow and Schroeder, 1948: 550, KwaZulu–Natal, South Africa; Bigelow and Schroeder, 1953: 315, KwaZulu–Natal, South Africa; Bigelow and Schroeder, 1962: 199, KwaZulu–Natal, South Africa; Smith, 1964: 288, pls. 26–27, Algoa Bay, South Africa; Hulley, 1970: 157, Pl. 1a, figs. a, b, off Durban, KwaZulu–Natal, South Africa; Hulley, 1972a: 86–96, figs. 58–59; Hulley, 1986: 117, fig. 25.3, Lüderitz, Namibia, to Durban, South Africa; Compagno, Ebert and Smale, 1989: 84, ill., Lüderitz, Namibia, to Durban, South Africa; *Raia smithi*, Smith, 1949: 66, fig. 68, South Africa, thought to be the young of *Bathyraja smithii*; *Cruriraja 'parcomaculata'*, *sensu* Smith, 1964. Compagno and Ebert, 2007: 141–143, fig. 8b; Lüderitz, Namibia, to Algoa Bay and possibly to East London, South Africa; Ebert and Compagno, 2007: 122; Ebert, Compagno and Cowley, 2008: 84–86, figs. 2a, 3a.

Other Combinations: None.

FAO Names: **En** – Roughnose legskate; **Fr** – Raia á nez hérissé; **Es** – Raya nariz áspera.

Field Marks: A rough-legged skate with an acute snout covered with large conspicuous light coloured thorns that are also around the eyes, shoulders, and in multiple rows from the nape to the first dorsal fin. Colour dorsally is a light brown often with scattered darker and lighter spots, very conspicuous on young, but obscure in adults; ventral surface white.

Diagnostic Features: Disc quadrangular, width slightly greater than disc length; snout tip pointed, lacking distal process or filament; disc anterior margins to spiracles weakly convex with short concavity near snout tip, weakly concave from spiracles to rounded apices of pectoral fins (more concave in adult males), becoming more convex on posterior margins; snout angle about 80° to 90°. Eye diameter about equal to inter-orbital space. Spiracle small, diameter about 0.5 to 0.8 times eye length; opening sub-rhomboidal in shape. Nostril sub-circular to oval; nasal anterior flap forming an open posterolaterally directed tube, mostly obscured by nasal curtain; posterior lobes well developed meeting medially to form nasal curtain; distal ends sub-rectangular with fringe on posterior margin. Mouth weakly arched; teeth arranged in quincunx, sexually dimorphic, with a single acute cusp in adult males, blunt and flat in juveniles and females. Tooth counts 37 to 47 upper jaw, 38 to 39 lower jaw. Pelvic fins large, anterior lobes well developed with deep incised separation from posterior lobes. Tail broad anteriorly, tapering posteriorly to first dorsal fin; width at pelvic-fin insertions about two times width at first dorsal-fin origin; tail moderately long, length about 61% of total length; lateral tail folds long and well developed. Dorsal fins medium-sized, similar in shape with rounded apices, first dorsal fin slightly higher and with slightly longer base length than second dorsal fin. Skin smooth except for thorns on dorsal surface; ventral disc surface smooth and lacking thorns. Thorn pattern on dorsal surface (adult): 4 to 5 small rostral thorns; 9 regularly spaced orbital thorns arranged in semi-circular pattern from preorbit to anterior margin of spiracle; 2 post-orbital thorns; 1 to 3 nuchal thorns; scapular thorns in close-set, irregular patches, and numbering from 3 to 9; mid-back thorns arranged in 1 to 5 linear rows followed by tail thorns usually in 5 linear rows; 39 to 47 predorsal thorns; 6 inter-dorsal thorns; adult males with malar thorns ranging from 1 to 5 (at greatest distance) rows of short strongly recurved thorns and alar thorns ranging from 1 to 5 rows in 16 columns. Vertebral counts: predorsal vertebral counts 66 to 69. Spiral valve counts: 6 to 7. Maximum total length is about 59 cm. **Colour:** dorsal surface yellowish to sandy brown lighter near fin margins and lateral to rostral cartilage; conspicuous dark brown blotches and spots in juveniles; ventral surface creamy to white.

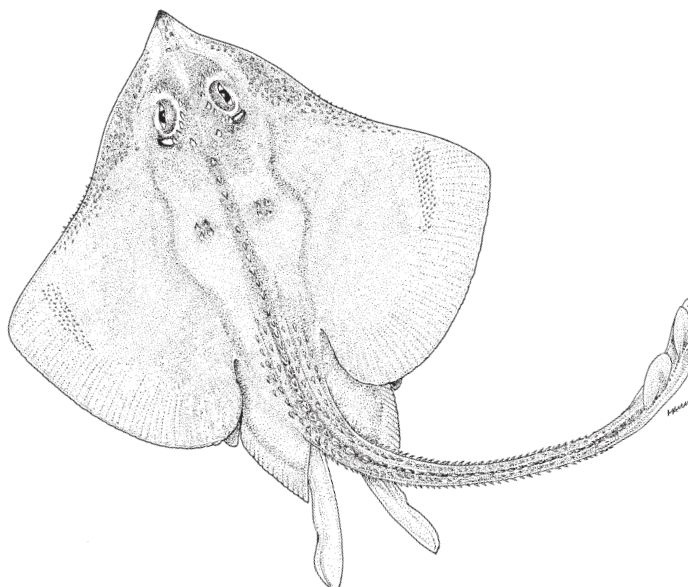


Fig. 79 *Cruriraja hulleyi*

Distribution: Southeast Atlantic and southwest Indian Oceans: southern Africa, from Lüderitz, Namibia to Algoa Bay, and possibly East London, South Africa.

Habitat: A moderately common species of the outer continental shelf and upper slope from 39 to 545 m, but most common between 200 and 500 m.

Biology: Oviparous with no defined reproductive seasonality, and females with egg cases *in utero* year-round. Egg cases small, vase-like, measuring less than 50 cm long excluding horns; surface coarsely striated and with narrow lateral keels; posterior horns about 45% longer than anterior horns, tapering to thin tips curving inwards and with fine attachment fibers; anterior horns hook-shaped, with acute tips.

Diet mainly consists of mysids, and other crustaceans including euphausiids and amphipods; cephalopods and small teleosts are relatively unimportant.

Size: Maximum total length 59.4 cm (female); females mature between 46 and 50 cm; male maximum length 58 cm, size at maturity between 45 and 50 cm. Females and males mature at a slightly smaller size on the south coast compared to the west coast of South Africa. Size at birth uncertain, smallest free-swimming individual was 9.6 cm total length.

Interest to Fisheries and Human Impact: A common bycatch on trawl fisheries, but discarded due to its small size.

The conservation status of this species was assessed as Least Concern, but as *Cruriraja parcomaculata*. As discussed below, *C. parcomaculata* is now known to be a senior synonym of *C. triangularis* and what was formerly referred to *C. parcomaculata* from the west and south coasts of Southern Africa is now known to be *C. hulleyi*.

Local Names: Hulley's skate.

Remarks: Aschliman, Ebert and Compagno (2010) recently clarified the taxonomic status of this species, which had been incorrectly referred to as *Cruriraja parcomaculata*, an east coast species originally described by von Bonde and Swart (1923). Smith (1964) in describing *C. triangularis* stated that the type material of *C. parcomaculata* was lost, but in fact the type material for *C. parcomaculata* had not been lost and had been deposited into the fish collection at the British Museum of Natural History (BMNH 1935.7.14.1). In comparing the type material of *C. parcomaculata* with the two common *Cruriraja* species it is clear that Smith (1964) had misidentified the species described by von Bonde and Swart (1923), and in effect renamed *C. parcomaculata* as *C. triangularis*. In the same publication Smith (1964) redescribed what he believed was *C. parcomaculata* (now = *hulleyi*), but which was in fact an undescribed species. Most subsequent authors since Smith's description had perpetuated this mistake until Compagno and Ebert (2007) recognized this error and the need to formally redescribe Smith's *C. parcomaculata*.

This is one of three legged skates of the genus *Cruriraja* that occurs in the waters off southern Africa. Of the other two species, *Cruriraja parcomaculata* is commonly taken in bottom trawls off the east coast of South Africa and the other species *C. durbanensis* is known only from two specimens taken in deep-water off the west coast of South Africa.

Literature: von Bonde and Swart (1923); Smith (1964); Hulley (1970, 1972a); Compagno, Ebert and Smale (1989); Compagno, Ebert and Cowley (1991); Ebert, Cowley and Compagno (1991); Compagno and Ebert (2007); Ebert and Compagno (2007); Ebert, Compagno and Cowley (2008); Aschliman, Ebert and Compagno (2010); Aschliman and Ebert (2013c).

Dipturus Rafinesque, 1810

Genus: *Dipturus* Rafinesque, 1810, *Caratt. Gen. Spec. Sicil.*: 16.

Type Species: *Raja batis* Linnaeus, 1758 by original designation.

Number of Recognized Deep-sea Indian Ocean Species: 14.

Synonyms: *Raja* (*Dipturus*) as subgenus (Stehmann, 1970).

Field Marks: Most striking external morphological characteristics are the usually long and pointed snout (internarial width less than 70% prenarial snout length), along with markedly concave anterior disc margins. Except for small juveniles, thorns on disc are usually absent, and present only in a median row along tail to first dorsal fin, along with often strong lateral thorns on low edges of tail and sometimes parallel rows on tail. Colour uniformly grey, brown to dark brown to blackish; ventral surface with an irregular pattern of numerous mucus and sensory pores marked as black dots and short streaks (often camouflaged through dark ground colour and/or blackish mucus coverage), as well as pores on upper side of head.



Fig. 80 *Cruriraja hulleyi*

■ Known distribution ■ Possible distribution

Diagnostic Features: Disc rhombic-shaped, moderate to very broad, with outer corners of disc sharply rounded to angular. Snout long to very long, generally exceeding 60% of head length, acutely angled, and moderate to greatly produced beyond anterior margin of disc. Eyes relatively small, diameter less than interorbital distance. Pelvic fins bilobed and continuous, with anterior lobe moderate to very long and approaching length of posterior lobe. Tail relatively short to moderately long and moderately narrow to narrow at base and slightly tapering to slightly broadening distally. Upper disc largely free of denticles and with few moderately small to small thorns. Thorn pattern on dorsal surface: orbital thorns present or absent, if present 1 pre-orbital thorn to about 9 thorns on orbital margin; thorns either present or absent on remainder of disc, if present 1 to several thorns may occur on each shoulder girdle, on nuchal region and in single row from nuchal region to base of tail; usually males with 1 thorn row, females with 3 to 5 rows along midline of tail to origin of first dorsal fin. Vertebral counts: pre-dorsal caudal vertebral counts 42 to 72; trunk vertebral counts 30 to 35. Maximum total length may reach over 200 cm. **Colour:** dorsal surface usually grey, dark brown to almost black and plain or maybe vaguely patterned; ventral surface greyish white to greyish brown with ampullary pores and sometimes ampullary canals darkly pigmented.

Remarks: About 40 species, 14 of which occur in the Indian Ocean deep-sea, but with several additional as yet undescribed species occurring in this region. The javelin skate (*Dipturus doutrei*) occurs primarily in the eastern Atlantic, from Mauritania to Namibia, but with several scattered records from the Eastern Cape Province, South Africa.

The following Key to Species below is modified after Aschliman and Ebert (2013b) and Last and Stevens (2009).

Key to Deep-sea Indian Ocean Species:

- 1a. Known only from the western Indian Ocean 2
- 1b. Known only from southern and western Australia (eastern Indian Ocean) 9
- 2a. Tail relatively long, slender, with width at first dorsal-fin origin less than one-half width at base of tail 3
- 2b. Tail not long, slender, with width at first dorsal-fin origin more than one-half width at base of tail 4
- 3a. Tip of anterior pelvic-fin lobe extending to or beyond distal margin of posterior lobe; length of tail (if intact) from end of second dorsal-fin base to tip greater than 5% of TL (Fig. 81) *Dipturus johannisdavisi*
- 3b. Tip of anterior pelvic-fin lobe not extending to distal margin of posterior lobe; length of tail (if intact) from end of second dorsal-fin base to tip less than 5% of TL (Fig. 82) *Dipturus lanceorostratus*
- 4a. Disc ventral surface broadly covered with denticles (Fig. 83). *Dipturus springeri*
- 4b. Disc ventral surface not broadly covered with denticles, although denticles may occur on snout and along anterior margin. 5
- 5a. Tail relatively short, distance from snout tip to posterior margin of cloaca equal to or greater than sum of distance from posterior margin of cloaca to tip of tail plus distance from tip of snout to anterior margin of upper jaw (Fig. 84). *Dipturus doutrei*
- 5b. Tail relatively long, distance from snout tip to posterior margin of cloaca less than sum of distance from posterior margin of cloaca to tip of tail plus distance from tip of snout to anterior margin of upper jaw 6

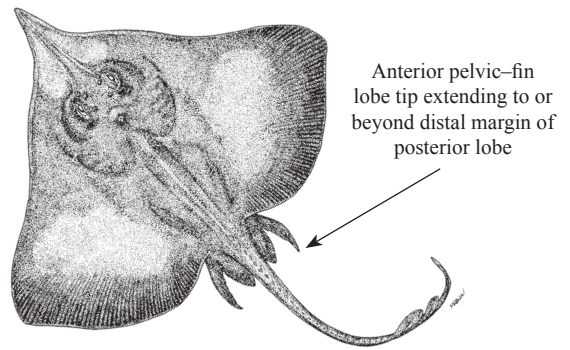


Fig. 81 *Dipturus johannisdavisi*

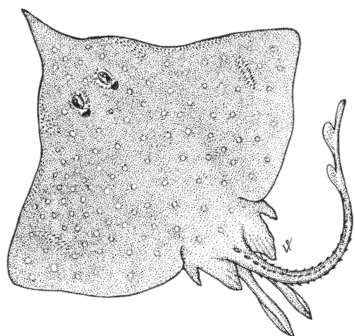


Fig. 82 *Dipturus lanceorostratus*

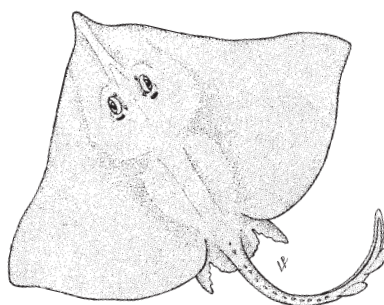


Fig. 83 *Dipturus springeri*

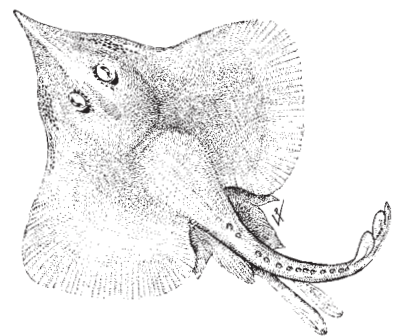


Fig. 84 *Dipturus doutrei*

6a. Snout very long, greatly produced, distance from snout tip to anterior margin of orbit about 5.5 times interorbital distance, preoral snout length about 3 times internarial distance (Fig. 85) *Dipturus stenorhynchus*

6b. Snout moderately long to long, moderately produced to produced, distance between snout tip and anterior margin of orbit about 3.0 to 4.5 times interorbital distance, preoral snout length about 2.5 or fewer times internarial distance 7

7a. Dorsal surface medium brown to greyish brown, without small dark spots; no mid-row thorns on disc (Fig. 86) *Dipturus crosnieri*

7b. Dorsal surface of disc light brown, with scattered small dark spots; mid-row thorns on posterior half of disc. 8

8a. Two poorly developed nuchal thorns; disc width at level of orbits 1.7 to 1.9 times preorbital length (Fig. 87) *Dipturus campbelli*

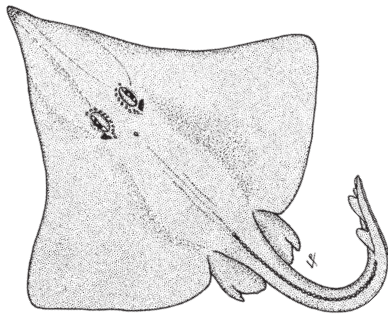


Fig. 85 *Dipturus stenorhynchus*

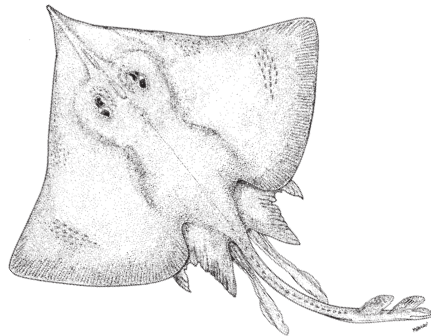


Fig. 86 *Dipturus crosnieri*

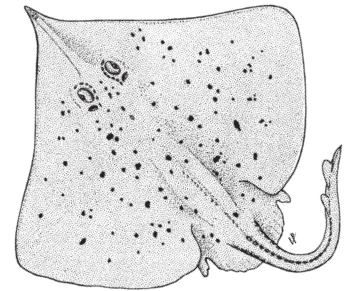


Fig. 87 *Dipturus campbelli*

8b. Single well developed nuchal thorn; disc width at level of orbits 2.3 to 2.5 times preorbital length (Fig. 88) *Dipturus pullopunctatus*

9a. Preorbital snout length more than five times orbit diameter; pectoral-fin apices distinctly angular 10

9b. Preorbital snout length less than five times orbit diameter; pectoral-fin apices broadly to narrowly rounded 13

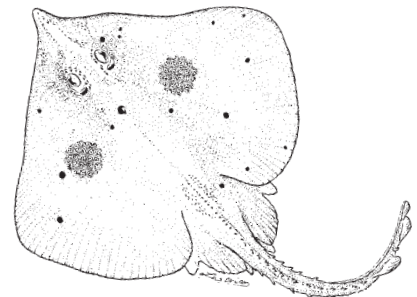


Fig. 88 *Dipturus pullopunctatus*

10a. Snout moderately elongated; disc ventral surface mostly blackish, slightly darker than dorsal surface; mucous pores on ventral snout surface not very distinctive against dark black coloured background (Fig. 89) *Dipturus wengi*

10b. Snout extremely elongated; disc ventral surface usually lighter, not darker than dorsal surface; mucous pores on ventral snout surface dark-edged, very distinctive against light coloured background. 11

11a. Pectoral-fin apices forming acute angle; nuchal thorns absent; malar thorns absent in adult males (Fig. 90) *Dipturus gudgeri*

11b. Pectoral-fin apices sharply angular; nuchal thorns usually present (except in *D. healdi*); malar thorns present in adult males. 12

12a. Snout extremely elongated; nuchal thorns present; pectoral-fin edges dark on ventral surface. (southern Australia) (Fig. 91) *Dipturus acrobelus*

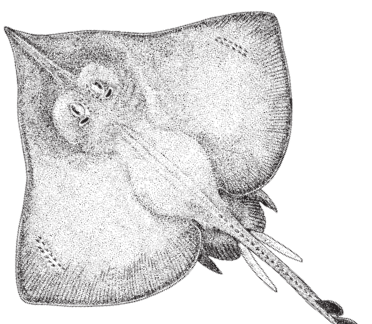


Fig. 89 *Dipturus wengi*

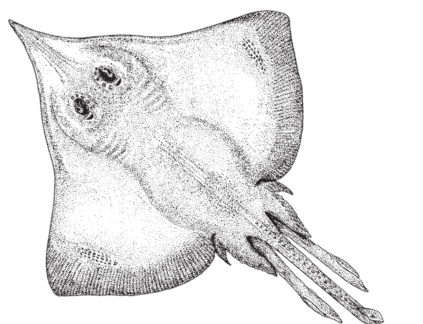


Fig. 90 *Dipturus gudgeri*

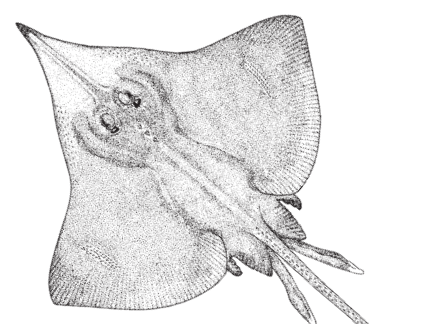


Fig. 91 *Dipturus acrobelus*

- 12b.** Snout moderately elongated; nuchal thorns rarely present; pectoral-fin edges lighter on ventral surface. (tropical Western Australia)(Fig. 92) *Dipturus healdi*
- 13a.** A single prominent dark ocellus on each pectoral fin (Fig. 93) *Dipturus oculus*
- 13b.** No prominent dark ocelli on pectoral fins (Fig. 94). *Dipturus canutus*

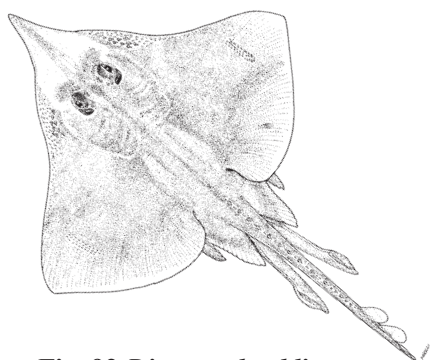


Fig. 92 *Dipturus healdi*

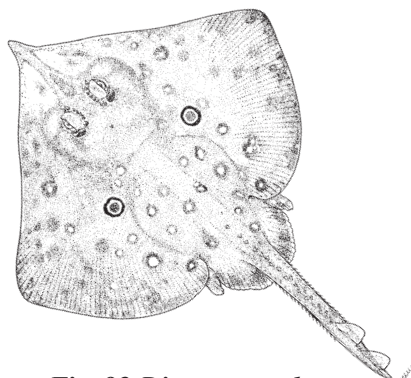


Fig. 93 *Dipturus oculus*

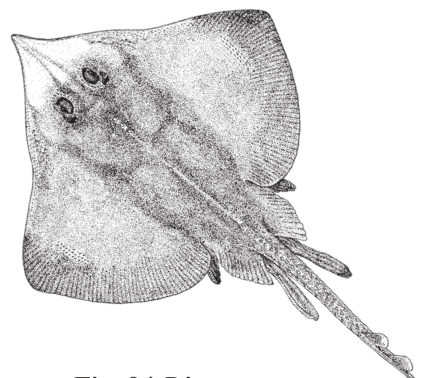


Fig. 94 *Dipturus canutus*

***Dipturus campbelli* (Wallace, 1967)**

Raja campbelli Wallace, 1967b, *S. Afr. Ass. Mar. Bio. Res., Oceanogr. Res. Inst., Invest. Rept.* (17): 24, fig. 12. Holotype: SAIAB [formerly RUSI] 992 [ex ORI B804], 663 mm TL female, 39 km East of Durban, KwaZulu-Natal, South Africa, 320 m.

Synonyms: *Raja pullopunctata* Hulley, 1970, *Ann. S. Afr. Mus.*: 55(4): 166. Hulley, 1986, *Smith's Sea Fishes*: 123.

Other Combinations: None.

FAO Name: En – Blackspot skate.

Field Marks: A longnose skate with an elongated, acutely triangular snout, a stout tail, slightly shorter than body length, and slightly swollen along mid-section, disc with rounded corners and smooth underside except for small denticles on edges and tip of snout and small thorns on nape and mid-back to first dorsal fin. Colour is a greyish-brown above, grey ventrally, with numerous small-scattered black spots.

Diagnostic Features: Disc rhombic-shaped, rather narrow, less than 60% total length, and with lateral corners angled with slightly rounded tips; snout length 17 to 20% total length, moderately produced, acutely triangular but not attenuating from the anterior margin of disc; snout angle in front of spiracles about 92° to 108°. Total pectoral radial counts not available. Mouth broad and weakly arched; teeth arranged in quincunx. Tooth counts 38 to 45 upper jaw, 38 to 42 lower jaw. Anterior pelvic-fin lobes of moderate length, not extending to posterior margin of posterior lobe. Tail relatively short, slightly shorter than distance from tip of snout to posterior margin of cloaca, and moderately wide over length to slightly broader at mid length than at base. Dorsal fins medium-sized, similar in shape with rounded apices, first dorsal fin slightly higher and with slightly longer base length than second dorsal fin. Skin mostly smooth, with fine spicules on margins of anterior upper disc surface; ventral surface mostly smooth. Thorn pattern on dorsal surface (adult): rostrum with minute spicules near tip; 7 regularly spaced orbital thorns arranged in semi-circular pattern from preorbit to anterior margin of spiracle; 1 to 2 nuchal thorns; mid-back thorns arranged in single linear row and extending to first dorsal fin; 20 to 24 predorsal thorns; 1 or 2 inter-dorsal thorns; short lateral row of thorns along anterior portion of tail originating near posterior margin of pelvic fins; adult males with minute malar thorns and alar thorns ranging from 1 to 3 rows in 10 columns; ventral surface usually without thorns. Vertebral counts not available. Spiral valve counts not available. Maximum total length is about 66 cm.

Colour: medium grey or brownish above with numerous small black spots; underside grey with conspicuous black pores.

Distribution: Southwestern Indian Ocean: east coast of South Africa and Mozambique.

Habitat: A little known skate of the outer continental shelves and upper slopes from 137 to 403 m deep. Its distribution appears to be somewhat patchy.

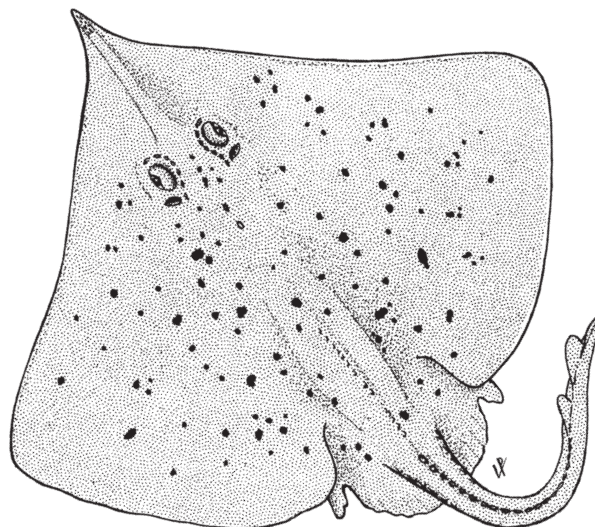


Fig. 95 *Dipturus campbelli*

Biology: Very little known. Egg cases have not been described for this species.

Size: Maximum total length 66.3 cm (female); size at maturity is 63.5 cm for females and 56.5 cm for males; maximum male length is 59.5 cm. Size at birth uncertain, but smallest known free-swimming individuals measured 18 and 20 cm total length.

Interest to Fisheries and Human Impact: None, this species is taken as bycatch in trawl fisheries, but there is no information on trends in catches of this species where it is known to occur.

The conservation status of this skate is Near Threatened due to its apparent limited distribution.

Local Names: None.

Remarks: *Dipturus campbelli* and *D. pullopunctatus* were referred to collectively by earlier researchers as the European *Raja batis* (Thompson, 1914; von Bonde and Swart, 1923) until Smith (1964) distinguished *D. pullopunctatus* from *R. batis*. Hulley (1966) confirmed Smith's distinction, but noted that two large "black bellied" skates occurred in South African waters, one being *D. pullopunctatus* and the other being *D. campbelli* that was later described by Wallace (1967b).

Literature: Wallace (1967b); Compagno, Ebert and Smale (1989); Séret (1989); McEachran and Dunn (1998); Smale (2004b); Compagno and Ebert (2007); Ebert and Compagno (2007); Ebert, Compagno and Cowley (2008); Aschliman and Ebert (2013b); D.A. Ebert (unpubl. data).

Dipturus crosnieri (Séret, 1989)

Raja (Dipturus) crosnieri Séret, 1989, *Cybium* 13(2): 116, fig. 1–9. Holotype: MNHN-1988.1089, 573 mm total length, adult male, off SW coast of Madagascar, 22°05–30'S, 43°00–09'E, 300–850 m.

Synonyms: None.

Other Combinations: None.

FAO Name: En – Madagascar skate.

Field Marks: A relatively small skate with a rhombic shaped disc, sharply rounded pectoral-fin corners, a long slender tail about equal to disc length, and upper surface with prickles along anterior margins of disc and on snout. Colour is a plain brown to greyish brown above, ventral surface also brownish, but with white mottling in juveniles.

Diagnostic Features: Disc distinctly rhombic-shaped, 1.3 times as wide a long; disc width 65 to 75% total length; maximum disc width broad, 63.5 to 65.5% of disc length, behind level of shoulder girdle; outer corners of disc sharply rounded; snout elongated, 17 to 21% total length and distinctly produced; preorbital length about 4.3 to 5.0 times inter-orbital width; snout angle at about 71° to 87°

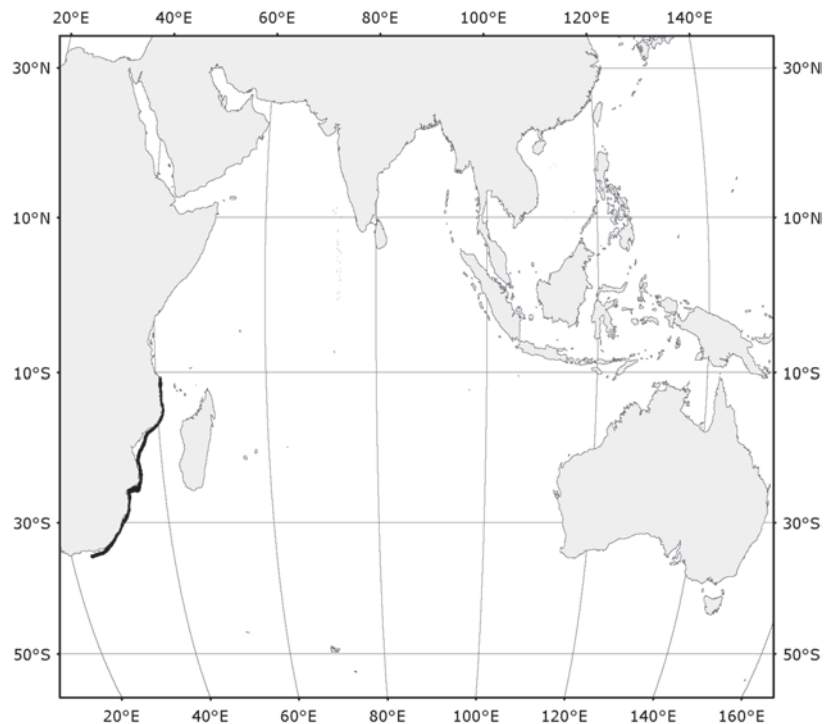


Fig. 96 *Dipturus campbelli*

■ Known distribution

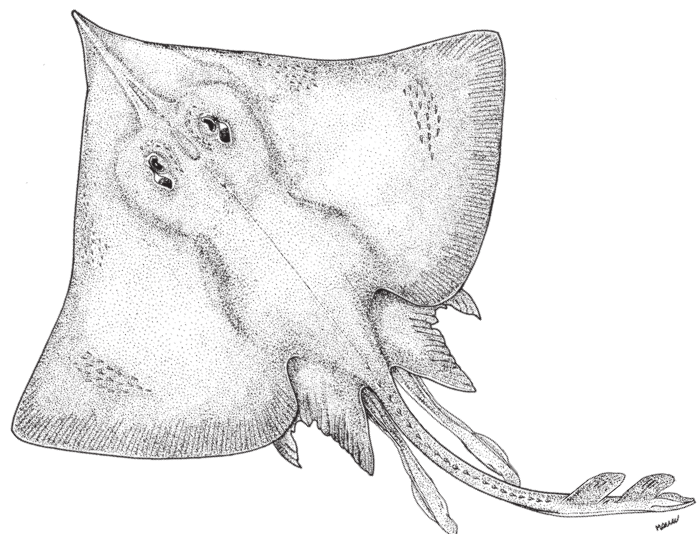


Fig. 97 *Dipturus crosnieri*

(young juveniles 90° to 95°). Pelvic fins deeply incised, anterior pelvic-fin lobes slender, of moderate length, not extending to posterior margin of posterior lobes. Tail moderately long, 45 to 54% total length, slightly longer than distance from tip of snout to posterior margin of cloaca, and moderately narrow at base but slightly broader at midlength. Orbits large, diameter about equal to inter-orbital width, and about 5 times in pre-orbital snout length. Spiracles about half as long as orbits. Nasal curtain subrectangular, with undulated outer margin, posterior margin transverse and set with relatively long lobelets, some being bifid or trifid. Mouth slightly arched; teeth arranged in quincunx, sexual dimorphism strong, adult male teeth with a single large acutely pointed cusp on a rounded crown; tooth shape changes posteriorly with cusp becoming indistinct at mouth corners; teeth of juveniles and adult females bluntly rounded, without a distinct cusp. Tooth counts 31 to 37 upper jaw, count not available for lower jaw. Dorsal fins are similar in size and shape, triangular with a broadly rounded apex and posterior margin; interdorsal space short, 0.9 to 1.9% total length. Caudal-fin fold long and low, continues ventrally as a very low fold to below the posterior one-third of postdorsal section of tail. Disc surfaces covered with coarse prickles, especially along anterior margins and on dorsal and ventral snout surfaces. Thorn pattern on dorsal surface: 8 to 13 (on adult) and 4 to 9 (on juvenile) small orbital thorns arranged in semi-circular pattern from preorbit to anterior margin of spiracle; 1 to 2 nuchal thorns; suprascapular thorns absent; mid-back and tail thorns arranged in single row of 20 to 31 (adult) and 14 to 26 (juvenile) thorns; females with irregular row of thorns on each side of tail; interdorsal space with 0 to 1 thorn; adult males with malar thorns and 14 to 34 alar thorns in 2 to 4 longitudinal rows; ventral surface smooth, without thorns. Vertebral counts: predorsal caudal vertebrae 51 to 60. Spiral valve counts not available. Maximum total length about 61 cm. **Colour:** after preservation dorsal surface uniformly greyish brown to brown; ventral surface white with dark margins along pectoral-fin margins in juveniles and dark brown in adults.

Distribution: Southwestern Indian Ocean: known only from off western coast of Madagascar at the present time

Habitat: A relatively small dipturid skate from the slopes off Madagascar at 300 to 850 m deep.

Biology: Unknown.

Size: Maximum known total length 61 cm (female) and 59.7 cm (male); male size at maturity about 55 cm and female size at maturity about 57 cm. Size at birth unknown.

Interest to Fisheries and Human Impact: Of no interest to fisheries, this species may be taken on occasion as bycatch in other fisheries such as for deep-water shrimps (*Heterocarpus* spp.).

The conservation status of this deep-water skate is Vulnerable due to concern over development of deep-sea fisheries.

Local Names: None.

Remarks: The only specimens of this rare species are from the type series.

Literature: Séret (1989); Brash, Séret and Compagno (2006); Ebert and Compagno (2007); Aschliman and Ebert (2013b).

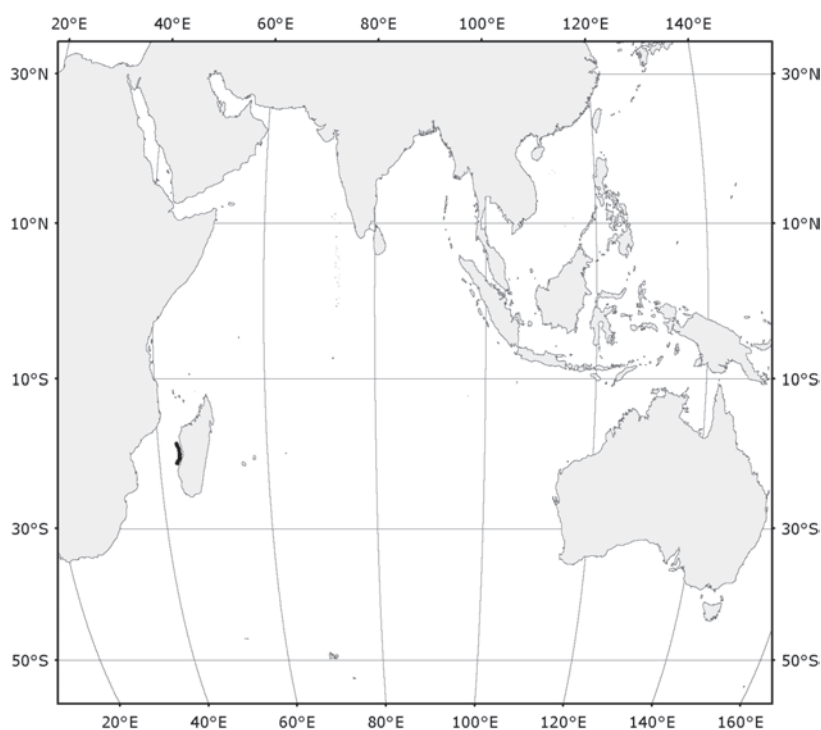


Fig. 98 *Dipturus crosnieri*

Known distribution

Dipturus gudgeri (Whitley, 1940)

Zearaja gudgeri Whitley, 1940, *Royal Soc. New South Wales, Zoological Handbook*, pt. 1: 188, fig. 217. Holotype: AMS E.4284, 706 mm total length, 490 mm disc width, immature male, Great Australian Bight, Western Australia.

Synonyms: None.

Other Combinations: None.

FAO Name: En – Greenback skate.

Field Marks: A large skate (length up to 184 cm) with a relatively long, firm snout, a distinctive rosette of thorns around the eye (adults), and a relatively short, slender tail, its length less than disc length. Dorsal surface is a uniform greyish green; ventral surface dusky.

Diagnostic Features: Disc rhombic, its width less than 1.2 times length; disc width 69% total length; snout firm, very long (22.8 to 24.5 % total length), tip greatly produced, with an angle in front of spiracles of about 71° to 76°. Anterior disc margins undulate, acutely pointed at apices, posterior margins convex, and free rear tips broadly rounded. Total radial counts: pectoral radial counts 103 to 104. Pelvic fins deeply incised, anterior lobe long, extending beyond posterior lobe in juveniles and female specimens, and in large adult males about 1.75 times in posterior lobe length. Tail depressed, tapering posteriorly, relatively short, length about 0.7 to 0.8 times precloaca length. Orbits small, diameter about 1.2 to 1.9 times in inter-orbital width. Nasal curtain with undulated outer margin, posterior margin fringed. Mouth moderately arched; teeth arranged in quincunx, no sexual dimorphism in tooth shape reported. Tooth counts: 44 upper jaw, 40 to 44 lower jaw. Dorsal fins similar in size and shape, first dorsal fin slightly higher, more erect than second, broadly rounded at apices, its posterior margin short and convex; interdorsal space short, distance about 25% of eye diameter. Caudal fin poorly developed, base long and low, height less first dorsal-fin base. Disc dorsal surface smooth in juveniles, with fine patches of prickles on females, and coarser prickles on head and pectoral-fin anterior margins of large males; ventral surface mostly smooth to sandpaper-like with fine prickles on snout tip and anterior margins of juveniles, and around cloaca region on large males. Thorn pattern on dorsal surface: orbital thorns forming a rosette around eye in adults; juveniles with fewer thorns around eyes, usually 2 pre-, 1 median-, and 1 post-orbital thorns; nuchal, scapular, and mid-back thorns absent; tail thorns in 1 to 3 rows in adults, 1 row in juveniles; adult males with alar thorns, but malar thorns absent; ventral surface smooth, without thorns. Vertebral counts: trunk vertebral count 28, predorsal vertebral count 86, diplospondylous vertebral count 58. Spiral valve counts not available. Maximum length about 184 cm. **Colour:** dorsal surface uniformly grey to greyish-green, especially in adults, more brownish in some juveniles, slightly paler on snout above rostral cartilage; pectoral and pelvic posterior fin edges darker; juveniles often with dusky coloured blotches; ventral surface similar to dorsal, with very dark pectoral-fin margins; ventral pores greyish to black.

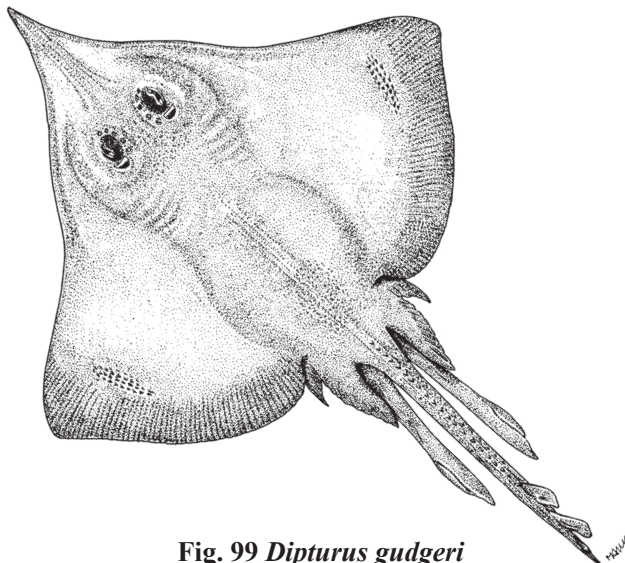


Fig. 99 *Dipturus gudgeri*

Distribution: Southern Australia: from Tweeds Head, New South Wales to Geraldton, Western Australia, including Tasmania.

Habitat: This skate occurs from the outer continental shelf to upper slopes from about 160 to 765 m deep. It seems to be most common in waters between 400 and 550 m deep, and to occur on muddy substrate.

Biology: Oviparous, but very little else is known about their reproductive cycle. The golden brown coloured egg cases are large, measuring about 19 cm in length, excluding the horns, and about 7 to 9 cm in width; surface texture with thick layer of fibroids on both sides of egg case; attachment fibers are present along the lateral margin; posterior horns enclosed in apron with the tips of each horn extending only slightly from the apron; anterior apron deeply arched and with horns curving inwards.

The maximum age is about 18 years for males and 17 years for females. Males mature at about 13 years, but female age at maturity in uncertain.

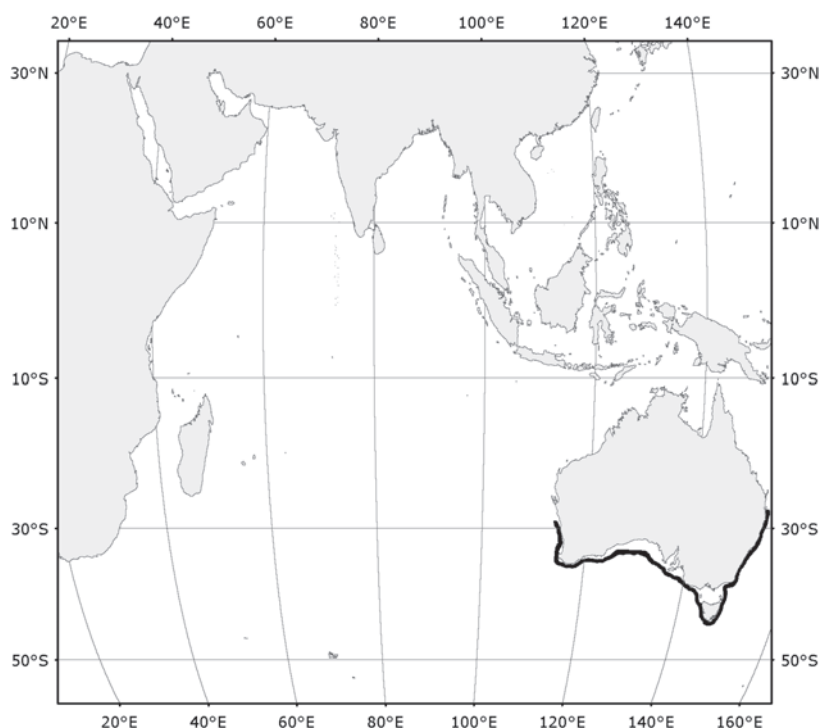


Fig. 100 *Dipturus gudgeri*

Known distribution

The diet includes mostly small bony fishes.

Size: Maximum total length at least 184 cm (females) and 156 cm (males); size at maturity for males and females is at about 120 cm and larger. Size at birth is about 20 to 26 cm based on smallest free-swimming individuals.

Interest to Fisheries and Human Impact: Of very little interest, the species is mostly discarded except for larger specimens that may be retained and sold at market. From 2005 to 2007 between 13 and 22% of *Dipturus gudgeri* were retained for market.

The conservation status of this large skate species is Near Threatened as catch rates appear to have declined between the 1970s and later 1990s.

Local Names: Bight skate (Australia).

Remarks: The rather large skate only known from southern Australia has sometimes been placed in the genus *Zearaja*.

Literature: Whitley (1940); Last and Stevens (1994, 2009); Treloar, Laurenson and Stevens (2006, 2007); Treloar (2008, 2009a).

Fenestraja McEachran and Compagno, 1982

Genus: *Fenestraja* McEachran and Compagno, 1982, *Bulletin Marine Science*, 32(2): 423.

Type Species: *Raja plutonia* Garman, 1881 by original designation, a synonym of *Gurgesiella* de Buen, 1959, but a valid genus as described.

Number of Recognized Deep-sea Indian Ocean Species: 2.

Synonyms: None.

Field Marks: Small skates with heart-shaped disc, small to moderate sized thorns along margins of eye orbits, scapular and nuchal regions, and along the midback and tail in 1 to 3 rows, snout angular to broadly rounded, tail with or without ventral caudal lobe, and length more than one-half total length. Colour is plain, mottled with irregular blotches or marked small dots above, and whitish below.

Diagnostic Features: Disc heart-shaped, narrow, usually less than 55% total length, with narrow to broadly rounded outer corners. Snout short, less than 11% total length, with tip slightly produced as small triangular process. Orbits relatively large, diameter equal to or greater than interorbital distance. Pelvic fins bilobed and continuous, with anterior lobe long, extending nearly to or beyond margin of posterior lobe. Tail very long, greater than 60% total length, slender at base and tapering distally. Anteriormost extension of pectoral fin abutting or nearly abutting tip of snout, not separated from snout by semi-translucent area; tip of snout flexible. Dorsal disc usually densely covered with denticles. Thorns on dorsal surface moderate to small in size and occurring over rostrum, on orbital margin, on nuchal and scapular regions but not forming triangular patch, and along midline of disc and tail in one irregular row with or without irregular lateral rows. Vertebral counts: predorsal caudal vertebral counts 64 to 84. Adults may reach 42 cm in total length. **Colour:** dorsal surface light tan to dark brown and either plainly coloured or patterned with dark spots, blotches, ocelli, or bars; ventral surface light tan to whitish.

Remarks: The genus comprises 8 species globally, with most occurring in the western Central Atlantic, but also in the western Pacific and Indian Ocean, where two species are known to occur. Genus follows Aschliman and Ebert (2013b).

Key to Deep-sea Indian Ocean Species:

1a. Disc heart-shaped; snout with small projection at tip; interdorsal space distinct, second dorsal fin separated from caudal fin (Fig. 101)
 *Fenestraja maceachrani*

1b. Disc rhombic-shaped; snout without small projection at tip; interdorsal space small, second dorsal fin confluent with caudal fin (Fig. 102)
 *Fenestraja mamillidens*

Small projection at
snout tip

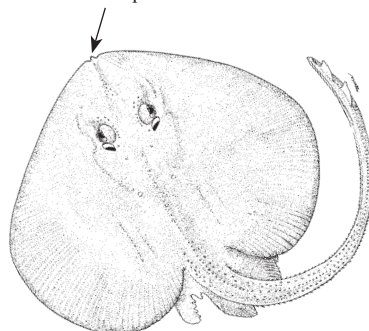


Fig. 101 *F. maceachrani*

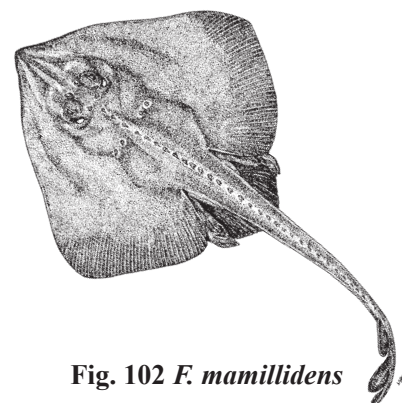


Fig. 102 *F. mamillidens*

***Fenestraja maceachrani* (Séret, 1989)**

Gurgesiella (Fenestraja) maceachrani Séret, 1989, *Cybiurn* 1989, 13(1): 56, figs. 1–3. Holotype: MNHN–1988.641, 415 mm total length, female, 12°28'S, 48°11'E, 600 to 605 m.

Synonyms: None.

Other Combinations: None.

FAO Name: En – Madagascar pygmy skate.

Field Marks: A deep-water skate with a heart-shaped disc, broadly rounded outer and inner pectoral corners, a short, bluntly angled snout, with a small triangular process at its tip, tail slightly longer than disc length and slender, pelvic fins deeply incised with the anterior lobe length about the same length as the posterior lobe, but not reaching posterior margin of posterior lobe, two subtriangular shaped dorsal fins and a caudal fin with a very short, low ventral fold. Colour is light tan above, with no mottling or distinct patterns.

Diagnostic Features: Disc heart-shaped, width about 1.2 times as broad as long, with outer corners broadly rounded; disc length about 40.8 to 42.6% of total length; snout moderately short, between 9 and 11% total length, tip bluntly angled; snout angle at about 125° to 133°. Anterior pelvic-fin lobes moderately long but fail to reach posterior margin of posterior lobe. Tail long, about 62 to 64% total length, and slender, semi-circular in cross-section, dorsal side rounded, ventral side flat. Eyes very large, diameter almost as long as inter-orbital space, and 37 to 39% preorbital snout length. Spiracles small. Nasal curtain subrectangular, with rounded margins, posterior margins with short lobelets; oronasal pits present. Mouth weakly arched; teeth small, with oval crown and a short, blunt median cusp, arranged in quincunx; sexual dimorphism of teeth not reported. Tooth counts 39 to 40 upper jaw, count not available for lower jaw. Dorsal fins small and separated at base by distance less than one-half first dorsal-fin base length. Disc covered with coarse denticles. Thorn pattern on dorsal surface: a patch of 3 to 6 preorbital thorns; 2 to 6 small orbital thorns arranged in semi-circular pattern from preorbit to anterior margin of spiracle; 7 to 8 nuchal thorns in irregular row; 1 to 2 suprascapular thorns and 2 scapular thorns on each shoulder; mid-back and tail thorns arranged in irregular, parallel rows of 76 to 80 thorns, thornlets on lateral tail row more distinct and regularly spaced; 0 to 1 interdorsal thorns; 0 to 3 small thorns between second dorsal-fin base and caudal fin; ventral surface smooth, void of dermal denticles and thorns. Vertebral counts: predorsal caudal vertebral counts 79 to 82. Spiral valve counts not available. Maximum total length at least 41.5 cm. **Colour:** after preservation dorsal surface is beige to pale tan without patterning; ventral surface is whitish with mottling of brownish blotches.

Distribution: Southwestern Indian Ocean: Madagascar.

Habitat: Found along upper slopes off Madagascar at about 600 to 765 m, on calcareous sandy and mud bottoms. Nothing else is known about its habitat.

Biology: Oviparous, but nothing else known.

Size: Maximum total length at least 41.5 cm (female). Size at birth unknown, but smallest free-swimming individual was 23.3 cm long.

Interest to Fisheries and Human Impact: None, it may be taken on occasion as bycatch.

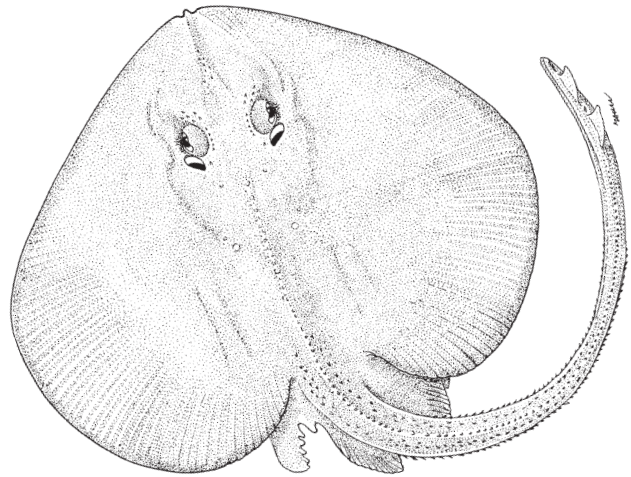


Fig. 103 *Fenestraja maceachrani*



Fig. 104 *Fenestraja maceachrani*

Known distribution

The conservation status of this skate is Data Deficient.

Local Names: Heart skate; McEachran's skate.

Remarks: This skate is known from only two female specimens taken in very deep-water off Madagascar.

Literature: Séret (1989); Holtzhausen, Compagno and Ebert (2009); Aschliman and Ebert (2013b).

***Leucoraja* Malm, 1877**

Genus: *Leucoraja* Malm, 1877, *Göteborgs och Bohusläns Fauna*: 609–610.

Type Species: *Raja fullonica* Linnaeus, 1758 by subsequent designation of Jordan (1919).

Number of Recognized Deep-sea Indian Ocean Species: 3.

Synonyms: *Raja* (*Leucoraja*) as subgenus (Stehmann 1970).

Field Marks: Disc subcircular, tail length about equal to or somewhat longer than body length, median row of thorns on back and trunk and along tail becoming gradually reduced with growth and completely disappearing in large adults, concurrently one or more parallel rows of thorns increasing in size, orbital thorns set as continuous half-rings, with additional thorns over nape and shoulder region forming a triangle. Colour on dorsal surface range from a light to dark background and with a plain to colorful pattern of spots, rings, ocelli or reticulations.

Diagnostic Features: Disc heart-shaped, moderate to relatively broad, usually greater than 52% total length, with outer corners narrowly to broadly rounded. Snout moderately short and broad, with tip slightly produced beyond anterior margin of disc as small oblique process. Orbits moderately sized, diameter slightly less to slightly greater than interorbital distance. Pelvic fins bilobed and continuous, with anterior lobe usually much shorter than posterior lobe, rarely about as long as posterior lobe. Tail relatively short, generally less than 60% of total length, and relatively broad at base and attenuated distally. Dorsal fins rather large and confluent or separated by a distance less than half of first dorsal-fin base. Dorsal surface sparsely to densely covered with coarse denticles, generally more dense in juveniles than in adults. Moderate sized thorns on tip of snout, along orbital rim, medial to spiracles, forming triangular patch on nuchal and scapular regions, and along mid belt of disc and tail in several fairly regular rows, with mid row along mid length of disc and tail reduced or absent in large juveniles and adults. Vertebral counts: predorsal caudal vertebral counts 64 to 81. Adult maximum total length about 40 to 150 cm. **Colour:** dorsal surface tan to dark grey or brown, and either plain or patterned with spots, bars or ocelli; ventral surface light and either plainly coloured or with dark blotches.

Remarks: The genus comprises 13 species, with a few more known but not yet described species. Three species are known to occur in the Indian Ocean.

Key to Deep-sea Indian Ocean Species:

1a. Anterior pelvic-fin lobe about as long as posterior lobe; tooth rows about 38 (Fig. 105). *Leucoraja compagno*
(endemic to Southern Africa)

1b. Anterior pelvic-fin lobe considerably shorter than posterior lobe; tooth rows 43 to 69 **2**

2a. Dorsal fins confluent at base (Fig. 106) *Leucoraja pristispina*
(endemic to Australia)

2b. Dorsal fins separated by small space at base (Fig. 107). *Leucoraja wallacei*
(endemic to Southern Africa)

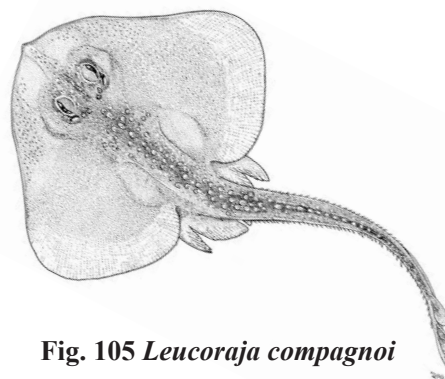


Fig. 105 *Leucoraja compagno*

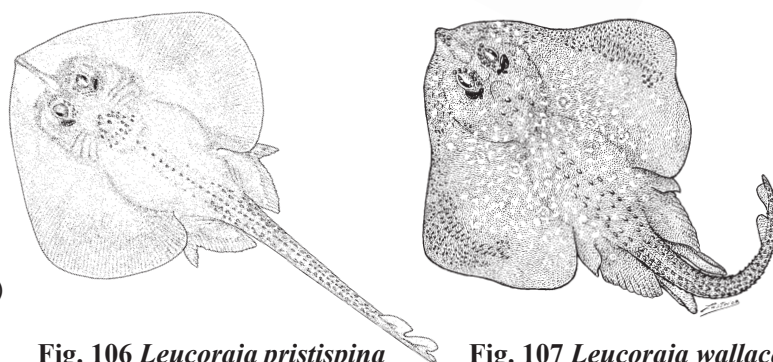


Fig. 106 *Leucoraja pristispina*

Fig. 107 *Leucoraja wallacei*

***Leucoraja wallacei* (Hulley, 1970)**

Raja wallacei Hulley, 1970, *Ann. S. African Mus.*, 55(4): 210, pl. 12, figs. 19. Holotype: ORI B.126, 842 mm total length, adult male, off Cape Town, 34°10'S, 17°45'E, 292 m.

Synonyms: *Raja barnardi* (non Norman) Wallace, 1967b: 39, figs. 20–21. *Raja (Leucoraja) wallacei* Hulley, 1972a: 77.

Other Combinations: None.

FAO Name: En – Yellowspotted skate.

Field Marks: A distinctive medium-sized skate with a relatively short, blunt, broad snout, moderately broad disc, with 2 to 4 very rough rows of thorns from mid-back to first dorsal fin, disc apices broadly rounded and tail longer than the disc length. Colour is a yellowish-brown with very distinctive bright yellow spots, often in rosettes and whorls, sometimes forming eye-like markings on pectoral-fin bases; ventral surface mostly white.

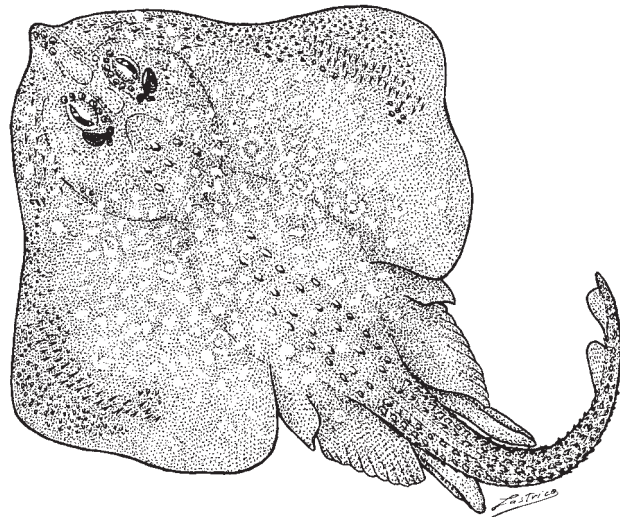


Fig. 108 *Leucoraja wallacei*

Diagnostic Features: Disc moderately broad, 56 to 62.5% total length, 1.2 to 1.3 times as wide as long, with outer corners broadly rounded. Snout relatively short in length, slightly produced, obtuse, with rounded terminal process; snout length 9.6 to 11% TL, 2.3 to 3.1 times interorbital distance; angle of snout anterior to spiracles 110°. Nasal curtain fringed. Mouth slightly arched. Tooth counts in upper jaw 59 to 67; teeth sexually dimorphic, with male cusps sharper than those of females. Anterior pelvic-fin lobes relatively short, considerably shorter than posterior lobes. Tail relatively short, 53 to 55% TL, and moderately broad at base and attenuated distally. First dorsal fin larger than second, separated by a small space. Between 7 and 10 small thorns on orbital rim, 2 and 3 supraspiracular thorns, triangular patch of thorns over nuchal and scapular region, mid-dorsal thorns either absent or about 34 from nuchal region to first dorsal-fin origin, flanked by an additional row on each side, becoming two flanking rows at pelvic fins to first dorsal-fin origin; no interdorsal thorns. Mid row of thorns on disc and tail either smaller, partially absent or totally absent in large juveniles and adults. Dorsal surface with spinules on snout tip, anterior margin of disc and tail; below, spinules on snout tip and anterior margin of disc. Vertebral counts: predorsal caudal vertebrae 64 to 74. Spiral valve counts not available. Moderate-sized skate, maximum size 96.3 cm total length. **Colour:** yellowish-brown above with scattered, bright yellow spots sometimes in rosettes or whorls; mottled eyespot at the base of each pectoral fin; lower surface pale, with a single, dark blotch on tip of anterior lobe of pelvic fins.

Distribution: Southeastern Atlantic and southwestern Indian Ocean: from southern Namibia to southern Mozambique.

Habitat: A little known skate with a patchy distribution off the west and south coasts of South Africa. It occurs from the outer continental shelf to upper slopes from 73 to 517 m deep, with most records from between 150 and 300 m. The distribution of this species is bimodal off the west and



Fig. 109 *Leucoraja wallacei*

■ Known distribution

southeast coasts of South Africa, with the highest concentrations between the Orange River and Cape Columbine, and between Cape Point and Cape Agulhas to Algoa Bay.

Biology: Oviparous, with medium-sized egg cases measuring about 80 to 83 mm, excluding horns, with a surface of very fine striations, smooth, with no fibres or lateral keels, and a posterior horn length nearly twice that of the anterior horns. There does not appear to be a defined breeding season as females with egg cases *in utero* have been observed year-round. The age at maturity has been estimated at about nine years, with an estimated longevity of 15 years. The diet of this skate mostly includes prawns and small bony fishes including dragonets and ophichthid eels.

Size: Maximum total length is 87.0 cm (males) and 96.3 cm (females); size at maturity is between 64 and 77 cm for males and 64 to 73 cm for females. Size at birth is uncertain, but based on the smallest free-swimming individuals it is less than 16 cm.

Interest to Fisheries and Human Impact: Of no commercial fishing interest, this moderate-sized skate species is a common bycatch species, but is usually discarded.

The conservation status of this skate is Least Concern.

Local Names: Yellowspotted skate, Blancmange skate, Witpoeding-rog.

Remarks: The above genus and species accounts are modified after Ebert and Stehmann (2013) and Aschliman and Ebert (2013b).

Literature: Hulley (1970, 1972a); Compagno, Ebert and Smale (1989); Compagno, Ebert and Cowley (1991); Ebert, Cowley and Compagno (1991); Compagno and Ebert (2007); Ebert and Compagno (2007); Ebert, Compagno and Cowley (2008); Smale (2009); Aschliman and Ebert (2013b).

Neoraja McEachran and Compagno, 1982

Genus: *Neoraja* McEachran and Compagno, 1982, *Bull. Mar. Sci.* 32(2): 399–425.

Type Species: *Breviraja caerulea* Stehmann, 1976 by original designation.

Number of Recognized Deep-sea Indian Ocean Species: 1.

Synonyms: *Breviraja* (*partim*), *Neoraja* (*Neoraja*) subgenus.

Field Marks: Dwarf-sized skates with heart-shaped disc, short bluntly angled snout, tail greater than 60% of total length, upper disc and tail with dense coverage of fine dermal denticles, underside of tail at least edged with, or totally covered with dermal denticles and typically a median thorn row on tail dwindling in size rearward and totally disappearing in posterior third of tail length among dense dermal denticles a fair distance in front of first dorsal fin. Colour is a brown to greyish brown above; light with wide margin of brown to greyish brown below.

Diagnostic Features: Disc heart-shaped and relatively narrow, usually 50 to 60% total length, with broadly rounded outer corners; anterior margin of disc strongly concave to straight; anteriormost extension of pectoral fin abutting or nearly abutting tip of snout, not separated from snout by semi-translucent area. Snout moderately short and broadly rounded or angular, usually 8 to 10% total length, with tip slightly produced beyond anterior margin as small triangular process. Eyes relatively large, diameter equal to or greater than inter-orbital distance. Pelvic fins bilobed and continuous, with anterior lobe relatively long but failing to reach posterior margin of posterior lobe. Tail moderately long, usually 55 to 60% total length, moderately slender at base and tapering distally. Dorsal surface densely covered with fine denticles. Thorn pattern: small thorns on orbital margin, on nuchal and scapular region but not forming triangular patch, along mid row of disc and on at least basal half of tail in one to three irregular rows. Vertebral counts: predorsal caudal vertebral counts 65 to 74. Very small skates growing to maximum total length of about 38 cm. **Colour:** a light ochre to medium greyish-brown above, with apparent pattern of symmetrically arranged white and dark brown dots and spots, with underside white in only one species; remaining species plain dark or bluish on upper disc without any pattern, and underside largely to totally dark.

Remarks: The genus is comprised of five species, all of which occur in the Atlantic Ocean, with one species range extending just into the Eastern Cape Province, South Africa.

Neoraja stehmanni (Hulley, 1972)

Breviraja stehmanni Hulley, 1972b, *Ann. S. African Mus.*, 60(9): 254, figs. 1–5. Holotype: SAM 26636, 354 mm total length, adult male, 33°53.7–57.3'S, 17°23.9–22.2'E, 640 m.

Synonyms: None.

Other Combinations: None.

FAO Name: En – African pygmy skate.

Field Marks: A dwarf skate with a bluntly pointed snout and very large, close-set eyes, a tail length greater than disc length in adults, an angular disc with rounded corners, small to moderate sized orbital thorns, scapular thorns, and an interrupted row of back and tail thorns. Colour is a brownish grey above, paler ventrally, with 6 to 7 darker bands on tail.

Diagnostic Features: Disc heart-shaped, length about 54 to 58% of total length, with broadly rounded outer margins, and anterior edges more undulated in adult males than females; snout moderately short, obtuse, 8.9 to 11.5% total length, 2.9 to 3.8 times inter-orbital space; snout angle about 115° to 130°. Anterior pelvic-fin lobes relatively long, nearly reaching posterior margin of posterior lobes. Tail relatively long, 58 to 60% total length, moderately slender at base and attenuated distally. Eyes close-set, orbit diameter slightly greater than inter-orbital space. Spiracles small. Nasal curtain fringed. Mouth weakly arched; teeth arranged in quincunx, sexually dimorphic, with a single long acute cusp in adult males, blunt and flat in juveniles and females. Tooth counts 38 to 44 upper jaw, counts not available for lower jaw. Dorsal fins continuous, similar in shape and size. Disc covered with denticles above, naked below. Thorn pattern on dorsal surface (adult): 2 to 10 small to moderate sized orbital thorns arranged in semi-circular pattern from preorbit to anterior margin of spiracle; 1 to 4 nuchal thorns; 1 scapular thorn on each shoulder; mid-back and tail thorns arranged in single row of 11 to 39 thorns usually interrupted between the pectoral and pelvic girdles and extending to mid-length or two-thirds tail length; adult males with alar and malar thorns; ventral surface smooth, without thorns. Vertebral counts: predorsal vertebral counts 65 to 74. Spiral valve counts not available. Maximum total length is about 38 cm. **Colour:** greyish to greyish-brown above, with black spot at tip of snout and dorsal disc margin darker, paler grey below; tail with 6 to 7 darker crossbars.

Distribution: Southeastern Atlantic and southwestern Indian Ocean: South Africa, from southwest of the Orange River mouth, Western Cape Province, to Algoa Bay, Eastern Cape Province.

Habitat: A little known skate with a patchy distribution on the west and south coasts of South Africa. It occurs from the outer continental shelf to upper slopes from 102 to 1025 m deep, with most records from below 600 m. The distribution of this species is unusually localized compared to other offshore southern African skates, but it may be that they have very specialized habitat requirements. Several records of this species have come from around offshore seamounts and may suggest an association with this habitat.

Biology: Oviparous, with very small, smooth surfaced egg cases with broad lateral keels, but lack attachment fibers. Nothing is known about its reproductive cycle or age. The diet of this skate is poorly known, but includes small benthic shrimps.

Size: Maximum total length is 37.6 cm (males) and 36.8 cm (females); size at maturity is about 31 cm for males and 29.5 cm for females. Size at birth is uncertain, but based on smallest free-swimming individuals it is less than 15 cm total length.

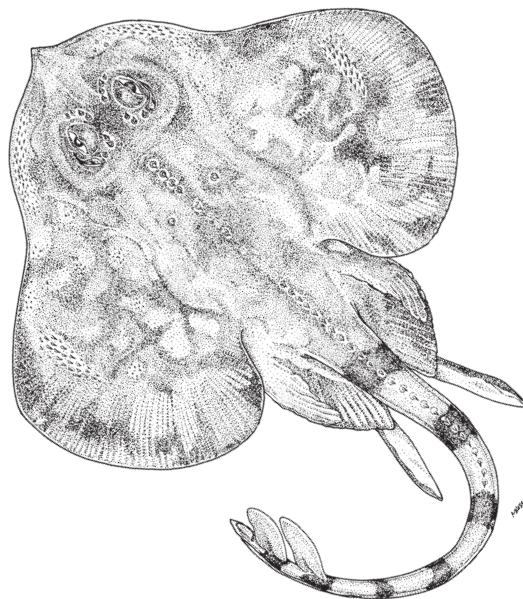


Fig. 110 *Neoraja stehmanni*

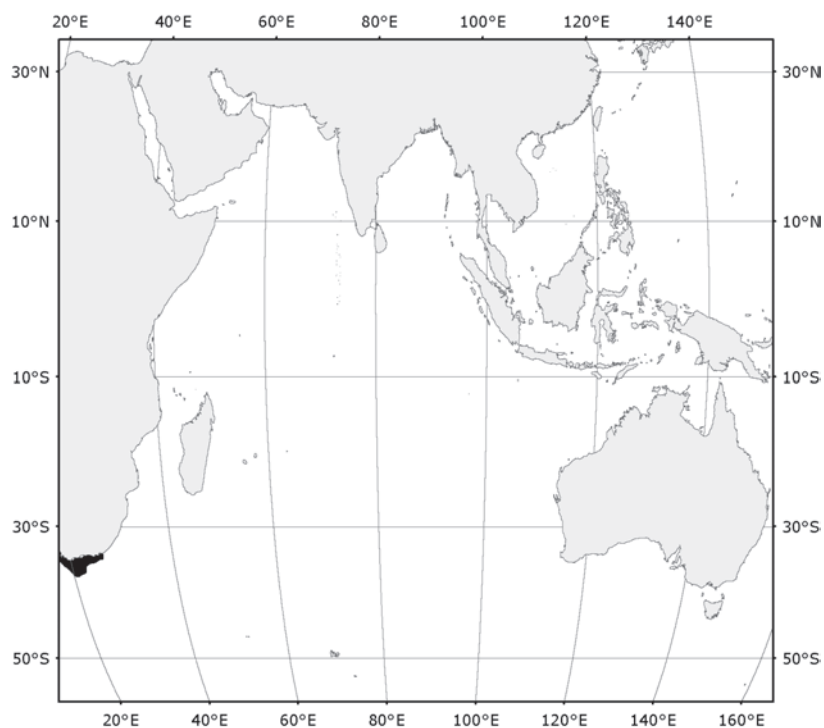


Fig. 111 *Neoraja stehmanni*

Known distribution

Interest to Fisheries and Human Impact: Of no commercial fishing interest, this rather small skate species is not likely taken in large numbers given its size and patchy distribution. Probably incidentally caught by hake bottom trawlers.

The conservation status of this skate is Data Deficient.

Local Names: South African pygmy skate.

Remarks: The above genus and species accounts are modified after Ebert and Stehmann (2013).

Literature: Hulley (1972a, b); Compagno, Ebert and Smale (1989); Compagno, Ebert and Cowley (1991); Ebert, Cowley and Compagno (1991); Compagno and Ebert (2007); Ebert and Compagno (2007); Ebert, Compagno and Cowley (2008); Ebert and Stehmann (2013); Aschliman and Ebert (2013b).

Okamejei Ishiyama, 1958

Genus: *Okamejei* (subgenus of *Raja*) Ishiyama, 1958, *Journal of the Shimonoseki College of Fisheries*, 7 (2–3): 354 (162).

Type Species: *Raja fusca* Garman, 1885, type by original designation; synonym of *Raja* Linnaeus, 1758, but a valid genus *Okamejei* as described.

Number of Recognized Deep–sea Indian Ocean Species: 3.

Synonyms: None.

Field Marks: Skates with a relatively short to moderately long snout, a relatively long tail (in adults) about 1.2 to 1.5 times disc width, and with prominent thorns around rim of eyes, and numerous irregular rows on nuchal, midback and tail. Colour is a light yellowish to dark brown above, with darker spots, rings, ocelli and reticulations or may be plain above; creamy to white below with darker margins depending on the species.

Diagnostic Features: Disc rhombic–shaped, moderately broad, usually 55 to 65% total length, with outer corners sharply rounded. Snout acutely angled and moderately long, usually 13 to 17% total length, and little to moderately produced beyond anterior margin of disc. Orbits moderately small, diameter slightly greater than to less than interorbital distance. Pelvic fins bilobed and continuous, with anterior lobe much shorter than posterior lobe. Tail moderately long, 44 to 56% total length, moderately narrow at base and slightly tapering distally. Upper surface largely free of denticles. Several moderate–sized thorns on orbital margin, one to several thorns on nuchal region, rarely mid row thorns between nuchal region and base of tail, and in one to several regular to irregular rows on tail to origin of first dorsal fin. Vertebral counts: predorsal caudal vertebral counts 35 to 55. Adults maximum total length usually less than 55.5 cm. **Colour:** dark brown and either plain or patterned with yellowish or dark spots, rings, ocelli or reticulations above; whitish with dark margin below, with ampullary pores and sometimes canals darkly pigmented.

Remarks: This genus is in need of revision as most of the characters used to distinguish *Okamejei* from *Dipturus* are not currently useful. The genus Diagnostic Features is modified after Aschliman and Ebert (2013b). The genus has 14 species, of which at least five occur in the Indian Ocean, but only three of these are considered deep–sea species; there are several additional new species currently under investigation (M. Stehmann, pers. comm.).

Key to Deep–sea Indian Ocean Species:

1a. Dorsal surface of disc dark brown with numerous, symmetrically arranged bicoloured ocelli; known from the western Indian Ocean (Fig. 112). *Okamejei heemstrai*

1b. Dorsal surface of disc brownish grey to greenish brown or yellowish without numerous, symmetrically arranged bicoloured ocelli; known from the eastern Indian Ocean **2**

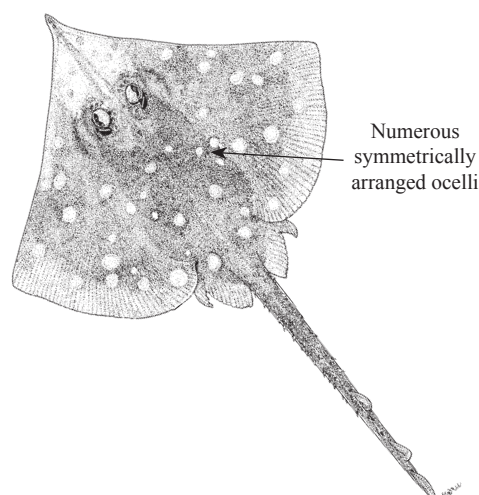


Fig. 112 *Okamejei heemstrai*

2a. Tail width at pelvic-fin insertions less than 3.7% total length; caudal fin more than 9% total length (Fig. 113)
 *Okamejei arafurensis*

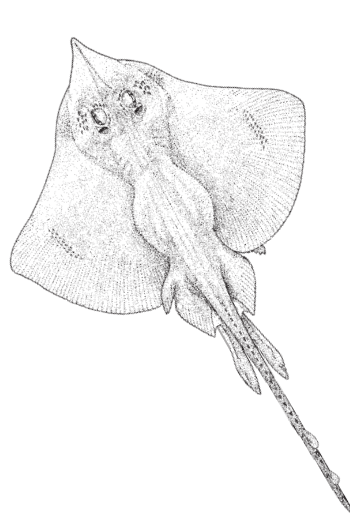


Fig. 113 *Okamejei arafurensis*

2b. Tail width at pelvic-fin insertions usually slightly more than 3.7% total length; caudal fin mainly less than 9% total length (Fig. 114).
 *Okamejei leptoura*



Fig. 114 *Okamejei leptoura*

***Okamejei arafurensis* Last and Gledhill, 2008**

Okamejei arafurensis Last and Gledhill, 2008, *CSIRO Marine and Atmospheric Research Paper*, 021: 120, figs. 1–6, tab. 1. Holotype: NTM S 13580–010, 407 mm total length, adult male, Arafura Sea, off Northern Territory, Australia, 09° 04'S, 133° 04'E, 179 to 205 m deep, 20 October 1992.

Synonyms: None.

Other Combinations: None.

FAO Name: En – Arafura skate.

Field Marks: A small hardnose skate, with a strongly produced, elongated snout tip, a very long thin tail, longer than disc length; small orbital thorns present, but nuchal, scapular, and mid-back thorns absent; tail thorns in 1 (juveniles and adult males) to 5 (adult females) rows, interspersed with smaller thornlets. Colour is a uniform greyish brown above, white ventrally.

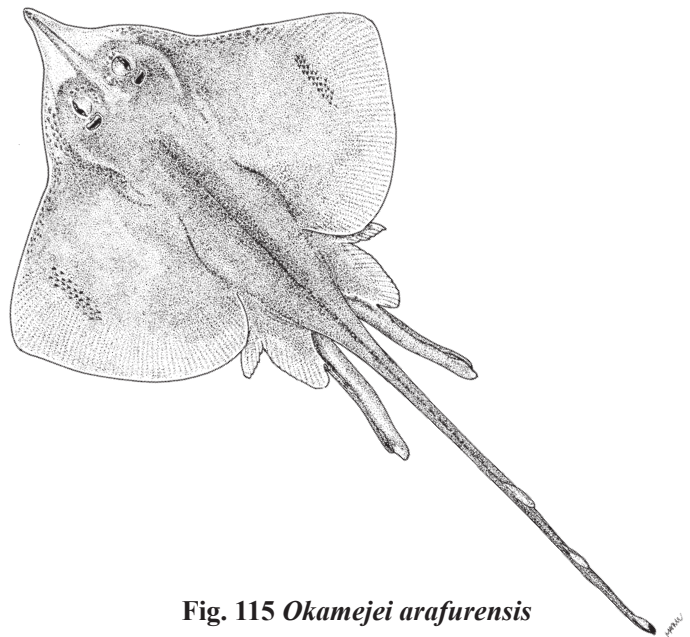


Fig. 115 *Okamejei arafurensis*

Diagnostic Features: Disc rhombic, width 1.6 times length; disc width 54 to 61% total length; snout short, length 13.4 to 15.1% total length, firm, tip strongly produced, prominent, narrowly pointed, no fleshy process at apex; angle in front of spiracles about 74° to 96°. Anterior disc margins strongly undulate, narrowly rounded to rather angular at apex, posterior margins moderately convex, and free rear tip broadly rounded. Total radial counts: pectoral radial counts 71 to 76, pelvic radial counts 1 + 17 to 20. Pelvic fins deeply incised, anterior lobes short, slender to broad, narrowly rounded, not extending to posterior margin of very elongated posterior lobes. Tail very slender, slightly depressed, tapering posteriorly, length about 1.1 to 1.3 times disc length to cloaca. Orbits moderate-sized, diameter about 0.7 to 1.0 times inter-orbital width. Spiracles small, about 1.4 to 1.6 in orbit length. Nasal curtain subrectangular, with undulated outer margin, anterior flap margin weakly lobed, posterior inner margin partially concealed by nasal curtain; posterior lobes well developed, with long fringing margin. Mouth strongly arched; teeth strongly sexually dimorphic, adult male teeth with single large acutely pointed cusp on oval-shaped crown, arranged in longitudinal rows; upper jaw medial teeth with cusp elongate, slender, acutely pointed, posteriorly directed, becoming shorter, more oblique laterally; teeth of females and juveniles arranged in quincunx, with broad oval crowns, and short blunt cusps. Tooth counts 34 to 38 upper jaw, 34 to 38 lower jaw. Dorsal fins small, similar in size and shape; broadly rounded at apices, posterior margins convex; interdorsal space very long, 1.4 to 2.7 in first dorsal-fin base. Caudal fin well-developed, base very long and low, height less than one-half tail width at fin origin. Disc mostly smooth on dorsal surface with thorn-like denticles along anterior margin of disc; ventral surface smooth except for rough patch of denticles on snout tip. Thorn pattern on dorsal surface: orbital thorns small, about 5 to 6 (usually 3 on pre-orbit and 2 to 3 on post-orbit); nuchal, scapular, and mid-back thorns absent; tail thorns, and smaller interspersed thornlets, in 1 (juveniles and adult males) to 5 (adult females) rows, lateral

rows (if present) more developed than median row, 9 to 16 pre-dorsal thorns (2 to 9) and thornlets (7 to 9); interdorsal space with 1 thornlet; adult males with about 13 to 14 enlarged, strongly recurved malar thorns in 2 to 3 rows; 28 to 30 alar thorns in about 4 to 5 longitudinal rows; ventral surface smooth, without thorns. Vertebral counts: total vertebral counts 120 to 132, trunk vertebral counts 25 to 27, predorsal caudal vertebral counts 42 to 47, predorsal vertebral counts 68 to 73, interdorsal vertebral counts between dorsal-fin origins 14 to 16, diplospondylous vertebral counts 94 to 105. Spiral valve counts not available. Maximum total length about 50 cm. **Colour:** dorsal surface uniformly greyish brown, darker on rostrum, paler along disc margins; no distinct blotches, ocelli, or spots; ventral surface uniformly white.

Distribution: Eastern Indian Ocean: off northwestern Australia from southwest of Scott Reef, Western Australia to the Arafura Sea, Northern Territory.

Habitat: A little known inhabitant of the outer continental shelf and upper slopes from 179 to 298 m deep.

Biology: Oviparous, but virtually nothing else known.

Size: Maximum total length is about 50 cm; males mature at 38 to 41 cm, but female size at maturity unknown. Size at birth is unknown.

Interest to Fisheries and Human Impact: Of no interest, the area where this skate occurs has very little bottom fishing occurring.

The conservation status of this skate is Least Concern.

Local Names: None.

Literature: Last and Gledhill (2008); Last and Stevens (2009); Awruch and White (2011).

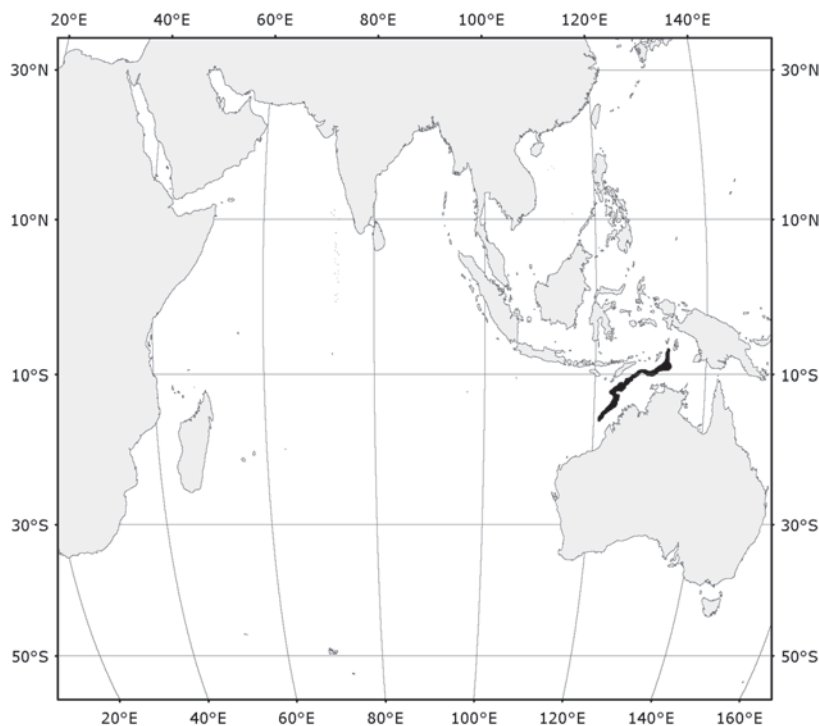


Fig. 116 *Okamejei arafurensis*

Known distribution

Rajella Stehmann, 1970

Genus: *Rajella* Stehmann, 1970, *Arch. FischWiss.* 21(2): 151.

Type Species: *Raja fyllae* Lütken, 1887 by original designation.

Number of Recognized Deep-sea Indian Ocean Species: 6.

Synonyms: *Raja (Rajella)*, as subgenus (Stehmann, 1970).

Field Marks: Disc usually subrhombic, with outer corners rounded to angular, snout short and bluntly angled, or moderately elongated and pointed, median thorn rows on back of trunk and along tail range from one to several rows in parallel; except in small juveniles, thorns on orbital rims mostly set in continuous half-rings, and mostly many thorns over nape and shoulder regions forming a triangle. Colour is mostly uniformly dark or light.

Diagnostic Features: Disc heart-shaped to rhombic-shaped and narrow to moderately narrow, generally 49 to 61% total length, with outer corners obtusely angled to broadly rounded. Snout moderately long to moderately short, acutely angled to broadly rounded and slightly to moderately produced beyond anterior margin of disc. Eyes of moderate size, diameter slightly greater to slightly less than inter-orbital distance. Pelvic fins bilobed, continuous, with anterior lobes short to moderately long but considerably shorter than posterior lobes. Tail moderately long to long, 51 to 60% total length, and moderately broad at base and attenuated distally. Dorsal surface largely covered with denticles and relatively densely covered with moderate to large sized thorns; usually a complete row of thorns on orbital rim, triangular patch of thorns on nuchal shoulder region, and one to several rows of thorns extending from shoulder region to origin of first dorsal fin, with thorns of mid-row equal in size or larger than those of lateral rows, and one to several thorns between dorsal fins. Vertebral counts: predorsal caudal vertebral counts 55 to 73. Maximum total length to about 90 cm. **Colour:** dorsal surface uniformly light grey, brown to brownish black; ventral surface whitish to nearly black.

Remarks: The genus currently has 17 nominal species described with several additional species awaiting formal description. Six species occur in the Indian Ocean, with five of six species occurring in the southwestern Indian Ocean and only one species present in the southeastern Indian Ocean. The members of this genus mostly occur in the eastern Atlantic, along the west coast of South Africa and Namibia, but the range of most species extends eastwards to the Eastern Cape Province with a few records to KwaZulu–Natal, South Africa. However, one member of this genus included within this region, *Rajella ravidula*, is known only from a single record from off Cape Point, Western Province, South Africa.

Key to Deep-sea Indian Ocean Species:

1a. Two rows of thorns along mid-dorsal region of back and tail; median row absent; no thorns above rostral cartilage (Fig. 117) *Rajella ravidula*

1b. Three or more rows of thorns along mid-dorsal region of back and tail; median row either continuous or interrupted **2**

2a. Tail length from cloaca to tip much longer than precaudal length from snout tip to cloaca **3**

2b. Tail length from cloaca to tip about to equal, or slightly shorter than precaudal length from snout tip to cloaca **4**

3a. Conspicuously large light coloured thorns on central disc mid-back and tail giving very rough texture; 5 rows of tail thorns (known from Western Province, South Africa and Namibia) (Fig. 118) *Rajella caudaspinosa*

3b. Inconspicuous thorns sparse to absent on central disc mid-back, in 3 to 5 rows on tail (known from southern Australia) (Fig. 119) *Rajella challengeri*

4a. Median row of thorns along back reduced in size or interrupted (Fig. 120) *Rajella dissimilis*

4b. Median row of thorns along back and tail continuous. **5**

5a. Dorsal surface medium grey to brownish often with blackish spots; thorns small and inconspicuous (Fig. 121) *Rajella leopardus*

5b. Dorsal surface light grey without blackish spots; thorns very large and conspicuously light to white (Fig. 122) *Rajella barnardi*

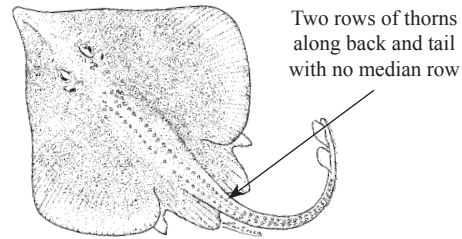


Fig. 117 *Rajella ravidula*

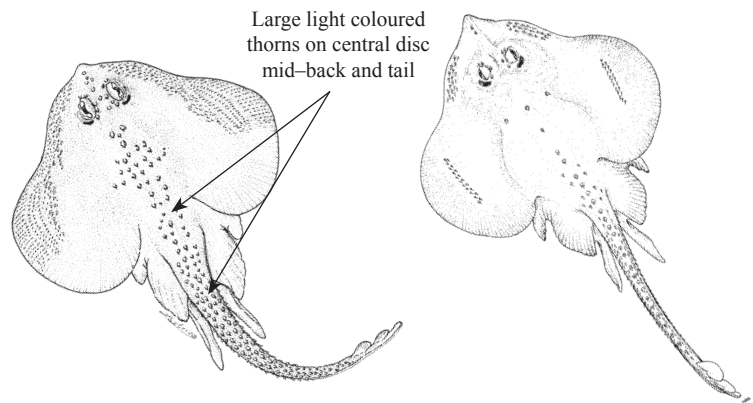


Fig. 118 *Rajella caudaspinosa* **Fig. 119** *Rajella challengeri*

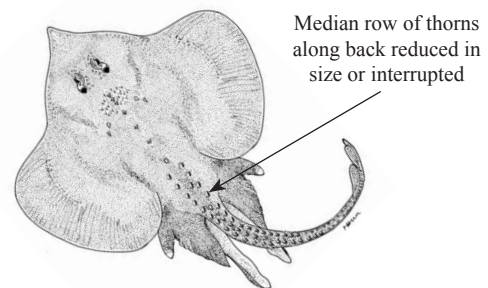


Fig. 120 *Rajella dissimilis*

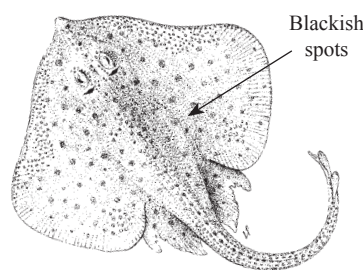


Fig. 121 *Rajella leopardus*

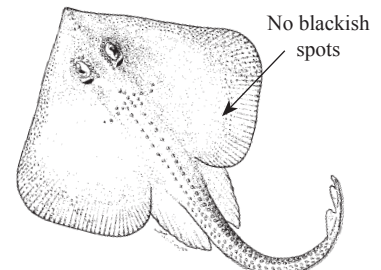


Fig. 122 *Rajella barnardi*

***Rajella caudaspinosa* (von Bonde and Swart, 1923)**

Rajella caudaspinosa von Bonde and Swart, 1923, *Fish. Mar. Biol. Surv. Union S. Africa* 3(Spec. Rept. 5): 8, pl. 21, fig. 1. Holotype: whereabouts unknown (unique), 346 mm total length, 172 mm disc length, female, from RV *Pickle* Sta. 336, 32°03'00"S, 16°12'00"E, west of Lambert's Bay, Western Cape, 512 m.

Synonyms: *Rajella albalinea* von Bonde and Swart, 1923, *Fish. Mar. Biol. Surv. Union S. Africa* 3(Spec. Rept. 5): 6, pl. 20, fig. 1. Syntypes: (several) BMNH 1935.7.14.4 (1), only specimen mentioned was 165 mm TL, 80 mm disc width, sex uncertain, but two stations were mentioned: *Pickle* Sta. 336, 32°3'00"S, 16°02'00"E, west of Lambert's Bay, Western Cape, 512 m; and *Pickle* Sta. 519, 31°27'00"S, 15°35'00"E, northwest of Lambert's Bay, 1098 m.

Other Combinations: None.

FAO Name: En – Munchskin skate.

Field Marks: A small skate with a very short, obtusely pointed snout, large, close-set eyes, and a thick disc, tail thick and longer than disc length, conspicuous lighter coloured thorns which make disc and tail extremely rough. Colour a light grey to brownish grey above, with or without darker scattered spots, ventral surface whitish.

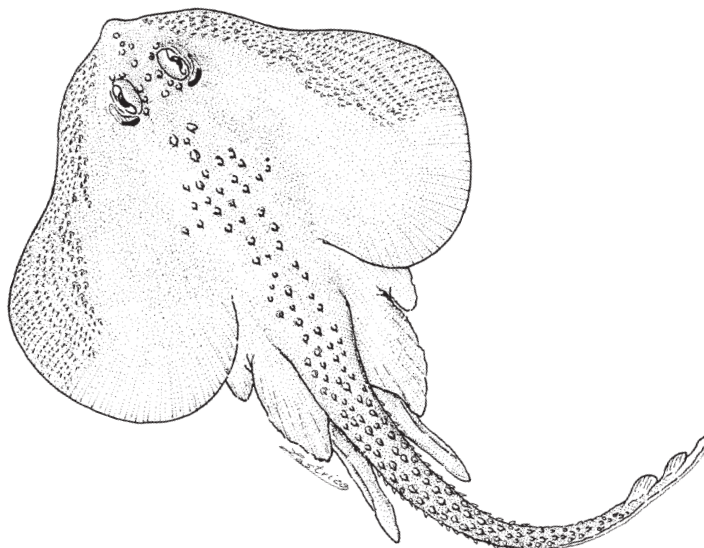


Fig. 123 *Rajella caudaspinosa*

Diagnostic Features: Disc with broadly rounded lateral margins, 1.2 to 1.4 times as wide as long. Snout very short and obtusely pointed with rounded terminal process, length 2.0 to 2.6 times inter-orbital distance; angle of snout anterior to spiracles 125° to 130°. Tail length longer than precaudal length, with broad base. Eyes large and close-set. Mouth small and jaws weak with blunt teeth. Tooth count upper jaw 32 to 36, lower jaw not available. Thorn pattern on dorsal surface (adult): 5 to 9 orbital thorns arranged in semi-circular pattern; 0 to 1 inter-orbital thorn; 1 to 2 inter-spiracular thorns; 4 to 5 nuchal thorns; scapular thorns in close-set, irregular patches, and numbering from 3 to 4; mid-back thorns arranged in irregular linear rows followed by tail thorns; mid-dorsal thorns number 22 to 23 from nuchal region to first dorsal-fin origin, decreasing in size toward posterior portion and flanked on each side by 1 row of thorns on back and 2 on tail; large, stellate-based thorns in 4 to 6 staggered rows on anterior margins of disc; anterior margins of disc and tail very spinulose; disc and tail smooth below. Dorsal fins are continuous. Vertebral counts: predorsal caudal vertebral counts 66 to 73. Spiral valve counts not available. The smallest member of the genus off southern Africa, with a maximum total length of 65 cm. **Colour:** light grey to brown above, sometimes with scattered darker spots; juveniles with white-barred pattern; pale below.

Distribution: Southeastern Atlantic and southwestern Indian Ocean: Luderitz, Namibia to Cape Point, South Africa with a few scattered records to Algoa Bay and one record from KwaZulu-Natal. Most records are from Namibia and South Africa.

Habitat: A skate of the outer shelf and slope found at depths of 102 to 1098 m, with almost all records below 200 m.

Biology: Oviparous, but little else known about its reproductive cycle. Egg cases have been described as having a finely striated surface, smooth beneath a fibrous covering; narrow lateral keels and posterior horns tapering to acute tips.

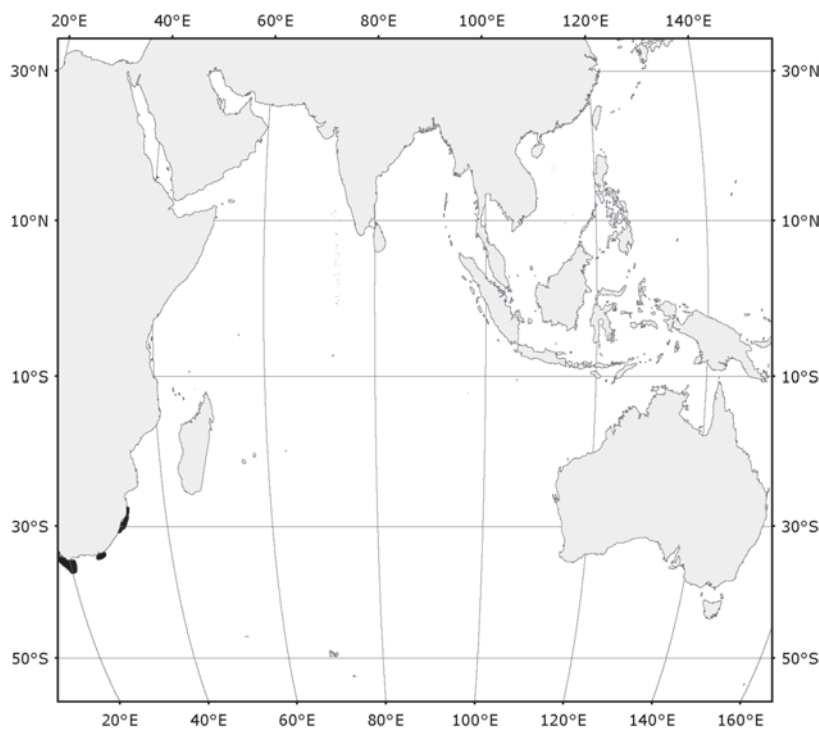


Fig. 124 *Rajella caudaspinosa*

Known distribution

The diet of this skates includes mysids, myctophids, and polychaetes.

Size: Maximum total length is about 65 cm; males mature at about 51 to 53 cm, and females mature at about 50 to 55 cm. Size at birth is about 10 cm or less.

Interest to Fisheries and Human Impact: None, except taken occasionally as bycatch in commercial bottom trawl fisheries.

The conservation status of this skate is Near Threatened due to its restricted geographic distribution and intensive fisheries that occur throughout its range.

Local Names: Spiny-tailed skate, White-lined skate, Roughttail skate (South Africa).

Literature: von Bonde and Swart (1923); Hulley (1972a); Compagno, Ebert and Smale (1989); Compagno, Ebert and Cowley (1991); Ebert, Cowley and Compagno (1991); Compagno and Ebert (2007); Ebert and Compagno (2007); Ebert, Compagno and Cowley (2008); Aschliman and Ebert (2013b).

Sinobatis Hulley, 1973

Genus: *Sinobatis* Hulley, 1973, *Annals of the South African Museum*, 62: 153.

Type Species: *Sinobatis* (subgenus of *Anacanthobatis*) Hulley, 1973. *Anacanthobatis borneensis* Chan, 1965. Type by original designation.

Number of Recognized Deep-sea Indian Ocean Species: 2.

Field Marks: Small legskates with nasal curtain relatively short and broad, with small lateral lobes. These skates are externally very similar to those of the genus *Anacanthobatis*, but are distinguished by distinct differences in the clasper morphology of adult males.

Diagnostic Features: Disc broad, flat, heart-shaped, width slightly less than disc length in juveniles and females, about equal in adult males; snout tip broad, short, slender, and filamentous; disc anterior margins to spiracles nearly straight with short concavity near snout tip, weakly concave from spiracles to broadly rounded apices of pectoral fins, becoming more convex on posterior margins; snout angle in front of spiracles 76° to 88° in adults, 88° to 103° in young juveniles. Total pectoral radial counts 66 to 76. Eyes and spiracles relatively small. Nostril small, anterior lobes weakly fringed, posterior nasal curtain with enlarged lobes overlapping the corners of the mouth. Mouth transverse, teeth arranged in quincunx. Tooth counts 18 to 29 upper jaw, 20 to 30 lower jaw. Pelvic-fin anterior lobes slender, distinctly separated from posterior lobes. Total pelvic radial counts 15 to 20. Tail very slender, short, its length less than disc length; flattened with a bulbous tip or filamentous and lacking a bulbous tip; caudal fin rudimentary at tip. No dorsal fins or lateral tail folds. Skin smooth on upper and lower surfaces; no thorns on dorsal or ventral surfaces, except for alar thorn on adult males. Vertebral counts: trunk vertebral counts 24 to 31, total vertebral counts 148 to 212. Spiral valve counts not available. Maximum known total length is at least 56 cm. **Colour:** dorsal surface uniform light pinkish brown, greyish-brown, or bluish, without any distinctive mottling or patterns; ventral surface uniformly whitish to semi-translucent, or bluish, with no distinctive markings.

Remarks: The genus comprises five described species, two of which occur in the eastern Indian Ocean. The Key to Indian Ocean species (below) is modified after Last and Séret (2008), and Last and Stevens (2009).

Key to Deep-sea Indian Ocean Species:

1a. Ventral head length 23 to 36% total length; dorsal surface light coloured, pale brown to greyish brown; ventral surface uniformly white to semi-translucent (Fig. 125). *Sinobatis bulbicauda*

1b. Ventral head length 38 to 42% total length; dorsal and ventral surfaces dark blue (Fig. 126) *Sinobatis caerulea*

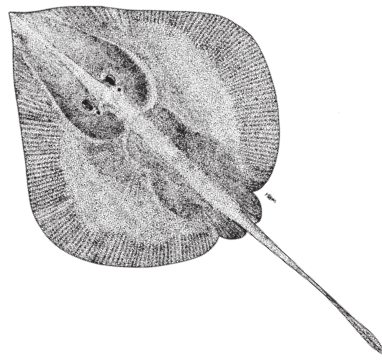


Fig. 125 *Sinobatis bulbicauda*

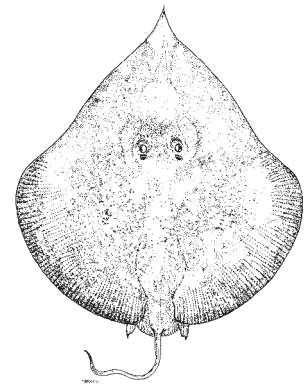


Fig. 126 *Sinobatis caerulea*

***Sinobatis bulbicauda* Last and Séret, 2008**

Sinobatis bulbicauda Last and Séret, 2008, *Zootaxa*, 1671: 37, figs. 1, 3–5, 11. Holotype: CSIRO H 2557–01, adult male, 429 mm total length, 261 mm disc width, West of Cape Farquhar, Western Australia, Australia, 23° 44'S, 112° 35'E, 612 to 620 m, 1991.

Synonyms: *Anacanthobatis* sp. A: Last and Stevens, 1994, *Sharks and rays of Australia*: 357–358, Pl. 64, fig. 35.1; Last and Compagno, 1999, in Carpenter and Niem, *FAO species identification guide for fisheries purposes. The living marine resources of the Western Central Pacific*, 1999: 1466. *Anacanthobatis* sp.: Séret, 1994 (abstract).

Other Combinations: None.

FAO Name: En – West Australian legskate.

Field Marks: A small, smooth-skinned, flat-bodied “legskate” with no dorsal fins and a reduced caudal fin, snout angular at tip, pectoral disc with rounded corners and no large thorns or denticles, tail short, very slender, length less than trunk length. Colour is a uniform pale brown to greyish brown above, lighter below.

Diagnostic Features: Disc broad, extremely depressed, “heart-shaped”, width slightly less than disc length in juveniles and females, about equal in adult males; snout tip broad, short, slender, and filamentous; disc anterior margins to spiracles nearly straight with short concavity near snout tip, weakly concave from spiracles to broadly rounded apices of pectoral fins, becoming more convex on posterior margins; snout angle in front of spiracles 80° to 84° in adults, 88° to 98° in young juveniles. Total pectoral radial counts 66 to 71. Eyes medium to relatively large, diameter slightly greater than inter-orbital space. Spiracles very small, diameter less than one-half length of eye length. Nostril small, anterior lobes weakly fringed, posterior nasal curtain with enlarged lobes overlapping the corners of the mouth. Mouth nearly transverse; teeth arranged in quincunx, with a single, short cusp, on an irregular oval base. Tooth counts 21 to 26 upper jaw, 20 to 28 lower jaw. Anterior pelvic-fin lobes slender, “leg-like” and separated from posterior lobes. Pelvic-fin posterior lobe well-developed, fused to pectoral fins for more than one-half its length; inner margin fused to side of tail for entire length. Total pelvic radial counts 15 to 20. Tail compressed, very slender, short, its length less than disc length; caudal fin greatly reduced, broad, becoming spatulate, lobe-like filament near tip. No dorsal fins or lateral tail folds. Skin smooth on upper and lower surfaces; upper surface with short row of mucous pores in front of orbits and spiracles, and a lateral row extending from scapular region to base of tail. No thorns on dorsal or ventral surfaces, except for alar thorns on adult males. Vertebral counts: trunk vertebral counts 25 to 31, total vertebral counts 148 to 171. Spiral valve counts not available. Maximum known total length is at least 56 cm. **Colour:** uniform light pinkish brown to greyish-brown above, ventral surface uniformly pale to whitish; no distinctive markings on dorsal or ventral surfaces.

Distribution: Eastern Indian Ocean: Western Australia from Gantheaume Bay (27°49'S, 113°01'E) northwards to Ashmore Terrace (13°25'S, 122°54'E). Western Central Pacific: eastern Indonesia off Tanimbar Island (07°46' to 08°00'S, 132°31 to 132°58'E).

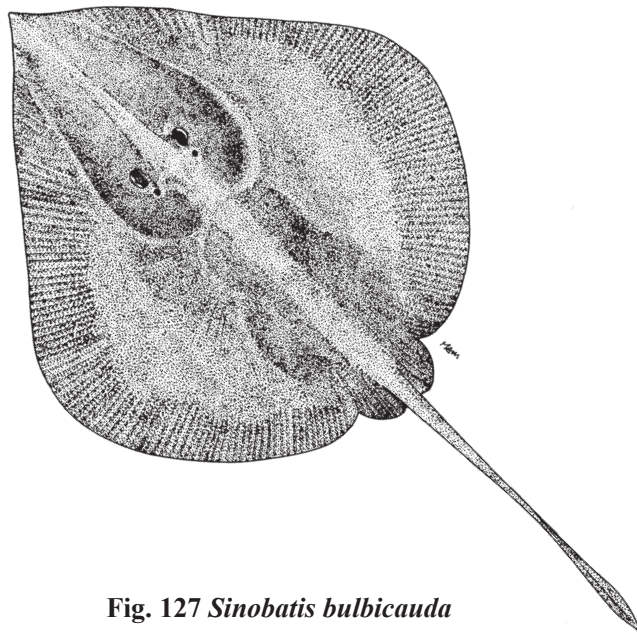


Fig. 127 *Sinobatis bulbicauda*

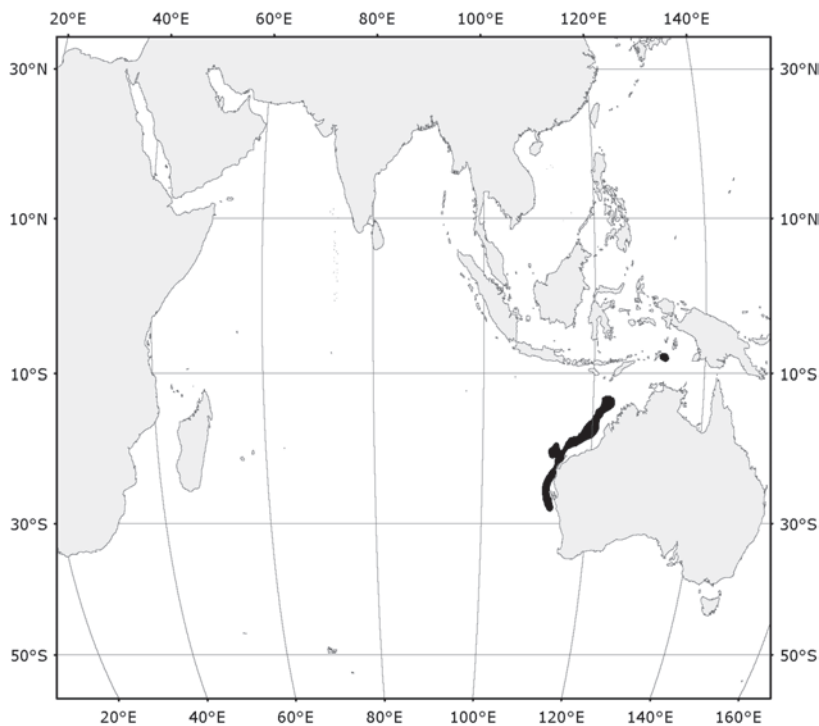


Fig. 128 *Sinobatis bulbicauda*

Known distribution

Habitat: A moderately common deep-water skate of upper continental and insular slopes from 150 to 1125 m. In eastern Indonesia it is most common from 215 to 470 m deep.

Biology: Nothing known.

Size: Maximum total length at least 56 cm. Males mature at 43 cm, female size at maturity unknown. Size at birth is about 13 cm based on smallest free-swimming specimen.

Interest to Fisheries and Human Impact: None, it has been taken on rare occasion as bycatch in trawl fisheries, but deep-water fisheries generally do not occur within this species range.

The conservation status of this species is Data Deficient.

Local Names: None.

Literature: Last and Stevens (1994, 2009); Last and Compagno (1999); Last and Séret (2008); Duryea and Ebert (2012).

2.3 Order MYLIOBATIFORMES – Stingrays

Order: Order Plagiostoma, Suborder Platosomia, “Groups” Dasybatoidei, Myloidei, Mobuloidei: Garman, 1913 (in part), *Mem. Mus. Comp. Zool. Harvard*, 36: 258, 259 (groups corresponding to Infraorder or Superfamily, and containing the Families Dasybatidae [plus Urolophidae and Gymnuridae] and Potamotrygonidae, Myliobatidae and Rhinopteridae, and Mobulidae. Essentially separate groups for the stingrays and butterfly rays, eagle and cownosed rays, and devil rays, respectively).

Number of Recognized Deep-sea Indian Ocean Families: 3.

Synonyms: Order Myliobatiformes, Suborder Hexatrygonoidei Heemstra and Smith, 1980, *Ichth. Bull. J.L.B. Smith Inst. Ichthyol.* (43): 13. Suborder of myliobatoids for the Hexatrygonidae. Order Hexatrematobatiformes Chu, Hu and Li, 1981, *Oceanol. Limnol. Sinica*, 12(2): 111. Order of batoids for the family Hexatrematobatidae (= Hexatrygonidae). Suborder Hexatrematobatoidea Chu, Hu and Li, 1981, *Oceanol. Limnol. Sinica*, 12(2): 111. Suborder of batoids within the Order Hexatrematobatiformes for the family Hexatrematobatidae (= Hexatrygonidae). Order Raiae, Suborder Masticura: Gill, 1872 (in part), *Smithsonian Misc. Colln.* (247): 22, 23 (order for all batoids, suborder for all myliobatoids). Order Hypotremi, Suborder Masticura, (group) Dasybatoidea: Gill, 1892, *Natn. Acad. Sci. (U. S.) Mem.* 6, 6: 130 (suborder for all myliobatoids, group ranked as infraorder or superfamily for stingrays, river rays, and butterfly rays). Order Hypotremi, Suborder Masticura, (group) Aetobatoidea: Gill, 1892, *Natn. Acad. Sci. (U. S.) Mem.* 6, 6: 130 (suborder for myliobatoids exclusively, group ranked as infraorder or superfamily for myliobatids, mobulids, and rhinopterids). Order Plagiostomi diplospondyli, Suborder Plagiostomi Tectospondyli, Group 2 Trygones Hasse, 1879, *Nat. Syst. Elasmobr.* (1): 47 (suborder for batoids, squatinids and pristiophorids, group equivalent to infraorder or superfamily for myliobatoids). Order Batoidea, Suborder Masticura, Superfamily Dasyatoidea: Whitley, 1940 (in part), *Fishes Australia. Part I. Aust. Zool. Handbook*: 69 (suborder exclusively for myliobatoids, superfamily for stingrays and eagle rays). Order Batoidea, Suborder Masticura, Superfamily Mobuloidea: Whitley, 1940 (in part), *Fishes Australia. Part I. Aust. Zool. Handbook*: 69 (suborder exclusively for myliobatoids, superfamily for devil rays). Order Batoidei, Suborder Masticura: Jordan and Evermann, 1896, *Bull. U. S. Nat. Mus.* 47(1): 59, 79 (exclusively for myliobatoids); Jordan, 1923 (in part), *Stanford Univ. Publ., Univ. Ser., Biol. Sci.*, 3: 104 (for myliobatoids, with ptychodonts). Order Rajae, [group] Myliobatoidei Fowler, 1941, *Bull. U. S. Natn. Mus.* (100) 13: 290 (exclusive group equivalent to suborder or superfamily for myliobatoids). Order Rajae Smith, 1949, *Sea fishes Southern Africa*: 37, 62 (common group without subdivisions for all batoids). Order Euselachii, Suborder Hypotremata, Division Batoidei Regan, 1906, *Proc. Zool. Soc. London* (1906): 724 (division ranking as infraorder or superfamily and inclusive of all batoids other than torpedinoids). Order Selachii, Group 2, Division B, Subdivision 2, Suborder Rajiformes, Tribe 2, Group Centrobatoidei: Goodrich, 1909, *In R. Lankester, ed., A treatise on Zoology* (9), Vertebrata Craniata: 161 (tribe equivalent to infraorder, and group equivalent to superfamily and exclusively for myliobatoids). Order Batea, Suborder Batida, Superfamily Dasybatoidea: White, 1936 (in part), *Amer. Mus. Novit.* (837): 5; White, 1937 (in part), *Bull. Amer. Mus. Nat. Hist.* 74: 38, tab. 1 (superfamily for myliobatoids, suborder also for rhinobatids, rhinids, platyrhinids, pristids, and rajoids, order for all rays apart from torpedinoids). Order Hypotremata, Suborder Batoidei: Engelhardt, 1913, *Abh. math.-phys. Klasse K. Bayer. Akad. Wiss., Suppl., Beitr. Naturg. Ostasiens*, 4: 101 (suborder for all living batoids except torpedinoids, order includes all living batoids). Order Euselachii, Suborder Trygoniformes: Bertin, 1939, *Bull. Inst. Oceanogr. Monaco* (775): 11 (suborder exclusive to myliobatoids, order for all living elasmobranchs). Order Rajiformes: Berg, 1940 (in part), *Trudy Zool. Inst. Akad. Nauk SSSR*, 5(2): 139 (includes all batoids except torpedinoids). Order Plagiostomi, Suborder Rajiformes or Rayiformes: Lozano y Rey, 1928 (in part), *Fauna Iberica. Peces*. Vol. 1: 281 (suborder for all batoids). Order Rajiformes: Lindberg, 1971 (in part), *Fishes of the world* (trans. 1974): 8, 260 (including all batoids other than torpedinoids); Nelson, 1976 (in part), *Fishes of the world*: 40 (order for all batoids; Nelson, *ibid.*: 41, suggests that myliobatoids could be recognized as a suborder Myliobatoidei with two superfamilies Dasyatoidea for stingrays and Myliobatoidea for eagle, cownose, and devil rays following Compagno, 1973, but doesn't utilize these taxa in his text or index). Order Rajiformes, Suborder Myliobatoidei: Nelson, 1984, *Fishes of the world*, ed. 2: 63 (suborder exclusively for myliobatoids, order for all batoids). Order Rajiformes, Suborder Trygonoidei: Berg and Svetovidov, 1955, *Trudy Zool. Inst. Akad. Nauk SSSR*, 20: 73 (suborder exclusive for myliobatoids, order for all batoids except torpedinoids). Order Myliobatiformes: Rass and Lindberg, 1971, *J. Ichthyol. (trans. Voprosy Ikhtiologii)* 11(3): 304 (exclusively for myliobatoids); Compagno, 1973, *J. Linn. Soc. (Zool.)*, 53, suppl. 1: 27 (order exclusively for myliobatoids); Applegate, 1974, *J. Mar. Biol. Ass. India*, 14(2): 743 (exclusively for myliobatoids); Chu and Meng, 1979, *Monogr. Fish. China, Sci. Tech. Press, Shanghai*: 114, tab. 2 (exclusively for myliobatoids); Cappetta, 1987, *Handb. Paleoichthyol.* 3B: 27, 162 (exclusively for myliobatoids); Eschmeyer, 1990, *Cat. gen. Recent fish.*: 438 (exclusively for myliobatoids); McEachran, Dunn and Miyake, 1996, *in Stiassny et al., Interrelationships fishes*: 80 (for myliobatoids, zanobatids and platyrhinids). Order Myliobatiformes, Suborder Myliobatoidei: McEachran, Dunn and Miyake, 1996, *in Stiassny et al., Interrelationships fishes*: 81 (suborder for all myliobatoids, order also for zanobatids and platyrhinids). Order Myliobatiformes, Suborder Myliobatoidei, Superfamily Hexatrygonoidea: McEachran, Dunn and Miyake, 1996, *in Stiassny et al., Interrelationships fishes*: 81 (superfamily exclusively for hexatrygonids). Order Myliobatiformes, Suborder Myliobatoidei, Superfamily Dasyatoidea: McEachran, Dunn and Miyake, 1996, *in Stiassny et al., Interrelationships fishes*: 81 (superfamily for myliobatoids other than hexatrygonids). Order Myliobatiformes, Superfamily Dasyatoidea: Compagno, 1973, *J. Linn. Soc. (Zool.)*, 53, suppl. 1: 27 (for stingrays and butterfly rays). Order Myliobatiformes, Superfamily Myliobatoidea: Compagno, 1973, *J. Linn. Soc. (Zool.)*, 53, suppl. 1: 27 (for eagle and cownose rays). Order Myliobatiformes, Superfamily Mobuloidea: Compagno, 1973, *J. Linn. Soc. (Zool.)*, 53, suppl. 1: 27 (for devil rays). Order Myliobatiformes, Suborder Dasyatoidea: Chu and Meng, 1979, *Monogr. Fish. China, Sci. Tech. Press, Shanghai*: 114, tab. 2 (suborder for urolophids, dasyatids, and gymnurids). Order Myliobatiformes, Suborder Myliobatoidea: Chu and Meng, 1979, *Monogr. Fish. China, Sci. Tech. Press, Shanghai*: 114, tab. 2 (suborder for myliobatids, aetobatids, and rhinopterids). Order Myliobatiformes, Suborder Mobuloidea: Chu and Meng, 1979, *Monogr. Fish. China, Sci. Tech. Press, Shanghai*: 114, tab. 2 (suborder for mobulids). Order Rajiformes, Suborder Rajoidei: Patterson, 1967 (in part), *in W.B. Harland et al., Geol. Soc. London, Spec. Pub.* 2: 672 (suborder for rajoids and myliobatoids, order includes all

batoids other than torpedinoids). Order Squatinida, Suborder Rajoidei, Superfamily Myliobatoidea: Glikman, 1967 (in part), in Y.A. Orlov, ed., *Fundamentals Paleontology*, 11: 220 (superfamily for myliobatoids, suborder for all batoids, order also including squaloids, orectoloboids, cetorhinids, squatinoids, and pristiophoroids). Order Rajida, Suborder Rajina, Superfamily Dasyatiidae: Fowler, 1969, *Q. J. Taiwan Mus.* 22(3–4): 179 (superfamily for myliobatoids other than mobulids, order and suborder for batoids other than torpedinoids). Order Rajida, Suborder Rajina, Superfamily Mobulidae: Fowler, 1970, *Q. J. Taiwan Mus.* 23(1–2): 80 (superfamily exclusively for mobulids, order and suborder for batoids other than torpedinoids). Order Rajida, Suborder Rajina: Matsubara, 1955, *Fish morphology hierarchy*, (1): 1–789 (suborder for rhinobatids, rhinids, platyrhinids, rajoids, and myliobatoids, order for all batoids). Order Batoidea: Romer, 1945, *Vert. Paleont.* (ed. 2): 577 (for all batoids). Order Batoidea, Suborder Myliobatoidea: Bigelow and Schroeder, 1953, *Mem. Sears Fnd. Mar. Res.* (1) 2: 15, 331 (suborder exclusively for myliobatoids, order for all batoids); Romer, 1966, *Vert. Paleont.* (ed. 3): 351 (suborder exclusively for myliobatoids, order for all batoids). Order Hypotremata, Suborder Batoidea: Norman, 1966, *draft syn. Recent fishes*: 35 (suborder for batoids other than torpedinoids, order includes all batoids). Order Rajiformes: Blot, 1969, in J. Piveteau, ed. *Traité de Paleontologie*. 2: 702–776 (group for all living batoids). Order Batoidea, Suborder Rajiformes: Schultz and Stern, 1948, *Ways of Fishes*: 225 (suborder for all batoids other than torpedinoids, order for all living batoids). Order Rajiformes, Suborder Dasyatoidei: Arambourg and Bertin, 1958, in P.–P. Grasse, ed, *Traité de Zoologie*, 13: 2051 (suborder for myliobatoids and ptychodonts, order for all batoids other than torpedinoids). Order Batoidea, Suborder Myliobatoidea: Carroll, 1988, *Vertebrate paleont. evolut.*: 600 (suborder exclusively for myliobatoids, order for all batoids). Order Myliobatiformes, Superfamily Dasyatoidea: Cappetta, 1987, *Handb. Paleoichthyol.* 3B: 162 (for stingrays). Order Myliobatiformes, Superfamily Myliobatoidea: Cappetta, 1987, *Handb. Paleoichthyol.* 3B: 170 (for eagle and cownosed rays). Order Myliobatiformes, Superfamily Mobuloidea: Cappetta, 1987, *Handb. Paleoichthyol.* 3B: 175 (for mobulids). Ordo Plagiostomi, Subordo Rajini: Bleeker, 1859, *Acta Soc. Sci. Indo-Neerl.* 6: xiii (suborder for all batoids, order for all elasmobranchs). Order Selachii, Suborder Tectospondyli: Woodward, 1889 (in part), *Cat. fossil fish. BM(NH)* (1): 30 (suborder for squaloids, squatinoids, pristiophoroids, batoids, psammodonts, petalodonts, and pristodonts, order for other living sharks, fossil neoselachians, hybodonts and coelodonts). Order Rajiformes, Suborder Myliobatidoidei: Nishida, 1990, *Mem. Fac. Fish. Hokkaido U.* 37(1/2): 1, 97 (suborder exclusively for myliobatoids, order for all batoids). Order Rajiformes, Suborder Myliobatidoidei, Infraorder Plesiobatides, Superfamily Plesiobatoidea: Nishida, 1990, *Mem. Fac. Fish. Hokkaido U.* 37(1/2): 97 (infraorder and superfamily for Family Plesiobatididae, suborder for all myliobatoids, order for all batoids). Order Rajiformes, Suborder Myliobatidoidei, Infraorder Hexatrygones, Superfamily Hexatrygonoidea: Nishida, 1990, *Mem. Fac. Fish. Hokkaido U.* 37(1/2): 97 (infraorder and superfamily for Family Hexatrygonidae, suborder for all myliobatoids, order for all batoids). Order Rajiformes, Suborder Myliobatidoidei, Infraorder Myliobatidides: Nishida, 1990, *Mem. Fac. Fish. Hokkaido U.* 37(1/2): 98 (infraorder for myliobatids other than plesiobatidides and hexatrygonids, suborder for all myliobatoids, order for all batoids). Order Rajiformes, Suborder Myliobatidoidei, Infraorder Myliobatidides, Superfamily Dasyatidoidea: Nishida, 1990, *Mem. Fac. Fish. Hokkaido U.* 37(1/2): 98 (superfamily for dasyatids and urolophids). Order Rajiformes, Suborder Myliobatidoidei, Infraorder Myliobatidides, Superfamily Myliobatidoidea: Nishida, 1990, *Mem. Fac. Fish. Hokkaido U.* 37(1/2): 98 (superfamily for gymnurids and myliobatids *sensu lato*). Order Rajiformes, Suborder Rajoidei, Superfamily Myliobatidoidea: Shirai, 1996, in Stiasny *et al.*, *Interrelationships fishes*: 34 (superfamily exclusively for myliobatoids, suborder also for myliobatoids and rajoids, order for all batoids).

Field Marks: Batoids with enlarged, expanded pectoral fins completely fused to the head and trunk (except for Myliobatidae) and forming a subrhombic to diamond-shaped, or broadly lozenge-shaped disc, a single dorsal fin that is variably present or absent, one or more serrated spines or stingers on the upper tail base, and an extremely short or very long and slender whip-like tail.

Diagnostic Features: Disc subrhombic to diamond-shaped, no more than 1.3 times as wide as long, with long whip-like tail (Dasyatidae), pectoral fins completely fused with sides of head, eyes and spiracles on top of head; or disc extremely broadly lozenge-shaped, more than 2 times as wide as long, with extremely short tail being no longer than one fourth of disc length (Gymnuridae), pectoral fins completely fused with sides of head, with eyes and spiracles on top of head; or disc broadly lozenge-shaped, more than 2 times as wide as long, with wing-like pointed pectoral fins and with whip-like tail being at least two times longer than disc, and further with pectoral fins not completely fused with sides of head, elevated above pectoral-fin level and with eyes and spiracles on sides of head. Majority of species with a small dorsal fin on tail base, followed by one or more long serrated spines. Small jaw teeth set in pavement pattern and forming bands along jaws (Dasyatidae, Gymnuridae), or jaw teeth in only 7 to 9 rows of very thick and massive teeth forming grinding plate in each jaw, with teeth of median row being much wider than long and larger than teeth of adjacent rows (Myliobatidae). **Colour:** demersal species in shallow water (Dasyatidae, Gymnuridae) usually show substrate-like brown to olive or grey ground colour, and many display colour pattern on upper disc, whereas underside is white; benthic- and semipelagic species (Myliobatidae) are mostly uniformly coloured above in more or less dark brown to grey shades, but undersides are white.

Distribution: Worldwide in mostly shallow to inshore coastal waters of tropical to warm temperate latitudes, also in brackish and partly freshwater estuaries and river mouths.

Habitat: Most species are demersal, but some are also semi-pelagic and at least one species is pelagic.

Biology: All species are yolk-sac viviparous, with most species having relatively small litters, with many species having only one or two young per litter. The diet of these batoids includes various demersal and benthic invertebrates, and small fishes; the myliobatids have specialized dentition of thick grinding plates of a few tooth rows, with massive jaw muscles for crushing hard-shelled bivalves and crustaceans.

Interest to Fisheries and Human Impact: These batoids have traditionally been caught by artisanal fisheries and used for

human consumption dried and salted (wings) by local populations in tropical coastal areas. More recently, they are being taken in large numbers by trawl fisheries, often as bycatch in fisheries targeting bony fish species, and processed for their flesh, for fishmeal and for animal food. Local and regional populations of these species have thus become much depleted in many places and are in urgent need of fishery regulations and conservation measures.

Local Names: Stingarees, Giant stingarees, Sixgill stingrays, Pan rays, Stingrays, Butterfly rays, Eagle rays, Cownose rays, Devil rays, Mantas.

Remarks: The order has 10 families, with several subfamilies, most of which are shallow water benthic or semi-pelagic species, but 3 families (Plesiobatidae, Hexatrygonidae, and Urolophidae) are represented in the deep-sea; two of these families are monotypic.

Key to Deep-sea Indian Ocean Families:

1a. Six-paired gill openings; spiracles well separated from eyes (Fig. 129)
 **family Hexatrygonidae**

1b. Five-paired gill openings; spiracles close behind eyes **2**

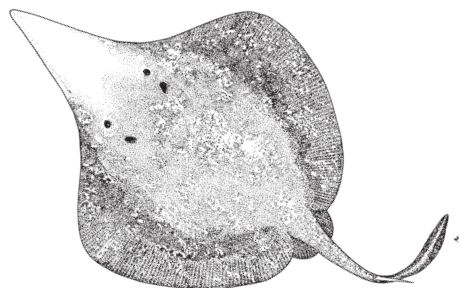


Fig. 129 *Hexatrygon bickelli*

2a. Snout long, over six times diameter of eye diameter; nasal curtain short, broad, not overlapping mouth; floor of mouth without lobate papillae (Fig. 130) **family Plesiobatidae**

2b. Snout short, much less than six times eye diameter; nasal curtain very long, narrow, and overlapping mouth; floor of mouth with lobate papillae (Fig. 131) **family Urolophidae**



Fig. 130 *Plesiobatis daviesi*

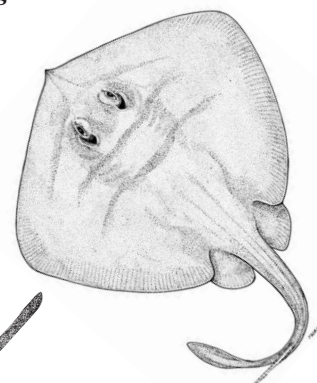


Fig. 131 *Urolophus expansus*

2.3.1 **Family PLESIOBATIDAE**

Family: Plesiobatididae Nishida, 1990, *Mem. Fac. Fisheries Hokkaido University*, 37(1/2): 98. Amended spelling to Plesiobatidae Nelson, 1994, *Fishes of the World*, ed. 3: 61.

Type Genus: *Plesiobatis* Nishida, 1990.

Number of Recognized Deep-sea Indian Ocean Genera: 1.

Synonyms: None.

Field Marks: See species account below.

Diagnostic Features: Disc oval, depressed, flattened, length greater than width. Head broad, depressed, not elevated above pectoral fins; snout moderately elongated, broadly angular, thinning anteriorly to lobe-like tip. Nostrils very wide, located just anterior to mouth, separated from it by distance much less than their width, connected by broad nasoral grooves with mouth; anterior nasal flaps short and medially expanded and fused into a very broad, short nasal curtain that ends just anterior to mouth. Mouth transverse, relatively straight, moderately broad, without prominent knobs, depressions or labial folds; no oral papillae on floor of mouth. Oral teeth small, rounded-oval in shape, with short cusps on crowns, not laterally expanded, plate-like, similar in shape. Tooth counts 30 to 62 in upper and lower jaws (more rows present in adults than in young). Gill openings small, numbering five pairs on underside of front half of pectoral disc, not visible in lateral view. Eyes small and dorsolateral on head, just anteromedial to spiracles. Disc covered with small, very fine dermal denticles on upper surface. Pelvic fins low,

rounded-angular, not divided into anterior and posterior lobes. Tail short, moderately stout, not whiplike, without dorsal fin, caudal fin well developed, length about 0.9 times disc length. Precaudal tail slightly depressed and subcylindrical, without lateral folds on sides, tail abruptly narrower than trunk, 1 to 3 prominent barbed stinging spines on dorsal surface of tail well behind pelvic fins; no electric organs in tail. Caudal fin moderately large, not shark-like, nearly symmetrical and very elongated (about half length of tail) and leaf-shaped, with vertebral axis not raised above body axis; lower caudal-fin lobe absent. Vertebral counts not available. Spiral valve turn counts from 14 to 15. Size large with adults to at least 270 cm total length. **Colour:** in life dorsal surface a uniform purplish-brown or purplish-grey, becoming dark brown or grey after preservation; sometimes with irregular dusky blotches or spots; white below with dusky margin on disc, underside of tail dark.

Distribution: Indian Ocean: South Africa and Mozambique to southern India, tropical northern Australia, and Indonesia. Western and Central Pacific: South China Sea off China, Philippines, Taiwan (Province of China), and southern Japan.

Habitat: A somewhat common to uncommon deep-sea stingray found mainly on upper continental and insular slopes from 275 to 680 m deep, although there is one record of this species from the outer continental shelf off Mozambique at 44 m. It appears to migrate into the water column as evidenced by midwater fishes and invertebrates found in the stomachs of some individuals, and by bite wounds from cookiecutter sharks (*Isistius* spp.).

Biology: See species account below.

Interest to Fisheries and Human Impact: See species account below.

Local Names: None.

Remarks: The above family account is modified after Compagno and Last (1999d).

Literature: Wallace (1967b); Nishida (1990); Compagno and Last (1999d); Ebert, Cowley and Compagno (2002); Akhilesh *et al.* (2009); Last and Stevens (2009).

List of Species Occurring in the Area:

 *Plesiobatis daviesi* (Wallace, 1967)

Plesiobatis Nishida, 1990

Genus: *Plesiobatis* Nishida, 1990 *Mem. Fac. Fish. Hokkaido Univ.*, 37(1/2): 98.

Type Species: *Urotrygon daviesi* Wallace, 1967b, by original designation.

Number of Recognized Deep-sea Indian Ocean Species: 1.

Synonyms: None.

Field Marks: See species account below

Diagnostic Features: See family account above.

Local Names: Deep-sea stingray.

Plesiobatis daviesi (Wallace, 1967)

Urotrygon daviesi Wallace, 1967, *S. African Ass. Mar. Biol. Res., Oceanogr. Res. Inst., Invest. Rept.* (16): 8, figs. 3–4. Holotype: SAIAB (formerly RUSI) 7861 [ex. ORI B865], 922 mm disc width, 1717 mm total length, adult male, taken off the Limpopo River mouth, ca. 25°25'S, 33°35'E, 430 to 439 m, September 1966.

Synonyms: *Urolophus* sp. Fourmanoir and Rivaton, 1979, *Cah. Indo-Pac.* (4): 443, male NE of Vate, New Hebrides, 350 m line. *Urolophus marmoratus* Chu, Hu, and Li, *in* Chu, Meng, Hu, and Li, 1981, *Oceanolog. Limnolog. Sinica*, 12(2): 108, fig. 3. Holotype: South China Sea Fisheries Research Institute, SCSFRI 0428, 742 mm TL female, 462 m depth, South China Sea off China?, 429 to 496 m depth. A junior homonym of *Urolophus marmoratus* Philippi, 1892, and probably a junior synonym of *Plesiobatis daviesi*.

FAO Name: En – Deep–water stingray.

Field Marks: A giant, plain looking stingray, with a nearly round disc, broadly pointed and elongated snout, small eyes, body shape similar to other stingarees, tail short, without a dorsal fin and with a well–developed caudal fin, and one or more long, serrated stinging spines originating slightly anterior to midpoint of tail. Colour in life is a purplish brown above, white below.

Diagnostic Features: See Family account above.

Distribution: See Family account above.

Habitat: See Family account above.

Biology: Very poorly known species. Reproduction is viviparous presumably without yolk–sac placenta. Gestation and reproductive cycle are unknown. Diet includes teleosts, cephalopods and crustaceans. Cookiecutter shark (*Isistius* spp.) bite wounds have been observed on specimens from off northern KwaZulu–Natal, South Africa and Western Australia.

Size: Maximum total length about 270 cm; males mature at 130 to 172 cm total length, and females immature at 189 cm, adolescents at 201 cm, with maturity likely at over 200 cm total length. Size at birth is about 50 cm total length.

Interest to Fisheries and Human Impact: Of little commercial value, the species is mostly taken as bycatch in bottom trawl and longline fisheries. It is however, a retained bycatch in fisheries in Taiwan (Province of China) for its flesh, which is consumed.

Conservation status of this species is Least Concern.

Local Names: Deepwater stingray, Finless stingray, Giant stingaree (Australia), Usu-ei (Japan); Ratão de profundidade (Mozambique).

Remarks: Unlike most members of this order *Plesiobatis daviesi* is a deep–sea inhabitant that is rarely found on the outer continental shelf, mostly remaining on upper continental and insular slopes.

Literature: Wallace (1967b); Compagno, Ebert and Smale (1989); Last and Stevens (1994, 2009); Compagno and Last (1999d); Ebert, Cowley and Compagno (2002); White, Kyne and Holtzhausen (2006); Akhilesh *et al.* (2009); Ebert (unpubl. data).

2.3.2 Family UROLOPHIDAE

Family: Gruppe Urolophi Müller and Henle, 1841 (Family Trygones Müller and Henle, 1841), *Syst. Besch. Plagiost.*, pt. 3: 173.

Type Genus: *Urolophus* Müller and Henle, 1837.

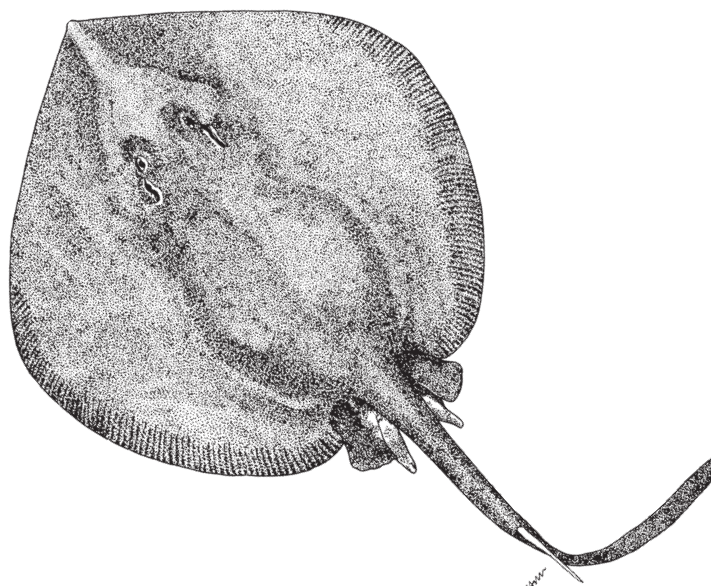


Fig. 132 *Plesiobatis daviesi*

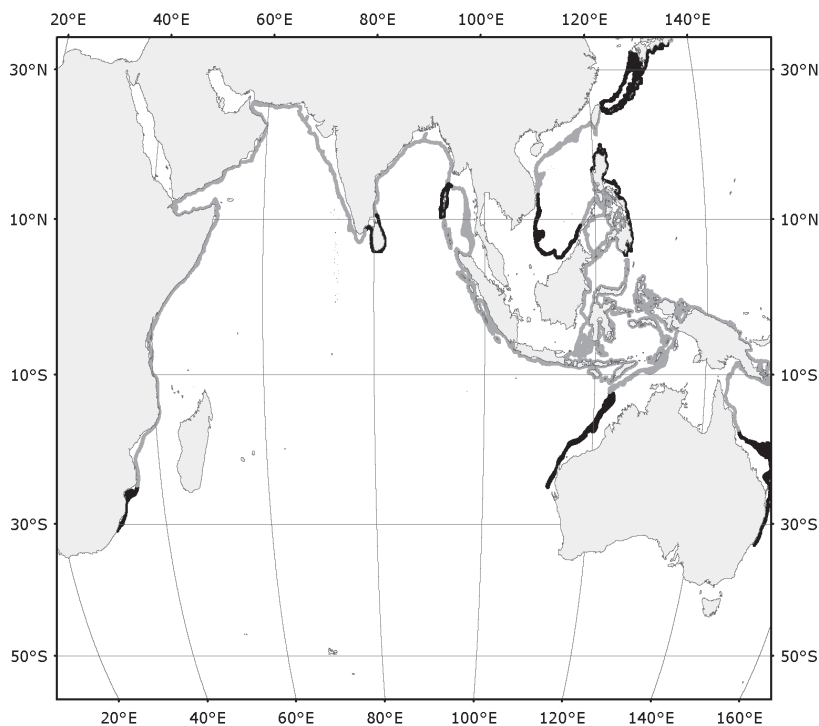


Fig. 133 *Plesiobatis daviesi*

■ Known distribution ■ Possible distribution

Number of Recognized Deep-sea Indian Ocean Genera: 1.

Synonyms: Gruppe Trygonopterae Müller and Henle, 1841 (Family Trygones Müller and Henle, 1841), *Syst. Besch. Plagiost.*, pt. 3: 174. Type genus: *Trygonoptera* Müller and Henle, 1841. [Subtribe?] Urolophi Gray, 1851 (Family Raiae Gray, 1851), *List Fish British Mus., Pt. 1, Chondropterygii, British Mus. (Nat. Hist.)*: 125. Type genus: *Urolophus* Müller and Henle, 1837. [Subtribe?] Trygonopterae Gray, 1851 (Family Raiae Gray, 1851), *List Fish British Mus., Pt. 1, Chondropterygii, British Mus. (Nat. Hist.)*: 125. Type genus: *Urolophus* Müller and Henle, 1837. Family Urolophidae Whitley, 1939, *Australian Zool.* 9(3): 257. Type genus: *Urolophus* Müller and Henle, 1837.

FAO Name: En – Stingarees.

Field Marks: Flattened batoids with short rounded or angular snouts, small nostrils, nasal curtains reaching the mouth, spiracles adjacent to eyes, short slender tails, a large round or subangular pectoral disc with no denticles or small thorns, a small dorsal fin or none, a small rounded or moderately elongated caudal fin, and a sting on the tail.

Diagnostic Features: Disc oval, subcircular or rounded–rhomboidal, depressed, flattened, width 0.9 to 1.3 times length. Head broad, depressed; snout short to moderately elongated, broadly angular to rounded. Nostrils anterior to mouth, separated from it by distance much less than their width, connected by broad nasoral grooves with mouth; anterior nasal flaps long and medially expanded and fused into a broad, elongated nasal curtain that overlaps mouth. Mouth transverse, straight or broadly arched, and narrow, without prominent knobs, depressions or labial folds, but some species with prominent papillae on lower lip; lobate oral papillae present on floor of mouth. Teeth small, rounded–oval in shape and with short cusps or keels on their crowns, not laterally expanded and plate–like, similar in shape. Tooth counts in upper and lower jaws less than 50 rows in either jaw. Gill openings small, numbering five pairs on underside of front half of pectoral disc, not visible in lateral view. Eyes moderately large, dorsolateral on head, just anteromedial to spiracles. Disc entirely naked above and below or with a coarse covering of small dermal denticles; sometimes with small thorns on the upper surface present. Pelvic fins low, rounded or rounded–angular, and not divided into anterior and posterior lobes. Tail short, moderately stout, not whiplike, length about 0.6 to 1.2 times disc length; some species with a single dorsal fin in front of stinging spine, other species with dorsal fin reduced to a low keel or completely absent. Dorsal fin if present is low, rounded–angular, with anterior and posterior margins either confluent or distinct. Precaudal tail moderately depressed or cylindrical, with or without lateral folds on sides, tail abruptly narrower than trunk, a prominent barbed stinging spine on dorsal surface of tail well behind pelvic fins; no electric organs in tail. Caudal fin small, nearly symmetrical, lanceolate, with vertebral axis not raised above body axis; lower caudal–fin lobe absent. Size small to moderate, adults between 15 and 80 cm total length. **Colour:** dorsal surface varies from uniform green, brown, grey, or yellowish, and may be either unspotted or variegated with light or dark spots, stripes, blotches, ocelli, or complex shapes or reticulations; ventral surface generally white.

Distribution: Indo–Western Pacific: Australia to Indonesia and New Caledonia, and to Taiwan (Province of China), Japan, and Korea. Absent from the western and northern Indian Ocean (including the Red Sea and Persian Gulf).

Habitat: A moderately large, diverse group of inshore to outer continental shelf and upper slope batoids found from the intertidal down to 420 m, and usually over soft bottoms. These are slow–swimming bottom–dwellers, often found on soft mud or sand or partially buried in it. Some inshore species occur in estuaries and enclosed bays but are apparently unable to penetrate freshwater to any extent and are absent from rivers and lakes.

Biology: Viviparous with developing embryos resorbing their yolk sac at an early stage and fed by histotroph or ‘uterine milk’ secreted by the uterine lining. Depending on the species some may breed in the intertidal off beaches or in shallow bays and lagoons. Litters are of one to six young born after approximately a three months gestation. Stingarees feed mostly on bottom crustaceans, worms, and small bottom fishes.

Interest to Fisheries and Human Impact: Of little to no commercial utilization, although most likely taken as bycatch in other fisheries. These rather small, inshore batoids have a large, prominent barbed, toxic, stinging spine that can inflict a painful injury if stepped on or touched. Beachgoers, swimmers, fishermen, and divers should be cautious in areas where these stingarees occur as they often occur in dense aggregations in shallow waters along beaches and coastal lagoons and on soft sand or mud bottoms frequented by people engaged in these water activities. Otherwise, they are relatively inoffensive to people.

The conservation status of this group is mostly Data Deficient or Least Concern, but several species are considered Vulnerable and at least one species is considered to be Critically Endangered.

Local Names: None.

Literature: Nishida (1990); Last and Compagno (1999); Nelson (2006); Séret and Last (2003); Last and Stevens (2009).

List of Species Occurring in the Area:

 *Urolophus expansus* McCulloch, 1916

***Urolophus* Müller and Henle, 1837**

Genus: *Urolophus* Müller and Henle, 1837, *Ber. K. preuss. Akad. wiss. Berlin*, 2: 117.

Type species: *Raja cruciata* Lacepède, 1804, by original designation (also monotypic).

Number of Recognized Deep-sea Indian Ocean Species: 1.

Synonyms: *Leiobatis* (subgenus of *Raja*) Blainville, 1816, *Bull. Sci. Soc. Philomat. Paris*, (8): 121. Junior homonym of *Leiobatus* Rafinesque, 1810. Genus *Urolophus* Müller and Henle, 1838, *Arch. Naturg.* 4: 85. Probable error for *Urolophus* Müller and Henle, 1837.

Field Marks: Small to medium sized batoids with a disc width less than 1.3 times its length, eyes and spiracles located dorsally and close to each other, nasal curtain completely united and reaching mouth, no broadly flattened fleshy lobe on mid-lateral nostril margin, a moderately long tail with a barbed spine, dorsal fin present in some species and a small well developed caudal fin.

Diagnostic Features: Disc broad, subcircular to rhomboidal, width about equal to or greater than length, broadest at level behind spiracles; pectoral-fin apices subangular to broadly rounded. Pelvic fins angular to broadly rounded. Eyes moderately large. Mouth transverse, straight, with papillae on floor of mouth; oral papillae curved in irregular row, 3 to 16. Disc dorsal surface smooth. Tail about equal in length to disc; dorsal fin absent; prominent stinging spine present. **Colour:** dorsal surface plain without noticeable markings or with prominent markings including blotches, bands, reticulations, and spots; ventral surface light to pale, sometimes with darker colours.

Local Names: None.

Remarks: This genus formerly included the genera *Urobatis* and *Urotrygon*, but both these genera have been placed into their own family Urotrygonidae following McEachran, Dunn and Miyake (1996). These are mostly shallow water to outer continental shelf species, but with some species occurring primarily in deeper water along the upper continental slope.

***Urolophus expansus* McCulloch, 1916**

Urolophus expansus McCulloch, 1916, *Biol. Results Endeavour*. 4(4): 178, fig. 2. Syntypes: (5) AMS E.3501 (1), AMS E.3505 (1), AMS I.14040 (1), 113 to 208 mm disc width, Great Australian Bight, South Australia, 24 to 36 m.

Synonyms: None.

FAO Name: En – Wide stingaree.

Field Marks: A small to medium sized stingaree, with a “skirt-shaped” internasal flap, a short pointed lobe at the posterior end of the nasal curtain, tail folds present, no dorsal fin, and a moderately long tail with a barbed spine. Colour is a greyish green with two faint crossbars behind eyes and similar bars extending in front of eyes.

Diagnostic Features: Disc broad, rhomboidal, width about 1.1 times length, broadest just behind level of spiracles; pectoral-fin apices broadly rounded; anterior profile obtuse. Pelvic fins broadly rounded. Eyes relatively large, about one-half inter-orbital distance. Mouth moderately wide, about equal to internasal length. Internasal flap “skirt-shaped”, with a short lobe at posterior angles; curtain weakly fringed, very short. Oral papillae simple or irregular, numbering 6 to 9 on mouth floor. Tooth counts not available. Disc dorsal surface smooth. Tail elongated, anteriorly depressed, becoming oval in cross-section, with a barbed spine originating about halfway along its length; lateral tail folds prominent; dorsal fin absent. Caudal fin moderately elongated. Vertebral and spiral valve counts unavailable. Maximum total length at least 52 cm **Colour:** greyish green above with faint blue-grey bars extending laterally in front of each eye, and two crossbars posterior to eyes; whitish to yellow below with darker disc margins; tail with blotches.

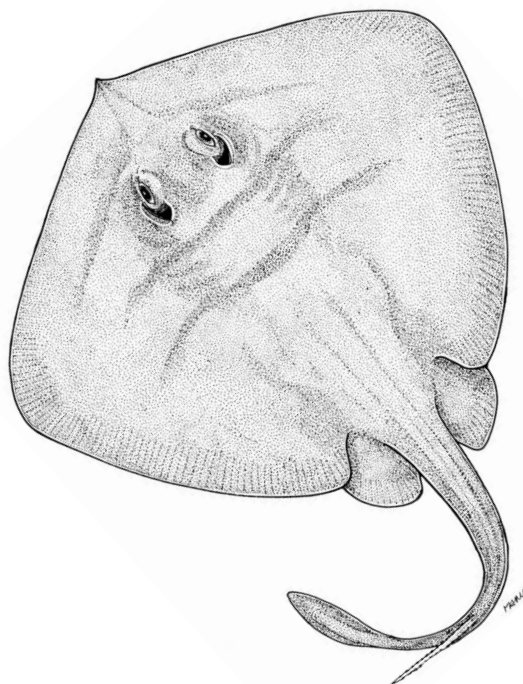


Fig. 134 *Urolophus expansus*

Distribution: Eastern Indian Ocean: South Australia (Port Lincoln) to Western Australia (Perth).

Habitat: Little known other than found from 130 to 420 m deep, mostly 200 to 300 m.

Biology: Viviparous with yolk-sac being resorbed and the embryos being nourished by histotroph (uterine milk) secreted by the uterine lining; litters possibly 1 or 2 per year, but little else known about their reproductive cycle. Age at maturity is about seven years for males, unknown for females, with a maximum estimated age of 11 years. The diet consists of isopods and polychaetes.

Size: Maximum total length at least 52 cm; males mature at 30 to 36 cm and females at about 40 cm. Size at birth not reported.

Interest to Fisheries and Human Impact: Of no commercial value, this species is frequently taken as bycatch in those parts of its range that are subject to bottom trawl fisheries. However, large areas of its range are not subject to fisheries.

The conservation status of this deepwater urolophid is Least Concern.

Local Names: Broadbacked stingaree (Australia).

Literature: McCulloch (1916); Last and Stevens (1994, 2009); Treloar (2006).

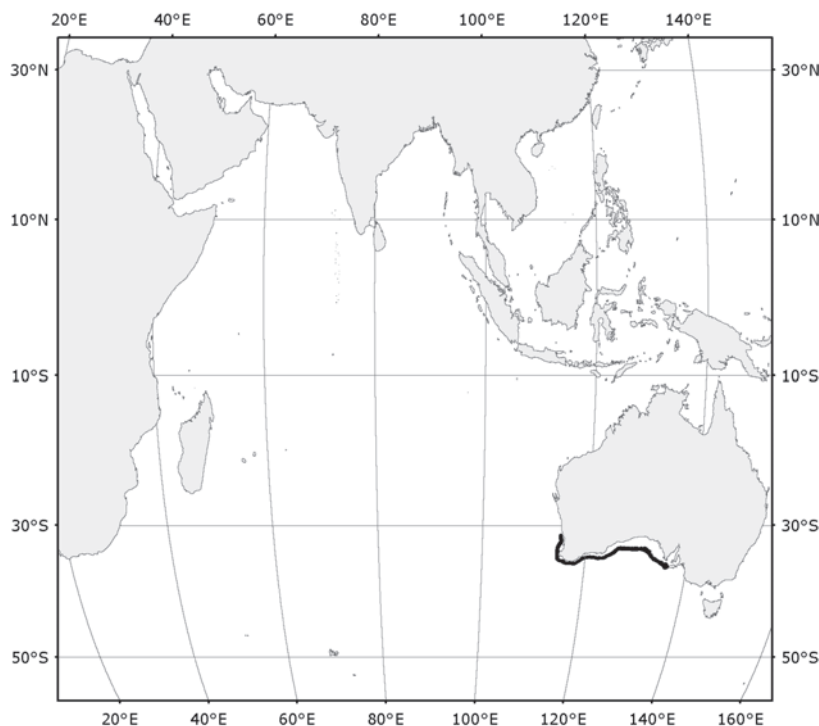


Fig. 135 *Urolophus expansus*

Known distribution

2.3.3 Family HEXATRYGONIDAE

Family: Family Hexatrygonidae Heemstra and Smith, 1980, *Ichth. Bull. J.L.B. Smith Inst. Ichthyol.* (43): 1. Type genus: *Hexatrygon* Heemstra and Smith, 1980.

Type Genus: *Hexatrygon* Heemstra and Smith, 1980.

Number of Recognized Deep-sea Indian Ocean Genera: 1.

Synonyms: Family Hexatrematobatidae Chu and Meng, in Chu, Meng, Hu, and Li, 1981, *Oceanol. Limnol. Sinica*, 12(2): 111. Type genus: *Hexatrematobatis* Chu and Meng, 1981.

Field Marks: A large soft-bodied stingray unique in that it is the only batoid species with six-paired gill openings.

Diagnostic Features: Disc shape nearly circular posterior to snout, with rounded pectoral apices; body depressed, flattened, soft, very flabby with a greatly elongated, thick, fleshy pointed snout; snout shape changes ontogenetically with growth. Nostrils very wide, located just anterior to mouth, separated from it by a distance much less than their own width, not connected by broad nasoral grooves with mouth; anterior nasal flaps very short and medially expanded and fused into a very broad, very short nasal curtain that ends just anterior to mouth. Mouth transverse, nearly straight, moderately broad, without prominent knobs, depressions or labial folds; no oral papillae on floor of mouth. Oral teeth small, rounded-oval in shape and with low ridges on their crowns, not laterally expanded and plate-like, similar in shape. Tooth counts 44 to 102 in upper and lower jaws (more rows present in adults than in young). Only known batoid with six paired gill openings. Eyes small and dorsolateral on head, well anterior to spiracles. Disc smooth, without denticles or thorns. Pelvic fins low, rounded, and not divided into anterior and posterior lobes. Tail short, moderately stout, not whiplike, without a dorsal fin, well developed, length about 0.5 to 0.7 times disc length. Precaudal tail moderately depressed or cylindrical, without lateral folds on sides, tail abruptly narrower than trunk, with 1 or 2 prominent barbed stinging spines on dorsal surface of tail well behind pelvic fins; no electric organs in tail. Caudal fin moderately large, not shark-like, nearly symmetrical and very elongated (about half length of tail) and leaf-shaped, with vertebral axis not raised above body axis; lower caudal-fin lobe absent. Vertebral counts: total vertebral count 101, vertebral count from first synarcual to cloaca 51, vertebral count from cloaca to stinging spine 50. Spiral valve count 14 for one individual. Maximum total length to at least 168 cm. **Colour:** in life, purplish-brown on dorsal surface becoming dark brown after preservation; ventral surface white with dusky margin on disc and pelvic fins; underside of tail dark.

Distribution: See species account below.

Habitat: See species account below.

Biology: See species account below.

Interest to Fisheries and Human Impact: See species account below.

Local Names: None.

Remarks: The family account above is after Compagno and Last (1999e).

Literature: Heemstra and Smith (1980); Compagno and Last (1999e); Last and Stevens (2009).

List of Species Occurring in the Area:

 *Hexatrygon bickelli* Heemstra and Smith, 1980

***Hexatrygon* Heemstra and Smith, 1980**

Genus: *Hexatrygon* Heemstra and Smith, 1980, *Ichth. Bull. J.L.B. Smith Inst. Ichthyol.* (43): 1.

Type species: *Hexatrygon bickelli* Heemstra and Smith, 1980, by original designation (also monotypic).

Number of Recognized Deep-sea Indian Ocean Species: 1.

Synonyms: Genus *Hexatrematobatis* Chu and Meng, in Chu, Meng, Hu, and Li, 1981, *Oceanol. Limnol. Sinica*, 12(2): 111. Type species: *Hexatrematobatis longirostrum* Chu and Meng, 1981 by original designation. Genus *Hexatrematibatis* Chu and Meng, in Chu, Meng, Hu, and Li, 1981, *ibid.*: 116. Error for *Hexatrematobatis*.

Field Marks: See species account below.

Diagnostic Features: See family account above.

Local Names: None.

***Hexatrygon bickelli* Heemstra and Smith, 1980**

Hexatrygon bickelli Heemstra and Smith, 1980, *Ichth. Bull. J.L.B. Smith Inst. Ichthyol.* (43): 6, figs. 1–13, 15. Holotype: J.L.B. Smith Institute of Ichthyology, SAIAB [formerly RUSI] 997, 103 cm total length, 50 cm disc width, immature or near-adolescent female, washed up on beach at Port Elizabeth, South Africa, ca. 33°59.5'S, 25°40.7'E.

Synonyms: *Hexatrematobatis longirostrum* Chu and Meng, in Chu, Meng, Hu, and Li, 1981, *Oceanol. Limnol. Sinica*, 12(2): 111, fig. 4. Holotype: South China Sea Fisheries Research Institute, SCSFRI-00072, 63.3 cm total length immature male, South China Sea, in block 112–114°E, 18.5–21°N, 350 to 1000 m. *Hexatrygon yangi* Shen and Liu, 1984, *Act. Oceanogr. Taiwanica*, (15): 201. Holotype: National Taiwan University Museum, NTUM-06100, 1040 mm TL, 545 mm disc width subadult male, Tung-Kong fish market, SW coast of Taiwan (Province of China), 22°28'N, 120°26'E (Tung-Kong [Tongkang] fish market), trawled off the coast at about 500 m depth. *Hexatrygon taiwanensis* Shen, 1986a, *J. Taiwan Mus.* 39(1): 175, fig. 1–5. Holotype: National Taiwan University Museum, NTUM-0655, 582 mm TL, 353 mm DW juvenile female, Tung-Kong fish market, SW coast of Taiwan (Province of China), 22°28'N, 120°26'E (Tung-Kong [Tongkang] fish market), trawled at depth of 370 m. *Hexatrygon brevirostra* Shen, 1986b, *J. Taiwan Mus.* 39(2): 106, fig. 1–3. Holotype: National Taiwan University Museum, NTUM-06597, 621 mm TL, 365 mm DW juvenile (?) female, Tong-Kung fish market, SW coast of Taiwan (Province of China), 22°28'N, 120°26'E (Tung-Kong [Tongkang] fish market), trawled at depth of 362 m.

FAO Name: En – Sixgill stingray.

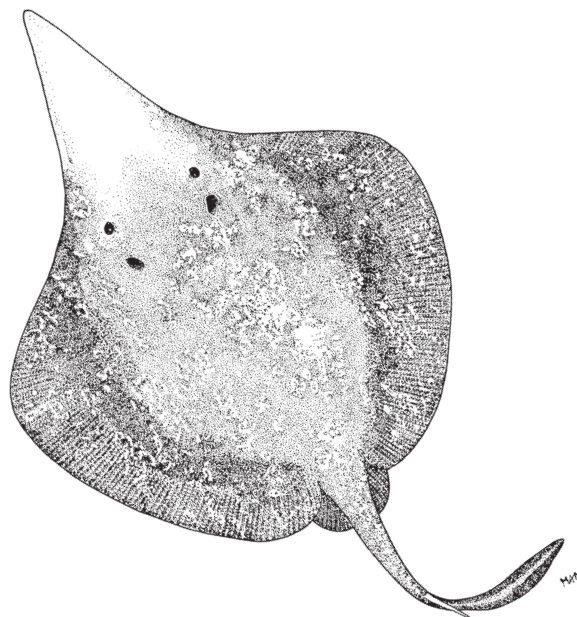


Fig. 136 *Hexatrygon bickelli*

Field Marks: Distinctive among batoids with six pairs of gill slits, large rounded–rhomboidal disc without denticles, body flabby, with an elongated, thick snout, oral papillae absent, nasal curtain very broad not extending to mouth, spiracles set far behind eyes, a short tail with a long, low caudal fin, no dorsal fins, and 1 or 2 prominent stinging spines. Colour is a dark violet blue or pinkish above, white below except for darker edges along disc.

Diagnostic Features: See family account above.

Distribution: Indian Ocean: South Africa (Western and Eastern Cape), India, Indonesia, western Australia (Western Australia off Exmouth Plateau to Shark Bay). Western and Central Pacific: South China Sea off China, Philippines, Taiwan (Province of China), Japan (Tokara Islands, Okinawa Trough and off Tokyo-Bay), Philippines, Australia (Queensland off Flinders Reef), and the Hawaiian Islands.

Habitat: This unique ray occurs on soft bottoms, mostly on the upper continental and insular slopes at depths of 300 to 1120 m, but with occasional records (including a live pregnant female with term foetuses) stranding on sandy beaches. Additionally, there is a possible angler's catch off the southwest coast of South Africa at depths of 20 to 30 m or less, and one was photographed feeding at moderate depths by the scuba diver team of Japan Broad Casting Corporation (NHK) Team (Ishihara, 1998).

Biology: Viviparous, without yolk–sac placenta, three to five embryos per litter, but little is known about their reproductive cycle.

Feeding habits unknown, although the very flexible snout tip and strongly protractible mouth in combination are used to probe about the bottom in search of food. This was observed by underwater video footage of an individual feeding on the bottom. One specimen examined had a wound from a 'cookie–cutter' shark.

Size: Maximum total length to at least 168 cm (adult female); females and males mature at 105 to 113 cm in length. Size at birth is about 48 to 50 cm total length.

Interest to Fisheries and Human Impact: Interest to fisheries minor, infrequently caught in bottom trawls as bycatch and mostly discarded, although in Taiwan (Province of China) it is retained and marketed.

The conservation status is Least Concern.

Local Names: Mutsuera-ei (Japan).

Remarks: Several species of sixgill stingrays have been named from the western Pacific based mostly on snout length and shape, but these nominal species were based on allometric variation with growth (the snout is much longer in adults than young) and after preservation the snout is very soft, turgid, and watery, and may shrink greatly if allowed to dry out, if stored in a freezer for too long, or if treated with strong fixative and preservative.

Literature: Heemstra and Smith (1980); Compagno, Ebert and Smale (1989); Ishihara (1998); Compagno and Last (1999e); Last and Stevens (2009); McCormack *et al.* (2009); Babu *et al.* (2011); L.J.V. Compagno (pers comm. and unpubl. data.).

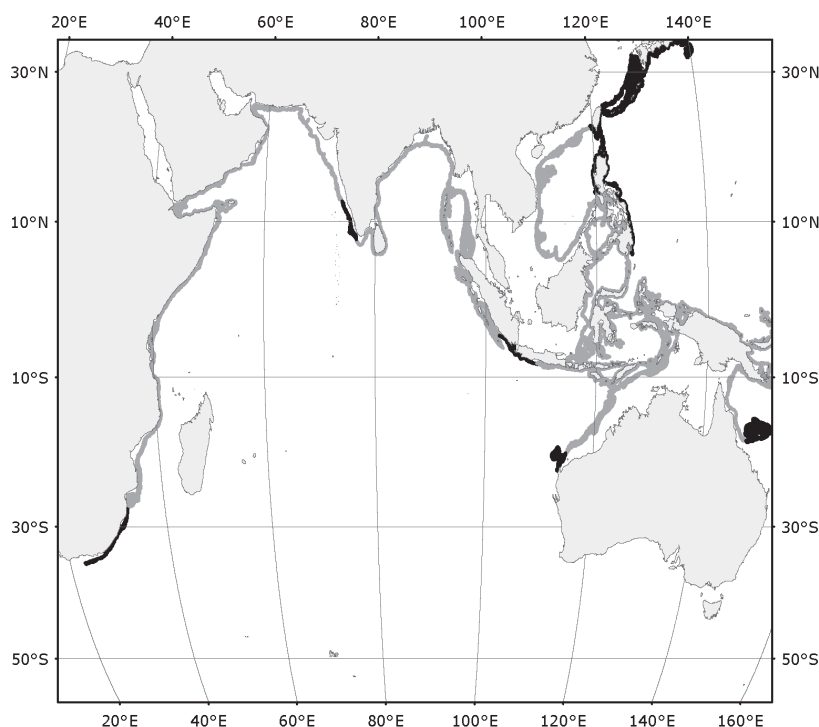


Fig. 137 *Hexatrygon bickelli*

■ Known distribution ■ Possible distribution

3. Subclass HOLOCEPHALI

3.1 **Order CHIMAERIFORMES – Chimaeras**

Order: Chimaeriformes: Patterson, 1965, *Philos. Trans. R. Soc. London B Biol. Sci.* 249: 101–219.

Number of Recognized Deep-sea Indian Ocean Families: 2.

Synonyms: See Bigelow and Schroeder 1953, Order Chimaerae page 516. See Garman 1901, 1906, 1911

FAO Names: **En** – Chimaeras; **Fr** – Chimères; **Sp** – Quimeras.

Field Marks: Body elongated and tapering rearwards to a filamentous tail, head very large, a prominent first dorsal-fin spine preceding a large, erect triangular dorsal fin, second dorsal fin low and elongated, broad pectoral fins, and noticeable open lateral line canals on head and trunk. Colour variable from silvery to grey, brown, reddish, or black with lighter or darker shades of each; prominent spots or stripes may be present on some species.

Diagnostic Features: Body more or less compressed, elongate, tapering posteriorly from large head to slender filamentous tail. Snout either short and conically rounded, elongate and spear-like, or with hoe-like proboscis. Eyes relatively large, and in life bright green. Nostrils large, located in front of mouth, connected with outer corner of mouth by a deep groove covered by lateral lobe of upper lip. Mouth ventrally located on head, anterior to eye level, transverse and small. Teeth plate-like, paired, with two pairs on upper jaw, a single pair on lower; plates with more or less conspicuous ridges and bumps on surface. Gill openings anterior to pectoral fins, one on each side and covered by a fleshy operculum. Spiracles absent. Skin smooth, often deciduous. Lateral line canals well developed, especially on head. Pectoral and pelvic fins broad, ovoid-shaped, and well developed. First dorsal fin triangular, erect, usually much higher than second, and preceded by an elongate, smooth or serrated edged spine; fin spine may or may not reach apex of first dorsal fin. Second dorsal fin lower than first, elongated, with margin either relatively straight or undulating distally, and terminating anterior to upper caudal-fin lobe. Second dorsal fin separated from first, elongated, and much lower in height than first; margin of second relatively straight to undulating distally, terminating before upper caudal-fin lobe. Anal fin absent or present; if present, small, low, and distinctly separated from caudal fin by a deep notch. Caudal fin lanceolate, with upper and lower lobes, dorsal lobe margin with or without tubercles; lower lobe without tubercles; whip-like tail filament variably present or absent. Sexual dimorphism strong, males (adults only) with bulbous, denticulate frontal tenaculum set in pouch atop head. Pre-pelvic tenaculum blade-like with or without large denticles along the medial edge, retractable into pouches anterior to the pelvic fins. Claspers may be slender and rod-like in some, bifurcate in others, or with some being tripartite. Size small 60 cm to relatively large at 150 cm total length or possibly more. **Colour:** uniform pale to whitish, silvery, brown, grey, or black; some species lighter or darker ventrally; depending on the species some may or may not exhibit striking patterns of spots and stripes.

Distribution: Circumglobal in all oceans except Antarctic waters. The western Indo-Pacific has the highest diversity of these fishes followed by the North Atlantic region. The family Chimaeridae tends to exhibit a high degree of endemism with some species having very restricted ranges while members of the family Rhinochimaeridae generally have a broader, but widely scattered distribution; most members of both these families are primarily deep-sea. The shallow water family Callorhynchidae is restricted to the Southern Hemisphere.

Habitat: Chimaeroids are mostly deep-water inhabitants occupying outer continental shelves, slopes, seamounts, offshore island chains, and underwater ridges from depths of 500 m to more than 2500 m. A few species, mainly those in the family Callorhynchidae, occur in relatively shallow, coastal waters. Chimaeroids occur on both soft bottom and rocky reef habitats, some in areas of relatively high vertical relief.

Biology: Reproduction is oviparous, but for most species very little else is known about their reproductive cycle, fecundity, or age and growth. There have been some limited diet studies that suggest they consume mostly benthic invertebrates including polychaetes, amphipods, molluscs, including bivalves, gastropods and cephalopods, crustaceans, brittle stars, and small benthic fishes. The behavior of most chimaeroids is poorly known although it is well known that some species will form large aggregations, segregate by size and sex, while some species will occupy different habitats depending on the stage in life.

Interest to Fisheries and Human Impact: A few species, mostly the callorhynchids, are targeted in commercial fisheries, but most species are taken as bycatch and either discarded at sea or retained for market.

The conservation status of most species is either Data Deficient or Least Concern due to their deep-water habitat and lack of information on their abundance, life history, and population trend.

Local Names: None.

Remarks: The present arrangement of the Chimaeriformes families and genera follows recent revisions by Didier (1995, 2004) and Didier, Kemper and Ebert (2012). The shallow-water occurring Callorhynchidae are not discussed further.

Literature: Garman (1901, 1908, 1911); Bigelow and Schroeder (1953, 1954); Krefft *in* Hureau and Monod (1973a, b); Stehmann and Bürkel *in* Whitehead *et al.* (1984); Compagno, Stehmann and Ebert (1990); Didier (1995, 2002a, b, 2004); Nelson (2006); Last and Stevens (2009); Ebert and Winton (2010); Didier, Kemper and Ebert (2012); Ebert and Stehmann (2013).

Key to Deep-sea Indian Ocean Families:

- 1a. Snout short and blunt (Fig. 138)
 family **Chimaeridae**

- 1b. Snout elongated and tapering (Fig. 139)
 family **Rhinochimaeridae**

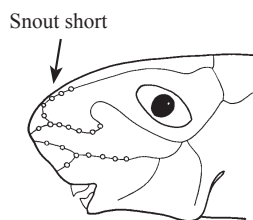


Fig. 138 *Chimaera* sp.

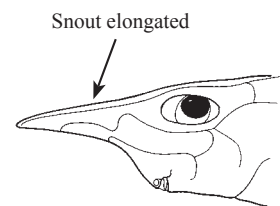


Fig. 139 *Rhinochimaera* sp.

3.1.1 Family CHIMAERIDAE

Family: Chimaeridae Bonaparte, 1831, *Giornale Arcadico di Scienze*, 49: 1–77.

Type genus: *Chimaera* Linnaeus, 1758.

Number of Recognized Deep-sea Indian Ocean Genera: 2.

Synonyms: None.

FAO Name: En – Shortnose chimaeras.

Field Marks: Small to large bodied chimaeras, with massive heads, but tapering posteriorly to a filamentous whip-like tail, snout fleshy, short, conical, and pointed at tip, first dorsal fin triangular, preceded by a prominent fin spine, anal fin variably absent or present. Body colour uniformly dark or light brown, grey, black, with spotting or lateral stripes in some species.

Diagnostic Features: Body elongate, compressed, tapering from very large head to a filamentous tail. Snout short, conical, fleshy, bluntly pointed at tip. Eyes large, bright green in life. Skin smooth, often deciduous, flaking off in patches during and after capture. Nostrils large, located in front of mouth. Gills, one opening on each side, located anterior to pectoral fins, and covered by a fleshy operculum. Spiracles absent. Mouth small, ventral on head, connected to nostrils by deep grooves. Teeth non-replaceable, in the form of three paired tooth plates; two pairs on upper jaw, one pair on lower jaw. Tooth plates robust with patches of dense hypermineralized tissue that appears as ridges and bumps on the surface. Lateral line canals appear as open grooves on head and flanks of body; canals on snout widening with regularly spaced expanded dilations. Pectoral and pelvic fins broad with delicate external fin webs supported by cartilaginous rays (ceratotrichia). First dorsal fin triangular, erect, preceded by an elongate, serrated spine. Second dorsal fin separated from first, elongated, and much lower in height than first; margin of second relatively straight to undulating distally, terminating before upper caudal-fin lobe. Anal fin, depending on the genera, absent or present; if present, small, low, and distinctly separated from caudal fin by a deep notch. Caudal fin lanceolate, with upper and lower lobes, and terminating with a whip-like tail filament of variable length. Sexual dimorphism strong, mature males with bulbous, denticulate frontal tenaculum set in pouch atop the head anterior to eyes. Pre-pelvic tenaculum blade-like with large denticles along the medial edge, hidden in pouches anterior to the pelvic fins. Claspers bifurcate or tripartite with fleshy, denticulate tips. Size variable, ranging from 60 to 150 cm total length. **Colour:** uniform brown, grey, or black, but with some species exhibiting striking patterns of spots and stripes.

Distribution: The Chimaeridae have an almost circumglobal distribution in arctic and cold temperate to tropical seas, although most species, especially in lower latitudes, occur in very deep-water. This is the most species-rich family of chimaeras with most species being regional endemics. The only area they do not appear to occur in is the Antarctic region.

Habitat: Members of the Chimaeridae generally inhabit deep-water, usually at depths greater than 200 m, with some species known to well over 2500 m deep. They occupy a wide range of benthic habitats from soft muddy or sandy bottoms to cobble and rocky reefs, sometimes in association with high vertical relief.

Biology: Reproductive mode is oviparous, but little is known about their fecundity or reproductive cycle. Females lay pairs of spindle-shaped egg cases that are deposited on the bottom. Embryological studies indicate that development may take as long as 9 to 12 months, but for some of the deeper living species the gestation time may be much longer.

Attempts to age chimaeras have met with mixed results, with the age not being validated for any species. Very little is known of their diet except where information is available they tend to feed on a variety of benthic invertebrates and small fishes.

Interest to Fisheries and Human Impact: Fisheries for chimaeras are poorly known with catches perhaps the least reported among any chondrichthyan group. Most shortnose chimaeras occur too deep and are not caught in sufficient numbers to warrant a targeted fishery, but are often retained as bycatch. The North Atlantic *Chimaera monstrosa* is one shortnose chimaera species for which landings are reported.

The conservation status of most members of this family are Data Deficient or Least Concern, but some species, including *Hydrolagus ogilbyi*, are considered Near Threatened due to current or potential fisheries that may impact their populations.

Local Names: Ratfishes, Rabbitfishes, Ghostsharks, Silver sharks.

Remarks: The current arrangement of this family follows Didier, Kemper and Ebert (2012) and Ebert (unpubl. data) in recognizing two genera and 38 species. The separation of the genera *Chimaera* and *Hydrolagus* has been subject to much debate as they are morphologically very similar with the primary difference being the presence (*Chimaera* spp.) or absence (*Hydrolagus* spp.) of an anal fin.

Literature: Garman (1901, 1908, 1911); Bigelow and Schroeder (1953); Krefft in Hureau and Monod (1973a); Stehmann and Bürkel in Whitehead *et al.* (1984); Didier (1995); Nelson (2006); Ebert and Winton (2010); Didier, Kemper and Ebert (2012); Ebert and Stehmann (2013).

List of Species Occurring in the Area:

Chimaera argiloba Last, White, and Pogonoski, 2008

Chimaera fulva Didier, Last, and White, 2008

Chimaera lignaria Didier, 2002

Chimaera macrospina Didier, Last, and White, 2008

➤ *Chimaera notafriicana* Kemper, Ebert, Compagno, and Didier, 2010

Hydrolagus africanus (Gilchrist, 1922)

Hydrolagus homonycteris Didier, 2008

Hydrolagus lemures (Whitley, 1939)

➤ *Hydrolagus ogilbyi* (Waite, 1898)

Hydrolagus trolli Didier and Séret, 2002

Key to Deep-sea Indian Ocean Genera:

1a. Anal fin present (Fig. 140). *Chimaera*

1b. Anal fin absent (Fig. 141) *Hydrolagus*

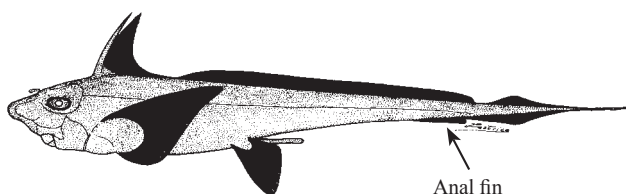


Fig. 140 *Chimaera*

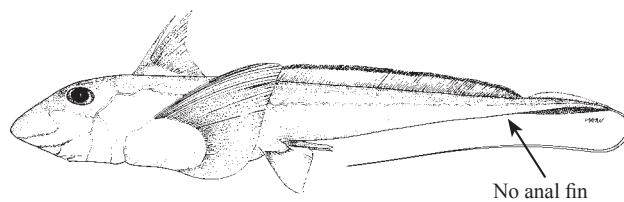


Fig. 141 *Hydrolagus*

***Chimaera* Linnaeus, 1758**

Genus: *Chimaera* Linnaeus, 1758, *Syst. Nat.*, ed. 10, 1: 236.

Type species: *Chimaera monstrosa* Linnaeus, 1758, by subsequent designation of Jordan and Gilbert, 1883, 54.

Number of Recognized Deep-sea Indian Ocean Species: 5.

Synonyms: Genus *Chimera* Rafinesque, 1815, *An. Nat.*: 92; emended spelling for *Chimaera* Linnaeus, 1758, by ref. to Linnaeus. Genus *Chimaira* Duméril, 1856, *Mem. Acad. Sci. France*, 27(1): 155; emended spelling for *Chimaera* Linnaeus 1758, by ref. to Linnaeus. Doubtful synonym Genus *Callorhynchus* Gronovius, 1772: 49. Type and only described species: *Callorhynchus americanus*.

Field Marks: Blunt-snouted chimaeras with dorsal-fin spine attached to first one-third to one-half of dorsal fin, the upper half unattached, second dorsal-fin height even along its length, never indented, and anal fin separated from the anterior margin of the ventral caudal fin by a deep notch.

Diagnostic Features: As for family, but species placed into the genus *Chimaera* have a deep notch separating the anal fin from the ventral caudal-fin margin.

Local Names: Rabbitfishes.

Remarks: The genus contains at least 14 or 15 species worldwide, with several possibly undescribed species currently under investigation; five species are known to occur in the Indian Ocean deep-sea. The recently described *Chimaera notafricana* was previously referred to as *C. monstrosa*, a North Atlantic species. This species is most abundant in the southeastern Atlantic, but with records extending to the Eastern Cape Province, South Africa.

Key to Deep-sea Indian Ocean Species:

1a. Body colour a uniform dark brown or black
..... 2

1b. Body colour pale, silvery, grey, tan, grey-blue or lavender 3

2a. Pectoral fin almost straight anteriorly, convex posteriorly; preopercular and oral canals share a common branch; body colour chocolate brown; locality Australia (Fig. 142)
..... *Chimaera macrospina*

2b. Pectoral fin when depressed extends to origin of pelvic fin; male pelvic claspers divided for distal one-third of their length; preopercular and oral canals share a common branch; body colour blackish-brown with dark bluish streaking; locality southern Africa (Fig. 143).
..... *Chimaera notafricana*

3a. Preopercular and oral lateral line canals usually not sharing a common branch; trunk lateral line canal with tight sinuous undulations or broad undulations anterior to pelvic fins (Fig. 144) *Chimaera argiloba*

3b. Preopercular and oral lateral line canals share a common branch from the infraorbital canal; trunk lateral line canal without sinuous undulations along its length 4

4a. Body colour silvery pink to pale brown; pectoral fins when depressed extend slightly posterior to pelvic-fin origins; pelvic fins large, paddle-shaped; male pelvic claspers divided for less than half of their length (Fig. 145) .
..... *Chimaera fulva*

4b. Body colour grey-blue or lavender; pectoral fins when depressed extend to pelvic-fin origins or beyond; pelvic fins large and rounded; adults massive in size; male pelvic claspers divided for distal one-third of their length (Fig. 146) *Chimaera lignaria*

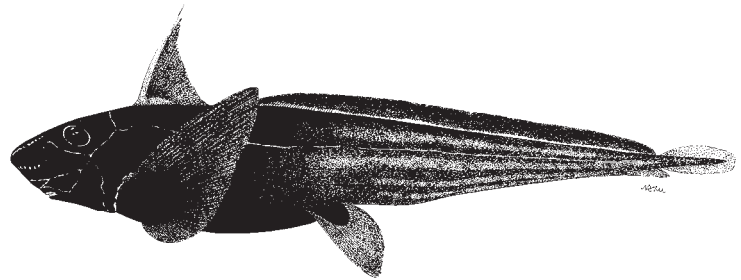


Fig. 142 *Chimaera macrospina*

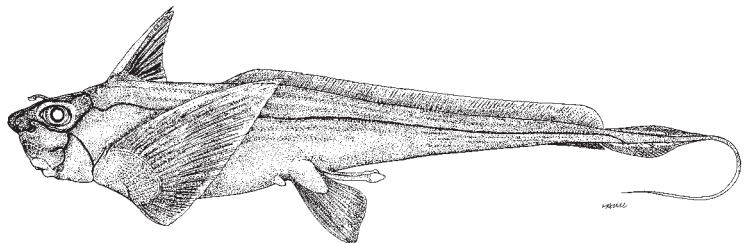


Fig. 143 *Chimaera notafricana*

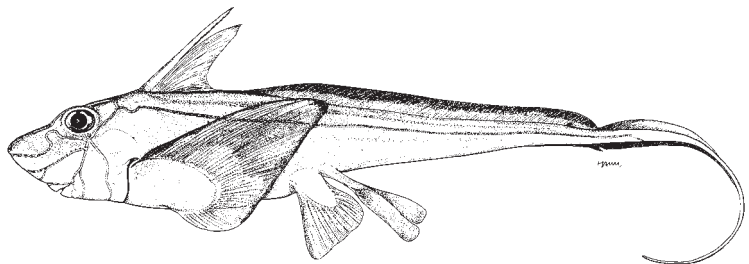


Fig. 144 *Chimaera argiloba*

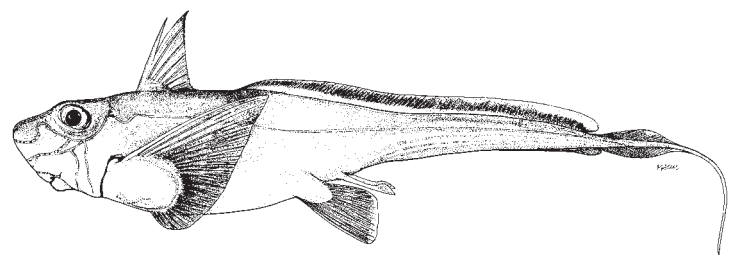


Fig. 145 *Chimaera fulva*

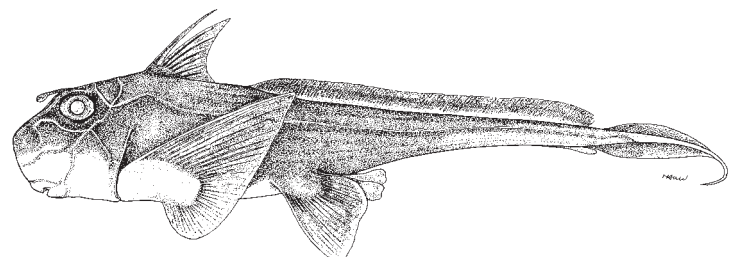


Fig. 146 *Chimaera lignaria*

***Chimaera notafriicana* Kemper, Ebert, Compagno, and Didier, 2010**

Chimaera notafriicana Kemper, Ebert, Compagno, and Didier, 2010, *Zootaxa*, 2532: 55–63, figs. 1–2, tabs. 1–2. Holotype: SAM 34517, adult male, 837 mm total length, 509 mm body length. Type locality: Cape Agulhas, southern Africa (34° 49'S, 20° 00'E), by the M/V *Boulonnais*, station 36.09.72, 18 September 1996.

Synonyms: *Chimaera monstrosa* Duméril, 1865: 688; Gilchrist, 1902: 162; Thompson, 1914: 166; Gilchrist, 1922: 5; Barnard, 1925: 94; Fowler, 1936: 143; Fowler, 1941: 489; Barnard, 1947: 30, probably not Pl. 5, fig. 3 = *C. monstrosa* from European sea; Smith, 1949: 76; Stehmann and Bürkel, 1984: 213; Compagno, 1986: 144, not fig. 32.1, which is European *C. monstrosa*; van der Elst and Vermeulen, 1986: 4. *Chimaera vaillantii*: Dean, 1906: 7 (MNHN 2557), *nomem nudum*. *Chimaera* sp.: Compagno, Ebert and Smale, 1989: 120, ill.; Compagno, Ebert and Cowley, 1991: 70; Compagno, 1999: 120.

Other Combinations: None.

FAO Name: En – Cape Chimaera.

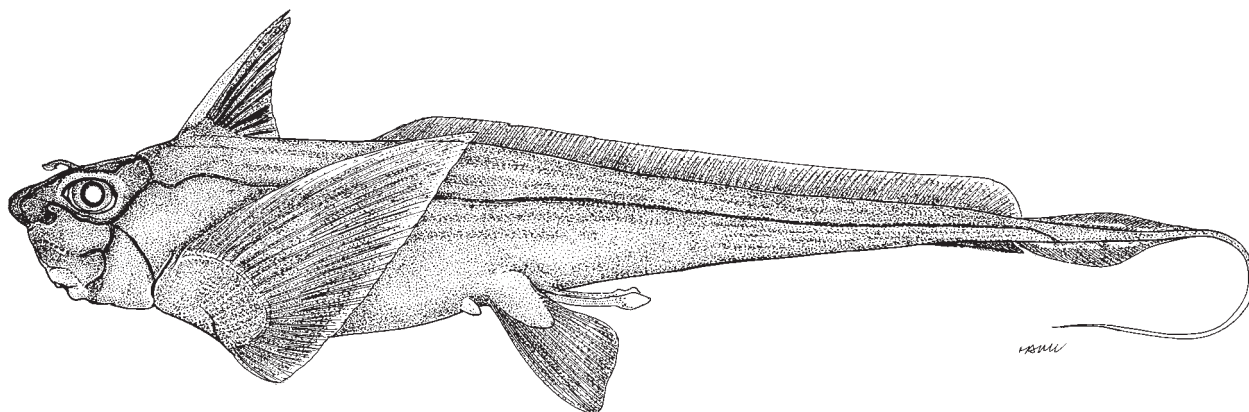


Fig. 147 *Chimaera notafriicana*

Field Marks: A uniform blackish brown coloration with dark bluish streaking and longitudinal light and dark stripes along body flanks, pelvic claspers short, not extending past distal tip of pelvic fins, divided for distal one-third of length, distal edge of pelvic fins slightly rounded, dorsal-fin spine when depressed extending past origin of second dorsal fin and large triangular pectoral fin reaching to pelvic-fin origin when depressed.

Diagnostic Features: Body elongate, slender, tapering from head to whip-like tail filament; caudal filament length about 44 to 57% of total body length. Snout short, conical, and bluntly pointed. Eyes moderately large, 26 to 33% head length. Lateral line canals on head appear as open grooves, canals on snout characterized by wide dilations. Preopercular and oral lateral line canals share a common branch off the infraorbital canal. Skin deciduous, smooth. Pectoral fins large and triangular in shape, reaching to origin of second dorsal fin and just to origin of pelvic fin when laid back. Pelvic fins slightly rounded at apices, about one-half size of pectoral fins. Adult males with frontal tenaculum, slender, curving along dorsal surface to a rounded bulbous tip, and adorned with small denticles on the dorsal surface; length about one-half eye length. Pelvic claspers short, slender, rod-like, smooth, and with small dilated tip; fleshy tips bulbous and covered with shagreen of denticles; prepelvic tenacula with four spines along medial edge. First dorsal fin high, triangular, fin preceded by a keeled spine, strongly serrate along the posterior edge of the distal tip; spine tip when depressed reaches beyond second dorsal-fin origin. Second dorsal fin long and continuous to upper caudal fin, relatively straight along its length, slightly higher along posterior one-third of fin length, but margin not undulating. Anal fin small, low, and with pointed tip extending at least to second dorsal-fin insertion. Caudal-fin dorsal lobe slightly anterior to ventral lobe, about equal in height, but height nearly equal to or slightly less than second dorsal-fin height. Maximum total length 93 cm. **Colour:** uniform blackish brown, with dark bluish streaks laterally on body trunk, precaudal with longitudinal light and dark stripes, but no lighter spots or silvery sheen; pectoral, pelvic, and dorsal fins moderate to dark brown, with a bluish hue near the fin edges; pectoral fins lighter along posterior edges; dorsal-fin spine light brown, becoming darker in grooves; caudal-fin lobes moderately brown, darker near fin base, lighter near fin apices.

Distribution: Southeastern Atlantic and southwestern Indian Ocean: known only from off Lüderitz, Namibia, to the Cape of Good Hope and eastwards to Algoa Bay, Eastern Cape Province, South Africa.

Habitat: Upper continental slope from 680 to at least 1016 m.

Biology: Virtually unknown.

Size: Maximum total length 93 cm for an adult female, and about 84 cm for an adult male. Size at birth is unknown.

Interest to Fisheries and Human Impact:

Occasionally caught by hake trawlers, but not utilized.

The conservation status of this species is Least Concern.

Local Names: None.

Literature: Compagno, Ebert and Smale (1989); Compagno, Ebert and Cowley (1991); Kemper *et al.* (2010); Kemper and Ebert (2011).

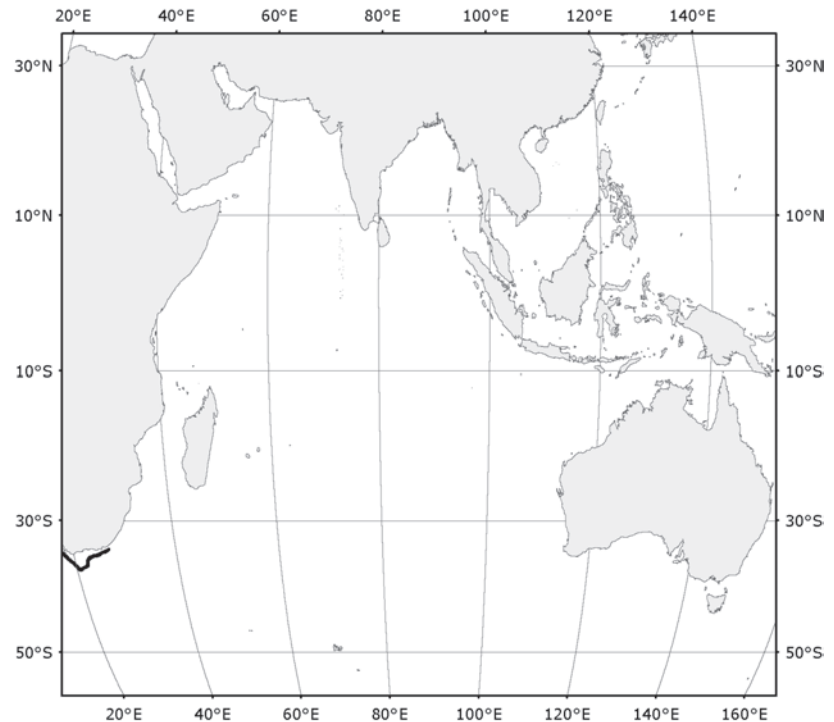


Fig. 148 *Chimaera notafriicana*

 Known distribution

***Hydrolagus* Gill, 1862**

Genus: *Hydrolagus* Gill, 1862, *Proc. Acad. Nat. Sci. Philad.*, 14: 331.

Type species: *Chimaera collieri* Lay and Bennett, 1839, off Monterey, California, U.S.A., by monotypy.

Number of Recognized Deep-sea Indian Ocean Species: 6.

Synonyms: Subgenus *Bathyalopex* Collett, 1904. *Forh. VidenskSelsk. Krist.*, (9): 5. Type: *Chimaera (Bathyalopex) mirabilis* Collett, 1904 (by monotypy) as a subgenus to *Chimaera*. Faroe Channel and Faroe Bank, 720 to 1200 m.

FAO Names: **En** – Ratfishes; **Fr** – Chimères; **Sp** – Quimeras.

Field Marks: Blunt-snouted chimaeras with a dorsal-fin spine either attached to first dorsal-fin entire length or free for distal one-half to one-third its length, second dorsal fin even in height along its length or with deep indentation separating the fin into anterior and posterior portions, and no deep notch separating an anal fin from the ventral caudal fin.

Diagnostic Features: As for family, but species placed into the genus *Hydrolagus* lack an anal fin.

Local Names: None.

Remarks: Worldwide there are 23 species recognized within this genus, five of which occur in the Indian Ocean deep-sea. A large bluish-black *Hydrolagus* species, at least 110 cm total length excluding the caudal filament, is somewhat common below 600 m and is found at scattered locations throughout the Indian Ocean. The species has been tentatively referred to as *H. trolli* and is currently under investigation by the author, Jenny Kemper (College of Charleston) and Dominique Didier (Millersville University).

Key to Deep-sea Indian Ocean Species:

1a. Trunk lateral line canal with regular, small sinuous undulations along its length. **2**

1b. Trunk lateral line canal lacking sinuous undulations **3**

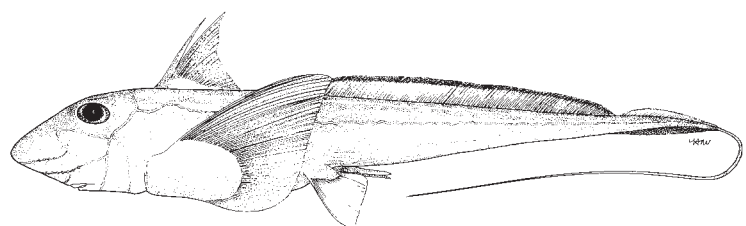


Fig. 149 *Hydrolagus lemures*

2a. Body colour usually a uniform pale cream, brown, or tan, sometimes paler ventrally, fins darker with distal margins black; a pale indistinct brownish stripe may be visible along the trunk (Fig. 149) *Hydrolagus lemures*

2b. Body colour pale, white, silvery, or tan, lighter ventrally, snout sometimes yellowish, fins dark, usually charcoal to black in colour (Fig. 150) *Hydrolagus ogilbyi*

3a. Small-bodied, slender fish, some adults almost dwarf-like; body colour pale, brown, tan, or silvery-grey (Fig. 151)
 *Hydrolagus africanus*

3b. Large-bodied fish, adults sometimes massive; body colour dark black, purplish, blue or grey 4

4a. Body colour dark brown, black, or purplish (Fig. 152) *Hydrolagus homonycteris*

4b. Body colour pale, blue or grey (Fig. 153) *Hydrolagus trolli*

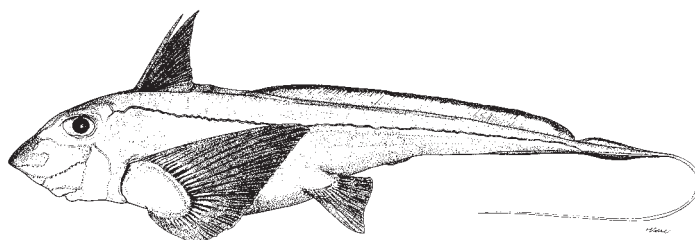


Fig. 150 *Hydrolagus ogilbyi*

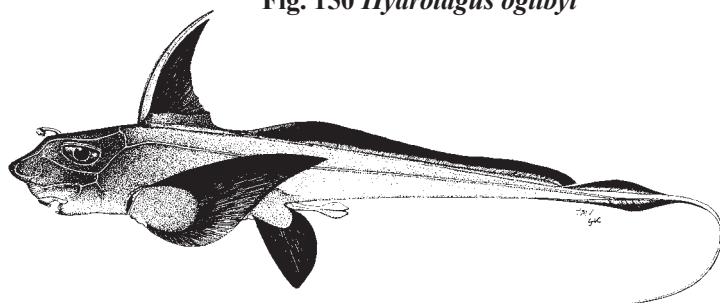


Fig. 151 *Hydrolagus africanus*

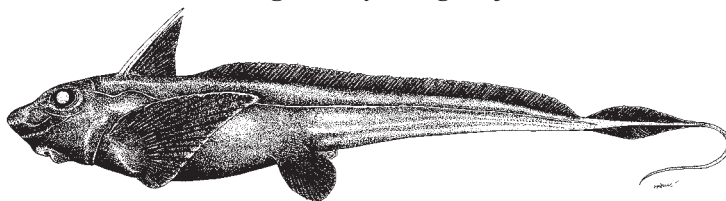


Fig. 152 *Hydrolagus homonycteris*

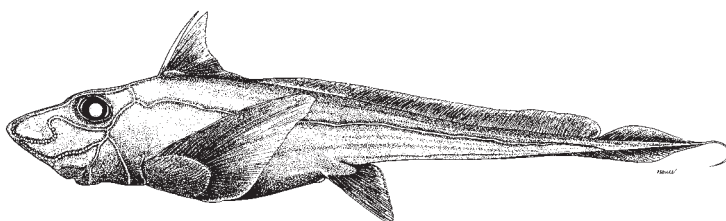


Fig. 153 *Hydrolagus trolli*

***Hydrolagus ogilbyi* (Waite, 1898)**

Chimaera ogilbyi Waite, 1898, *Scientific report on the fishes. Official Report, Sydney. New South Wales Fisheries*: 42 by original designation. Syntypes: AMS I.3732 (1), I.3734 (1), I.3736–7 (2). Type locality: NSW, Australia, off Port Hacking, 22–38 fm.

Synonyms: *Hydrolagus (Psychichthys) waitei* Fowler, 1908: 419, fig. 1; McCulloch, 1929: 32. *Chimaera waitei* Garman, 1911: 91; McCulloch, 1929: 32; Fowler, 1941: 499; Maxwell, 1980: 31. *Hydrolagus tsengi* Fang and Wang, 1932: 281, fig. 29. Lindberg and Legeza, 1959: 165

Other Combinations: None.

FAO Name: En – Ogilby's ghost shark.

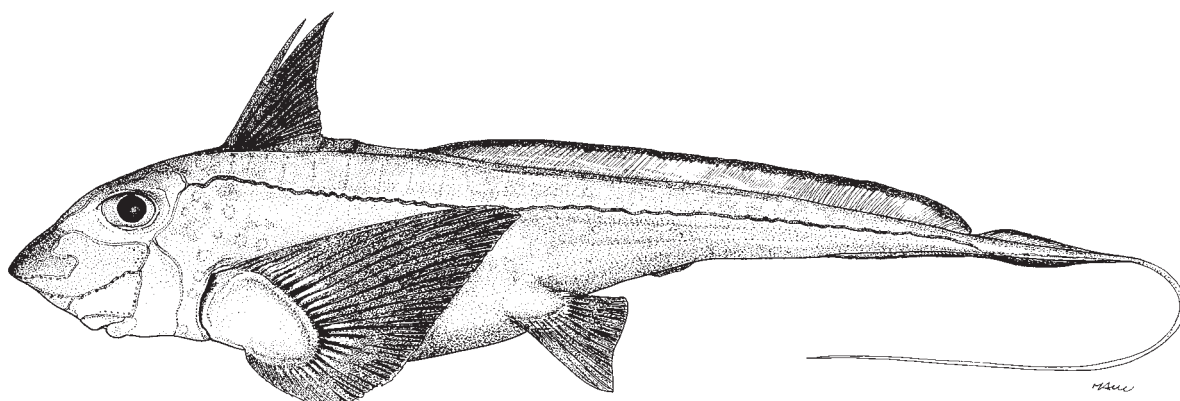


Fig. 154 *Hydrolagus ogilbyi*

Field Marks: A slender, medium bodied *Hydrolagus* with a relatively long snout for this chimaera group, preopercular and oral lateral line canals not sharing a common branch, second dorsal fin nearly straight, and a relatively short whip-like caudal filament. Colour is a uniform silvery with light brown blotches; fins are a bluish black to brownish.

Diagnostic Features: Body elongate, slender, rapidly tapering behind pelvic fins to very long, slender, narrow whip-like filamentous tail; caudal filament length greater than pectoral-fin length. Snout conical and bluntly pointed, and short. Eyes oval-shaped, relatively large, about 1.7 to 2.1 times into snout length. Gill openings relatively small. Preopercular and oral lateral line canals do not share a common branch. Lateral line wavy. Skin deciduous, smooth. Pectoral fins broadly rounded, reaching beyond pelvic-fin origins when laid back. Pelvic fins angular at base, extending to pointed tip along lateral edge. Adult males with frontal tenaculum, curved dorsal surface, a rounded bulbous tip, and adorned with small denticles. Pre-pelvic tenaculum small, divided about one-half their length, with fleshy bulbous tips covered in an extremely fine shagreen of denticles; not reaching beyond the distal margin of the pelvic fins. First dorsal fin high, with a short fin-base; fin preceded by a slender fin spine that is less than height of first dorsal-fin tip; posterior spine edges serrated; spine extends beyond origin of second dorsal fin when depressed. Interdorsal fin space small, first and second dorsal fins joined by a fleshy ridge of skin. Second dorsal fin long, continuous to upper caudal-fin lobe; height less than one-third first dorsal-fin height; second dorsal fin with relatively straight dorsal margin. Maximum total length at least 85 cm without caudal filament. **Colour:** in life a silvery to pale white, occasionally with indistinct light brown blotches, but becoming darker after preservation; juveniles with dark brown stripe along lateral line. Ventral surface of snout and head lighter; first dorsal fin, pectoral and pelvic fins, and lower lobe of caudal fin bluish black to brown; second dorsal-fin margin dark brown, base distinctly lighter; dorsal-fin spine a dark brownish.

Distribution: Apparently endemic to Australia, from Coffs Harbour, New South Wales to Beachport, South Australia, also Tasmania. Records from Japan are not of this species.

Habitat: Relatively common, but very little known about its habitat, outer continental shelf to upper slopes from 40 to 524 m deep. This is one of the few Australian chimaera species known to venture onto the continental shelf on occasion.

Biology: Virtually nothing is known.

Size: Maximum total length at least 85 cm without caudal filament, 102 cm with caudal filament (55 cm body length). Males and females both mature at about 64 to 70 cm length (without caudal filament). Size at birth is unknown.

Interest to Fisheries and Human Impact: A relatively abundant species locally, it is taken as bycatch in Tasmanian waters by commercial bottom trawlers fishing for flathead (*Platycephalus* spp.), Latchet (*Pterygotrigla polyommata*), and Tarakihi (*Nemadactylus macropterus*). Its meat is of high quality and is marketed in small quantities.

The conservation status of this chimaera is Near Threatened due to local population declines in some areas where it occurs.

Local Names: Ghostshark, Spookfish, Whitefish (Australia).

Remarks: Tanaka (1908) reported this species from Japan, but it seems likely that he may have mistaken it for *Chimaera phantasma*, a very similar appearing, and common *Chimaera* species from the western North Pacific. Examination of *Hydrolagus ogilbyi*-like chimaeras from Taiwan proved to be conspecific with *C. phantasma* specimens that apparently lacked an anal fin (D.A. Ebert, unpubl. obs.).

Literature: Waite (1898); Dagit and Kyne (2006); Last and Stevens (2009).

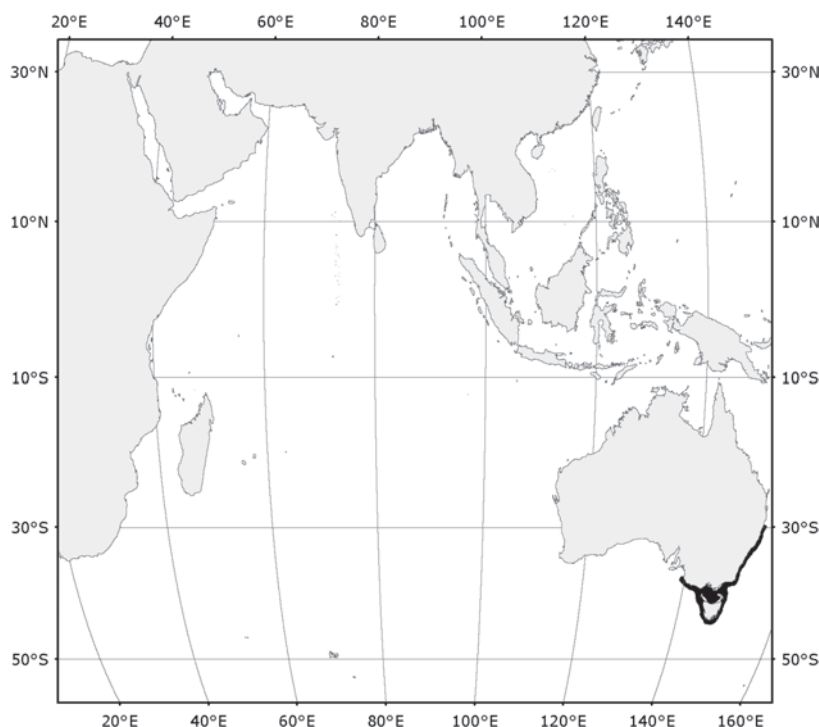


Fig. 155 *Hydrolagus ogilbyi*

Known distribution

3.1.2 **Family RHINOCHIMAERIDAE**

Family: Rhinochimaeridae Garman, 1901, *Proc. New England Zool. Club*, 2: 75–77.

Type genus: *Rhinochimaera* Garman, 1901.

Number of Recognized Deep-sea Indian Ocean Genera: 3.

Synonyms: None.

FAO Name: En – Longnose chimaeras.

Field Marks: Medium to large-sized chimaeras with large head, elongated bodies tapering posteriorly to filamentous tail, very long snout, distinctively spear-shaped, and flexible, first dorsal fin preceded by prominent fin spine and anal fin, depending on the genus, present or absent. Body uniformly pale to dark brown or blackish with fin edges darker in some species.

Diagnostic Features: Body elongate, somewhat compressed, tapering from large head to elongated filamentous tail. Snout fleshy, very elongate, broad, and spear-like, flexible, extending anterior to head and tapering to a blunt point. Eyes large and prominent, bright green in life. Skin smooth, often deciduous, flaking off in patches during and after capture. Gill openings, one on each side covered by a fleshy operculum, and located anterior to pectoral fins. Spiracles absent. Mouth small, ventral on head, connected to nostrils by deep grooves. Teeth non-replaceable, in the form of three paired tooth plates; two pairs on upper jaw, one pair on lower jaw. Tooth plates robust with patches of dense hypermineralized tissue that appears as ridges and bumps on the surface; some lacking robust ridges, with tooth plates that appear smooth. Lateral line canals appear as open grooves on the head and sides of body. Pectoral and pelvic fins somewhat ovoid in shape, broad with delicate external fin webs supported by cartilaginous rays (ceratotrichia). First dorsal fin triangular, erect, preceded by an elongate, smooth or serrated spine. Second dorsal fin separated from first, long, relatively low, with distal margin straight to slightly undulating. Anal fin present or absent. Caudal fin lanceolate, dorsal lobe with or without tubercles along margin; lower lobe without tubercles; whip-like tail filament present or absent. Sexual dimorphism strong, adult males with bulbous, denticulate frontal tenaculum that can retract into pouch atop head and anterior to eyes. Pre-pelvic tenaculum blade-like, retractable into hidden pouch anterior to each pelvic fin; tenaculum medial margin with large denticles. Claspers slender, rod-like with small fleshy denticulate tip. Size ranging from 65 to 130 cm total length. **Colour:** uniform pale to greyish or brownish, often lighter or white ventrally, fins darker in some species, and without distinct pattern of spots or stripes. Neonates and very small juveniles may be paler in colour, darker around the opercular flap, and with very dark brown or black fins.

Distribution: Rhinochimaerids have a circumglobal distribution with most members being wide-ranging although many species have a patchy or scattered distribution; the other chimaeroid families tend to exhibit a higher degree of endemism.

Habitat: Very little known about the habitat preference of longnose chimaeras. They tend to occur over muddy or soft bottoms, although this may be an artifact of sampling methods, and usually occur in very deep-water from over 1000 m, but with several species occurring to 3000 m.

Biology: Virtually nothing known about their reproductive biology or life history. Maturity is attained by about 40 cm body length in some species. Females lay egg cases in pairs; egg cases are tadpole-like, with broad, fan-like lateral flanges with numerous transverse ridges. Their diet is little known, but they appear to feed on small benthic invertebrates and fishes.

Interest to Fisheries and Human Impact: Longnose chimaeras are of minimal fishery interest and are mostly taken as bycatch in bottom trawl fisheries and may be utilized for fishmeal or other fish products.



The conservation status of most longnose chimaeras is Data Deficient or Least Concern due to their patchy distribution, deep-water habitat, and lack of commercial fisheries. However, more information is needed on the abundance, life history, and population trends of this poorly known group.

Local Names: Spookfishes.

Remarks: The above family account is modified, and updated, after Didier (1995, 2002, 2004) and Didier *et al.* (2012) and recognizes three genera and at least eight described species; all three genera and seven species occur in the Indian Ocean.

Literature: Garman (1901); Bigelow and Schroeder (1953, 1954); Stehmann and Bürkel *in* Whitehead *et al.* (1984); Didier (2002a, 2004); Nelson (2006); Last and Stevens (2009); Ebert and Winton (2010); Didier, Kemper and Ebert (2012); Ebert and Stehmann (2013); D.A. Didier and D.A. Ebert (unpubl. data).

List of Species Occurring in the Area:

- Harriotta haeckeli* Karrer, 1972
-  *Harriotta raleighana* Goode and Bean, 1895
-  *Neoharriotta pinnata* (Schnakenbeck, 1931)
- Neoharriotta pumila* Didier and Stehmann, 1996
- Rhinochimaera africana* Compagno, Stehmann, and Ebert, 1990
-  *Rhinochimaera atlantica* Holt and Byrne, 1909
- Rhinochimaera pacifica* (Mitsukuri, 1895)

Key to Deep-sea Indian Ocean Genera:

1a. Anal fin present (Fig. 156). . . *Neoharriotta*

1b. Anal fin absent. 2

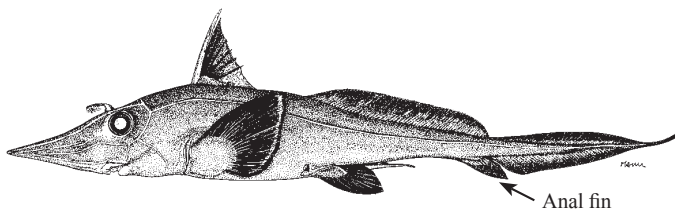


Fig. 156 *Neoharriotta pinnata*

2a. Lateral head profile convex; mouth located slightly in front of or over eyes; tooth plates with raised hypermineralized tritons on the surface; dorsal-fin lobe caudal margin without tubercles (Fig. 157) *Harriotta*

2b. Lateral head profile straight; mouth located well in front of eyes; tooth plates smooth, lacking raised hypermineralized tritons on the surface; dorsal-fin lobe caudal margin with tubercles (Fig. 158) *Rhinochimaera*

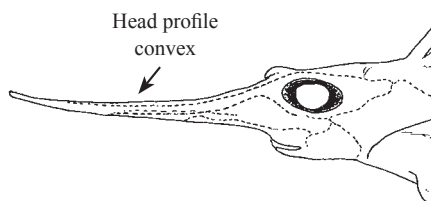


Fig. 157 *Harriotta* sp.

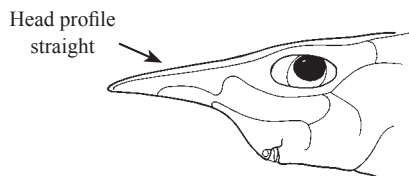


Fig. 158 *Rhinochimaera* sp.

***Harriotta* Goode and Bean, 1895**

Genus: *Harriotta* Goode and Bean, 1895, *Spec. Bull. U.S. Natl. Mus. Washington, D.C.*, 17: 471. *Harriotta* Goode, 1886, *Proc. Biol. Soc. Wash.*, 3: 104 (*nomen nudum*), "a long-rostrated chimaeroid fish" without further description and without species named.

Type species: *Harriotta raleighana* Goode and Bean, 1895, by monotypy.

Number of Recognized Deep-sea Indian Ocean Species: 2.

Synonyms: None.

FAO Name: En – Narrownose chimaeras.

Field Marks: Elongated snout, fleshy at base, and tapering to a fine point at the tip, distal tip of snout curved upwards, more so in adult males which also have a series of small rounded knobs dorsally, caudal fin rounded with elongate filament, upper and lower lobes almost equal in height with the upper lobe slightly taller, upper lobe margin without tubercles, and no anal fin present.

Diagnostic Features: Body large, elongate, tapering posteriorly to a whip-like filamentous tail; head relatively large, snout very long, fleshy, wide at base, tapering anteriorly to a pointed tip; snout may or may not curve upwards (depending on species) and with or without knobby protuberances at distal end. Eyes oval, small to moderately large. Nostrils moderate, slightly longer than wide. Mouth relatively small, located below eyes. Tooth plates thick, hypermineralized with transverse ridges and rounded tritons (except in small juveniles), anterior edge of tooth plates form sharp nipping blades. Canals on head relatively widely spaced; nasal canal on ventral surface of either not expanded or expanded, and may or may not join rostral canal; lateral line canals on trunk straight, not wavy. Pectoral fins broad, large, with tips extending, or not, to pelvic fin origin (depending on species). Pelvic fins broadly rounded. First dorsal fin small, short-based, its height not much greater than second dorsal fin; fin spine relatively short, height less than or slightly greater than fin height; spine may be recurved or straight. Interdorsal space small when first dorsal fin laid back, fin spine either reaching origin of second dorsal fin or not. Second dorsal fin relatively even or slightly convex in height, base short. Anal fin absent. Caudal fin upper and lower lobes similar, or slightly different, in length and height; upper dorsal margin without tubercles. Tail short and filamentous. **Colour:** uniform light to dark brown above, may be darker below and along fin edges; fin spine light to whitish.

Local Names: None.

Remarks: This genus has two wide-ranging, but patchily distributed species. These are very poorly known chimaeras and if encountered should be retained for detailed examination.

Key to Deep-sea Indian Ocean Species:

1a. Eye relatively small; dorsal-fin spine not reaching second dorsal-fin origin (Fig. 159).

..... *Harriotta haeckeli*

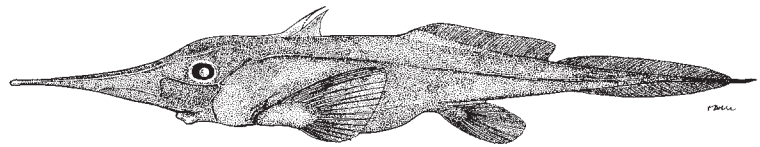


Fig. 159 *Harriotta haeckeli*

1b. Eye moderate-sized; dorsal-fin spine reaching second dorsal-fin origin (Fig. 160)

..... *Harriotta raleighana*

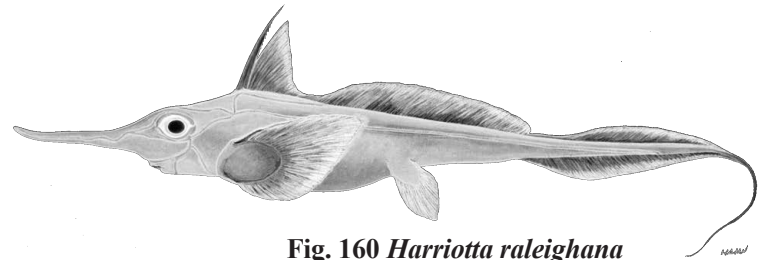


Fig. 160 *Harriotta raleighana*

***Harriotta raleighana* Goode and Bean, 1895**

Harriotta raleighana Goode and Bean, 1895, *Proceedings of the United States National Museum*, 17(1014): 472, pl. 19, figs 1–2. Lectotype (Syntype): USNM 35520, Albatross station 2210, female, 100 mm TL. Type Locality: Northwest Atlantic, Gulf Stream, New Jersey, USA, (39° 37'N, 71° 18'W), 1812 m. Collected 21 August 1884. Goode and Bean (1895) based their description on four specimens, but without designating a holotype, therefore making them syntypes. However, according to Eschmeyer (2012) a lectotype was established in Jordan and Evermann (1900) from the caption to plate 19, p. 3234, “*Fishes of North and Middle America*.”

Synonyms: *Anteliochimaera chaetirhamphus* Tanaka, 1909: 7, Pl. 1. *Harriotta curtissjamesi* Townsend and Nichols, 1925: 6, fig. 2. *Harriotta opisthoptera* Deng, Xiong, and Zhan, 1983: 67, fig. 3.

Other Combinations: *Harriotta chaetirhamphus*.

FAO Name: En – Pacific longnose chimaera.

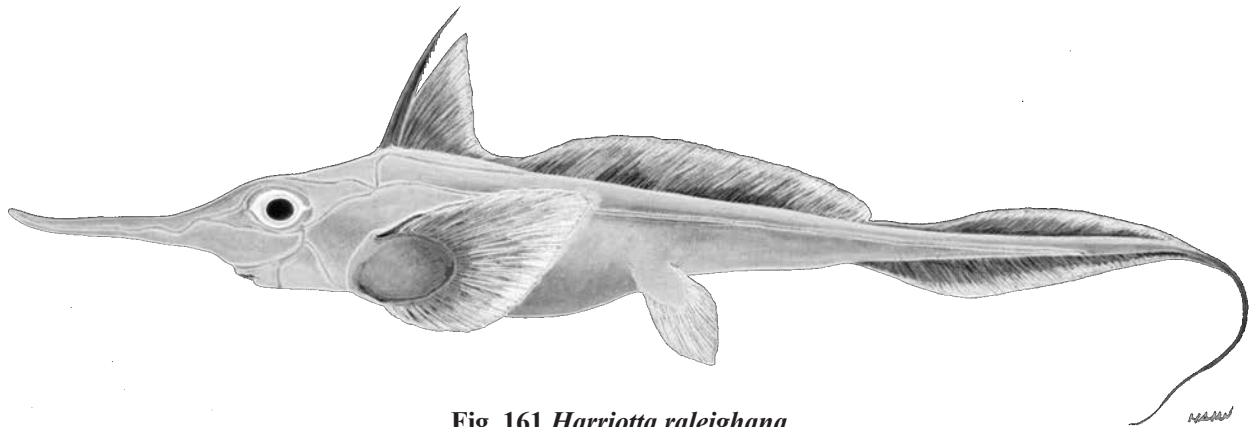


Fig. 161 *Harriotta raleighana*

Field Marks: A relatively small-bodied rhinochimaerid with a moderately long, spear-like snout, broader at base and tapering to a narrow tip, eyes moderate-sized, pectoral fins short and broad, and a caudal fin with no tubercles on upper edge, and a long terminal tail filament. Colour is a uniform dark brown.

Diagnostic Features: Snout wide at base, moderately long, slightly flattened, tapering to a fine point with knobby protuberances at distal end; snout tip curves upwards. Eyes moderately large, ovoid. Head canals separated by a relatively wide space; trunk lateral line canal straight, not wavy; nasal canal on ventral side of trunk expanded laterally at its distal end and joins rostral canal. Pectoral fins large, reaching past origin of second dorsal fin to near origin of pelvic fin (about 4/5 distance). Pelvic fins rounded in shape. Frontal tenaculum is small and slender with a pronounced curve and distal bulb bearing numerous spiny denticles. Prepelvic tenaculum with six stout spines along medial edge. Pelvic claspers in mature males are rod-like with a small fleshy denticulate tip. First dorsal fin relatively small, with a small spine about equal in length to height of first dorsal fin, keeled and weakly serrate along distal one-half. Interdorsal space small, when laid back first dorsal and fin spine reach origin of second dorsal fin. Second dorsal fin gently slopes anteriorly and posteriorly but relatively even in height. Caudal fin with short filament. Maximum total length about 120 cm. **Colour:** uniform dark brown; fin edges much darker, pelvic fins blackish.

Distribution: Circumglobal, but patchily distributed, most commonly found in the Atlantic. Indian Ocean: Western Cape Province, South Africa and Western Australia to Tasmania, Australia.

Habitat: Poorly known deep-water longnose chimaera with a depth range of 380 to 2600 m, although an unconfirmed Indian Ocean record was from only 100 m depth. It has been observed at depth by remote operated vehicles over soft mud and gravelly bottom substrates and on occasion in association with other deep-water chimaeras (*Hydrolagus* spp.). There appears to be an ontogenetic shift between 300 and 1000 m depth with large individuals occurring deeper than smaller individuals.

Biology: Oviparous, but little else known of its reproductive biology. Egg cases small, about 16 cm in length, strongly convex, more so on one side than the other, lateral flanges thin, with narrow transverse ridges numbering more than 50 rows on each side; capsule dark in colour, but lighter on flanges. Diet little known, but includes a variety of polychaetes, mollusks, and other small benthic invertebrates and teleosts. Smaller *Harriotta raleighana* feed mainly on polychaetes, gastropods, and small crustaceans, but the diet of larger individuals shifts more to crustaceans.

Size: Maximum total length about 120 cm (70 cm precaudal length); males mature at about 25 to 30 cm body length and females at about 30 cm body length. Size at birth about 10 to 13 cm precaudal length.

Interest to Fisheries and Human Impact: There is no targeted fishery for this species, but it is likely taken as bycatch on occasion.

The conservation status is Least Concern since it appears to be one of the few chimaeroids with a wide geographic distribution and occurs at depths below where most fisheries occur.

Local Names: Bigspine spookfish, Longnose chimaera, Long-nosed chimaera, Longnosed chimaera (English).

Remarks: This wide-ranging longnose chimaera is occasionally mistaken with *Harriotta haeckeli*, another wide-ranging member of this genus.

Literature: Goode and Bean (1895); Bigelow and Schroeder (1953, 1954); Stehmann and Bürkel in Whitehead *et al.* (1984); Compagno, Ebert and Smale (1989); Compagno, Stehmann and Ebert (1990); Compagno, Ebert and Cowley (1991); Moore *et al.* (2003); Møller, Jørgensen, & Kullberg (2004); Dagit (2006a); González *et al.* (2007); James *et al.* (2009); Last and Stevens (2009); Dunn *et al.* (2010); Ebert and Winton (2010); Møller *et al.* (2010); Didier, Kemper and Ebert (2012); Ebert and Stehmann (2013); D.A. Ebert (unpubl. data).

Neoharriotta Bigelow and Schroeder, 1950

Genus: *Neoharriotta* Bigelow and Schroeder, 1950, *Bulletin of the Museum Comparative Zoology*, 103(7): 406.

Type species: *Harriotta pinnata* Schnakenbeck, 1931, by original designation (also monotypic).

Number of Recognized Deep-sea Indian Ocean Species: 2.

Synonyms: None.

FAO Name: En – Sicklefins chimaeras.

Field Marks: No knobs or tubercles on snout tip or on upper caudal-fin margin, and a distinct anal fin present, separated by a deep notch from the ventral caudal-fin lobe.

Diagnostic Features: Body elongate, tapering to a caudal fin with whip-like filamentous tail. Head relatively large. Snout fleshy, slender, very long, wide at base, tapering to a pointed tip; snout not curve upwards and without tubercles at distal

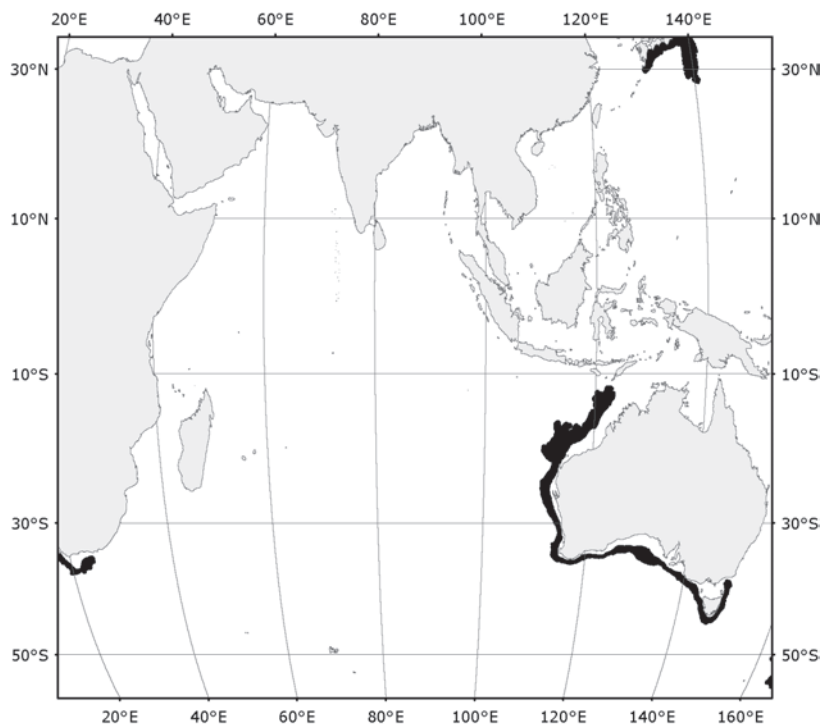


Fig. 162 *Harriotta raleighana*

Known distribution

end. Eyes oval, relatively large. Nostrils moderate, slightly longer than wide. Mouth relatively small. Tooth plates thick, with transverse ridges and hypermineralized tritons. Canals on head narrow to widely separated; lateral line canals on trunk straight, not wavy. Pectoral fins short and broad. Pelvic fins broadly rounded. First dorsal fin small, short-based; fin spine serrated, height about equal to or slightly greater than fin height; spine mostly straight, or slightly recurved. Second dorsal fin height relatively even or convex. Anal fin present, separated from lower caudal-fin lobe by a deep notch. Caudal fin upper and lower lobes uneven in height, lower lobe mostly greater in height than upper lobe; upper dorsal-fin margin without tubercles. Tail filamentous, whip-like. **Colour:** uniform light to dark brown or greyish, or mottled grey-brown for some species, with darker head, snout, and paired fins, becoming lighter ventrally.

Local Names: None.

Remarks: This genus has three very poorly known and patchily distributed species.

Key to Deep-sea Indian Ocean Species:

1a. Pelvic fins rounded along distal margin; second dorsal fin uniform in height; oral and preopercular lateral line canals separated by a large space; sexual maturity reached at 50 cm body length in males (Fig. 163)
 *Neoharriotta pinnata*

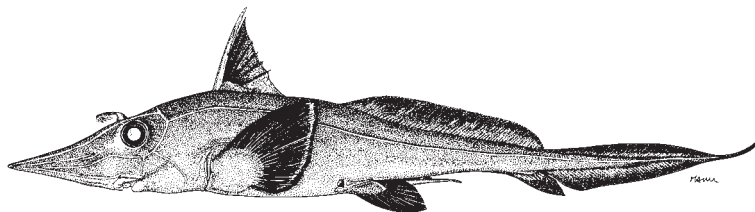


Fig. 163 *Neoharriotta pinnata*

1b. Pelvic fins with straight posterior margin; second dorsal fin not uniform in height, sloping posteriorly; oral and preopercular lateral line canals separated by a narrow space; sexual maturity reached at 16 cm body length in males (Fig. 164)
 *Neoharriotta pumila*

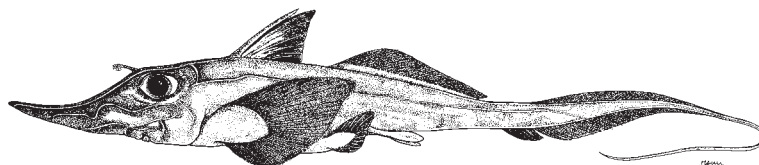


Fig. 164 *Neoharriotta pumila*

***Neoharriotta pinnata* (Schnakenbeck, 1931)**

Harriotta pinnata Schnakenbeck, 1931, *Mitt. Aus. Dem Zool. Mus. Hamburg*, 44: 40, figs. 6–9. Syntypes: (3) ZMH 10470 (only 1 now). Type locality: Walvis Bay, Namibia, in deep-water.

Synonyms: *Harriotta pinnata* Smith, 1949: 78 (in part, included in synonymy); Rodriguez-Roda, 1961: 89, figs 1–2 (off Cabo Blanco, Spanish Sahara–Mauritania, 330 m).

Other Combinations: None.

FAO Names: **En** – Sicklefim chimaera; **Fr** – Chimère faucillée; **Sp** – Narigón aletas de haz.

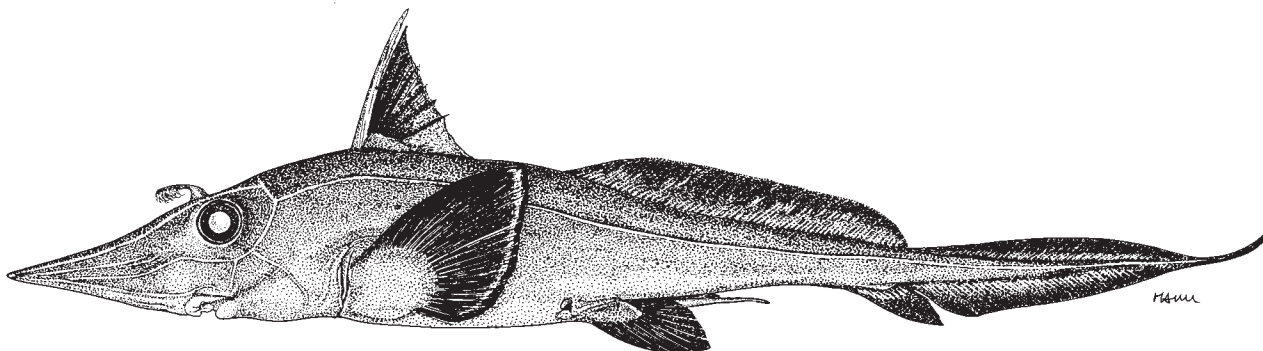


Fig. 165 *Neoharriotta pinnata*

Field Marks: A narrow elongated, slightly flattened, blunt-edged snout, oral and preopercular lateral line canals not branching, widely separated, first dorsal-fin spine height greater than fin apex, second dorsal fin uniform in height, pectoral fins short and broad, pelvic fins rounded, anal fin distinct and curved, caudal fin with short terminal filament, frontal tenaculum prominent in adult males. Colour is a uniform dark chocolate brown without any distinctive blotches, spots or stripes.

Diagnostic Features: See Field Marks above.

Distribution: Indian Ocean: Arabian Sea and off southwestern India.

Habitat: Occurs from 200 to 550 m, but nothing else known.

Biology: Oviparous, but nothing else known. Diet includes small invertebrates and fishes.

Size: Maximum total length 127 cm (58 cm body length); males and females mature at 50 to 60 cm body length. Size at birth uncertain, but smallest free-swimming individuals ranged from 7 to 10 cm body length (13 to 23 cm total length).

Interest to Fisheries and Human Impact: Uncommon and of no fishery importance throughout most of its range, except off southern-western India where this species is commonly taken in a deep-water fishery that includes other uncommon deep-sea elasmobranchs such as *Echinorhinus brucus*.

The conservation status of this chimaera is Data Deficient, but should be monitored in those areas where deep-sea fisheries are developing.

Local Names: None.

Literature: Compagno, Ebert and Smale (1989); Manilo and Movchan (1989); Krefft (1990); Compagno, Ebert and Cowley (1991); Didier and Stehmann (1996); Dagit (2006b); Didier, Kemper and Ebert (2012); Didier (unpubl. data).

Rhinochimaera Garman, 1901

Genus: *Rhinochimaera* Garman, 1901, by original designation, *Proc. New Engl. Zool. Club*, 2: 75–76.

Type species: *Harriotta* [sic] *pacifica* Mitsukuri, 1895, Kurikama, near Misaki, Sagami, by original designation.

Number of Recognized Deep-sea Indian Ocean Species: 3.

Synonyms: None.

FAO Names: **En** – Knife-nosed chimaeras; **Fr** – Chimères-couteau; **Sp** – Quimeras-navaja.

Field Marks: Snout elongated, fleshy, tapering to a fine blunt point, distal tip straight, without a series of small rounded knobs on adult males, caudal-fin lower lobe at least three times length of upper lobe, margin of upper caudal-fin lobe with row of tubercles, and no anal fin present.

Diagnostic Features: Body bulky, elongated, tapering posterior to pectoral fins, ending in a filamentous tail. Snout very elongate, straight, broad at base, fleshy from base to mid-length, distal tip of snout not fleshy, tip bluntly pointed, not upturn. Adult males with short frontal tenaculum, flat, not deeply curved, and with a distal fleshy bulb with numerous small denticles. Eyes relatively small. Mouth in front of eyes. Tooth plates thin, smooth, blade-like cutting edges, not formed as crushing plates, lacking hypermineralized tritons on surface. Pectoral fins elongate, oval to narrow, rounded apex and along distal edge near base. Pelvic fins broad or elongated, rounded at apex. Pre-pelvic tenaculum spatulate with denticles along the medial edge. Pelvic claspers simple, rod-like structures with a small, fleshy bulbous tip in which there are small pointed denticles. First dorsal fin short-based, low and relatively small, preceded by a serrated spine that extends beyond first dorsal fin height; spine tip does not reach second dorsal fin when depressed. Second dorsal fin low and elongate, separated from first dorsal and caudal fin by distinct gap, dorsal margin convex. Anal fin absent. Caudal fin dorsal margin narrow or sickle-shaped, with series of 19 to 68 tubercles along upper margin in adults; lower caudal fin similar in height to second dorsal fin; its origin anterior to upper caudal origin. Tail short to very elongated ending in whip-like filament; filament often broken. **Colour:** uniform dark to pale brown, greyish-brown or white, with no distinctive markings on body or fins.



Fig. 166 *Neoharriotta pinnata*

Known distribution

Local Names: None.

Remarks: Following Didier, Kemper and Ebert (2012) three wide-ranging species are recognized within this genus. *Rhinochimaera atlantica* is primarily found in the Atlantic Ocean, while *R. pacifica* is found in the Pacific Ocean. The wide-ranging *R. africana* overlaps both these species and is also known from the Indian Ocean.

Key to Deep-sea Indian Ocean Species:

1a. Body colour an even dark brown, snout broad and paddle-shaped; eye is small; junction of supraorbital and infraorbital canals on ventral side of snout closer to the tip of the snout than to the nasal canal (Fig. 167) *Rhinochimaera africana*

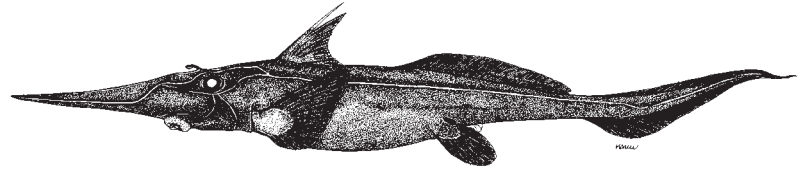


Fig. 167 *Rhinochimaera africana*

1b. Body colour a pale brownish grey with dark fins; snout narrow and conical shaped; junction of supraorbital and infraorbital canals on ventral side of snout nearly equidistant between the tip of the snout and the nasal canal **2**

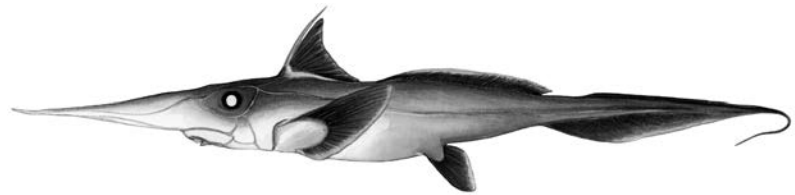


Fig. 168 *Rhinochimaera atlantica*

2a. Locality Atlantic Ocean and southwestern Indian Ocean; number of denticulations on upper lobe of caudal fin usually 19 to 33 (Fig. 168)
 *Rhinochimaera atlantica*

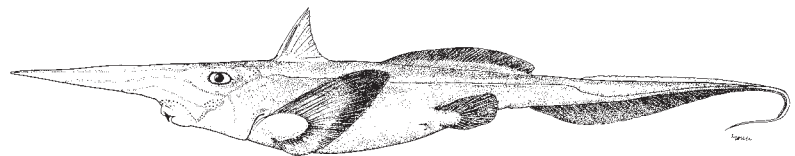


Fig. 169 *Rhinochimaera pacifica*

2b. Locality Pacific Ocean and eastern Indian Ocean; number of denticulations on upper lobe of caudal fin usually 41 to 68 (Fig. 169) *Rhinochimaera pacifica*

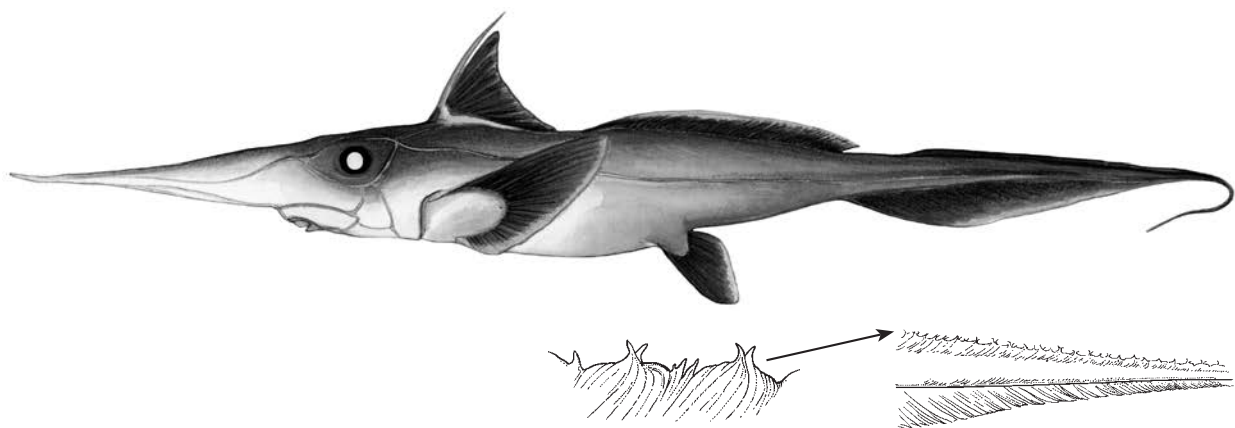
***Rhinochimaera atlantica* Holt and Byrne, 1909**

Rhinochimaera atlantica Holt and Byrne, 1909, *Ann. Mag. Nat. Hist.*, (8)3 v.15: 279. Holotype (unique): BMNH 1910.9.17.4, Type locality: Atlantic slope off southwest Ireland, 50° 31'N, 11° 31'W, 1225 to 1410 m. The species was later illustrated and described in more detail by Holt and Byrne, 1910: 18, pls. 3, 4, figs. 4, 5.

Synonyms: *Harriotta atlantica* Meyer, 1951: 116–117, fig 1.

Other Combinations: None.

FAO Names: **En** – Straightnose rabbitfish; **Fr** – Chimère à nez mou; **Sp** – Narigón sierra.



DETAIL OF DORSAL CAUDAL-FIN TUBERCLES

Fig. 170 *Rhinochimaera atlantica*

Field Marks: A large bodied *Rhinochimaera* with a narrow, conical snout, subtriangular and fleshy at the base, tapering to a narrow distal tip, moderate sized eyes, length of eye not less than 5% body length (range 5 to 10% body length) and caudal fin with a distal caudal filament. Colour a uniform pale to light brown or greyish–brown with darker fins, ventral side of snout and oronasal region white.

Diagnostic Features: Snout very long, straight, attenuated, subtriangular at base; snout base to mid-length fleshy, tapering to a narrow, bluntly pointed tip; distal tip of snout not fleshy; snout length 50 to 87% body length (body length 50 to 66% in adults, 54 to 87% in juveniles). Oronasal region with prominent antero–ventral protuberance at snout base; mouth anterior to eye. Tooth plates thin, smooth, dark grey to blackish in colour with thin, blade–like cutting edges, not formed as crushing plates. Eyes moderate in size, 5 to 10% body length (5 to 8% in adults, 5 to 10% in juveniles). Preopercular and oral lateral line canals branches separately from the infraorbital canal below the eye. Pectoral fins ovoid and elongate, more narrow and long rather than triangular and broad shaped. Pelvic fins ovoid, sometimes squared along the distal edge, with anterior and posterior edges somewhat rounded. Adult males with short frontal tenaculum, flat, not deeply curved, and with a distal fleshy bulb with numerous small denticles. Pre–pelvic tenaculum spatulate with five strong denticles along the medial edge. Pelvic claspers simple, rod–like, with a small, fleshy bulbous tip in which there are small pointed denticles; pelvic claspers just reach the distal edge of the pelvic fin. First dorsal fin triangular in shape, with concave posterior edge and a long fleshy base extending beyond the fin tip when depressed, but not connecting to second dorsal fin; fin preceded by fin spine that extends beyond first dorsal–fin height; fin spine connected to first dorsal fin along its posterior edge and when depressed together they form a deep groove; spine when depressed reaches one–half way to the origin of the second dorsal fin; spine keeled anteriorly with small serrations on distal one–third of the posterior edge; large adult specimens posterior serrations may become reduced or worn away. Second dorsal fin elongate, separated from both first dorsal and dorsal caudal fins by a space; dorsal edge is gently rounded, sloping at anterior and posterior ends, reaching maximum height in the centre; height of second dorsal fin ranges from 3 to 7% body length, and 7 to 16% second dorsal–fin base. Dorsal caudal fin very narrow, appears as thick fleshy ridge on dorsal surface of tail. In adults paired caudal tubercles are present along the distal edge of the dorsal caudal fin, most pronounced in males, but evident in adult females; tubercle counts range from 36 to 60. Ventral caudal fin tallest anteriorly, tapering posteriorly, giving the caudal fin a somewhat heterocercal appearance externally. Tail elongate ending in a firm, whip–like caudal filament, sometimes broken, but if intact filament can range in length from 4% to 32% body length. **Colour:** uniform pale brown or greyish–brown to white, somewhat darker dorsally and lighter ventrally, leading edges of pectoral fins, ventral caudal, and second dorsal fin tend to be darker; mouth region white below oral folds with white colour extending onto the snout that is white ventrally with darker coloration dorsally. After preservation fins darker, often appearing dark brown or purplish.

Distribution: Atlantic Ocean, where it is most common, and Western Indian Ocean from Cape of Good Hope to Natal, South Africa.

Habitat: A little known, but somewhat common, at depth, longnose chimaera that occurs from about 400 to at least 1500 m. It appears to occur mostly on soft–bottom habitat.

Biology: Oviparous, but nothing else known of its reproductive biology or feeding habits. This species appears to aggregate in large numbers, often grouping by size, sex, and maturity status.

Size: Maximum total length about 140 cm (precaudal length about 90 cm). Males adult at 107 cm total length (81.3 precaudal length, 47.3 cm body length), adolescent at 105.5 cm (80.3 cm precaudal length, 47.7 cm body length), maximum total length at least 112.7 cm (82.3 cm precaudal length, 46.6 cm body). Females adult at 127.4 cm (99.0 cm precaudal length, 59.0 cm body length), adolescent at 99.4 cm (75.0 cm precaudal length), maximum length at least 140 cm. Size at birth about 15 cm total length.

Interest to Fisheries and Human Impact: Of no commercial value, this species is taken occasionally as bycatch in bottom trawl fisheries.

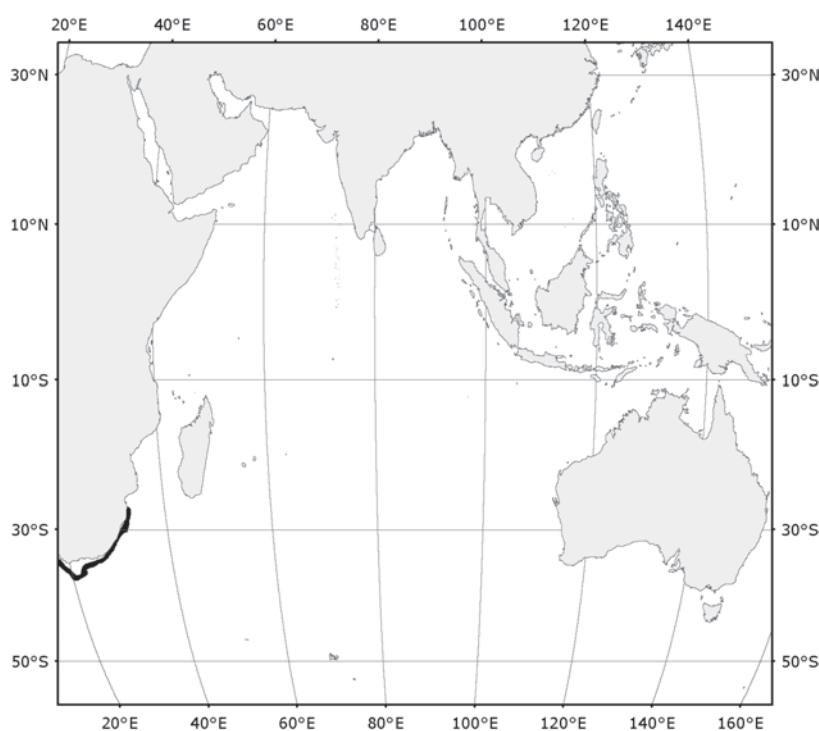


Fig. 171 *Rhinochimaera atlantica*

Known distribution

The conservation status of this poorly known longnose chimaera is Least Concern due to its widespread biogeography, deep-water habitat, and lack of directed commercial fisheries.

Local Names: Atlantic longnose chimaera, Spearnose chimaera, Straightnose rabbitfish, Broadnose chimaera, Knifenose chimaera (English).

Remarks: The differences between this species and *Rhinochimaera pacifica* is based exclusively on the number of caudal tubercles, a character that overlaps these two species. It will likely take molecular studies to resolve this issue. Another wide-ranging *Rhinochimaera*, *R. africana*, overlaps the distribution of both *R. atlantica* and *R. pacifica*, and is often misidentified with these two latter species.

Literature: Holt and Byrne (1909, 1910); Bigelow and Schroeder (1953, 1954); Stehmann and Bürkel in Whitehead *et al.* (1984); Compagno, Ebert and Smale (1989); Compagno, Stehmann and Ebert (1990); Compagno, Ebert and Cowley (1991); Didier (2002a); Moore *et al.* (2003); Møller, Jørgensen, & Kullberg (2004); Dagit and Compagno (2006); Møller *et al.* (2010); Didier, Kemper and Ebert (2012); Ebert and Stehmann (2013); D.A. Ebert (unpubl. data).

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5. INDEX OF SCIENTIFIC AND VERNACULAR NAMES

Explanation of the System

- Italics* : Valid scientific names (double entry by genera and species)
Italics : Synonyms and misidentifications (double entry by genera and species)
ROMAN : Family names
ROMAN : Names of classes, subclasses, cohorts, superorders and orders
Roman : Suborders, subfamilies, tribes, and FAO and local names

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This volume is a comprehensive, fully illustrated Catalogue of the Deep-sea Batoids and Chimaeras of the Indian Ocean, encompassing FAO Fishing Areas 51 and 57, and that portion of Area 47 off South Africa from about 18° 42'E to 30° 00'E. The present volume includes 4 orders, 10 families, 28 genera, and 78 species of batoid and chimaera-like fishes occurring in the Indian Ocean Deep-sea. The Catalogue includes a section on standard measurements for batoids and chimaeras with associated terms. It provides accounts for all orders, families, and genera and all keys to taxa are fully illustrated. A species representative of each genus is also provided and includes: valid modern names and original citation of the species; synonyms; the English, French, and Spanish FAO names for the species; a lateral view and often other useful illustrations; field marks; diagnostic features; distribution, including a GIS map; habitat; biology; size; interest to fisheries and human impact; local names when available; a remarks sections; and literature. The volume is fully indexed and also includes sections on terminology and measurements including an extensive glossary, a list of species by FAO Statistical Areas, a glossary, and a dedicated bibliography.

ISBN 978-92-5-108452-6 ISSN 1020-8682



9 789251 084526

I3888E/1/06.14