Biology and Ecology of Marine Life

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Ramasamy Santhanam

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Apple Academic Press Inc.
3333 Mistwell Crescent
Oakville, ON L6L 0A2 Canada

Apple Academic Press Inc.
9 Spinnaker Way
Waretown, NJ 08758 USA

Printed in the United States of America on acid-free paper
International Standard Book Number-13: 978-1-77188-538-6 (Hardcover)
International Standard Book Number-13: 978-1-315-20743-8 (eBook)

Library and Archives Canada Cataloguing in Publication

Santhanam, Ramasamy, 1946-, author
Biology and ecology of venomous stingrays / Ramasamy Santhanam, PhD.

(Biology and ecology of marine life)
Includes bibliographical references and index.
Issued in print and electronic formats.
ISBN 978-1-77188-538-6 (hardcover).--ISBN 978-1-315-20743-8 (PDF)
1. Stingrays. 2. Stingrays--Ecology. 3. Freshwater stingrays. 4. Freshwater stingrays--Ecology. 5. Rays (Fishes). 6. Rays (Fishes)--Ecology. I. Title. II. Series: Santhanam, Ramasamy, 1946-Biology and ecology of marine life

QL638.8.S26 2017 597.3'5 C2017-902627-5 C2017-902628-3

Library of Congress Cataloging-in-Publication Data

Names: Santhanam, Ramasamy, 1946-
Title: Biology and ecology of venomous stingrays / Ramasamy Santhanam, PhD.
Description: Toronto : Apple Academic Press, 2017. | Includes bibliographical references and index.
Identifiers: LCCN 2017017482 (print) | LCCN 2017018532 (ebook) | ISBN 9781315207438 (ebook) | ISBN 9781771885386 (hardcover : alk. paper)
Subjects: LCSH: Stingrays. | Stingrays--Ecology. | Freshwater stingrays. | Freshwater stingrays--Ecology. | Rays (Fishes) | Rays (Fishes)--Ecology.
Classification: LCC QL638.8 (ebook) | LCC QL638.8 .S26 2017 (print) | DDC 597.3/5--dc23
LC record available at https://lccn.loc.gov/2017017482

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LIST OF ABBREVIATIONS

DW	disc width
GFEMN	Global Fisheries Ecosystem Management Network
IUCN	International Union for Conservation of Nature
SMZ	sulfamethoxazole
STL	spine total length
TL	total length
TMAO	trimethylamine oxide
TMP	trimethoprim

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PREFACE

A total of 218 species of stingrays have so far been described, including 177 species of marine stingrays with 19 genera and 41 species of freshwater stingrays with seven genera. While marine stingrays have been found widely distributed throughout the coastal *tropical* and *subtropical* seas of the world, freshwater stingrays (family: Potamogtrygonidae) inhabit the brackish waters, lagoons, and freshwater tributaries of some of the major tropical river systems of South America and Africa. The marine stingrays include whiptail stingrays (Dasyatidae); stingrees or round stingrays (Urolophidae); eagle, bull, devil, manta, and cownose rays (*Myliobatidae*); butterfly rays (*Gymnuridae*), sixgill stingrays (*Hexatrygonidae*); and deepwater stingrays (*Plesiobatidae*). Among these marine stingrays, the dasyatid and urolophid stingrays along with potomotrygonid rays have been reported to cause the majority of venomous stings in humans.

Envenomations caused by stingrays are relatively common in fishing communities either from the seas or rivers. In the United States alone, 750–1500 stingray injuries have been reported per year. As more vacationers spend their leisure time exploring coasts and tropical reefs, often in isolated areas without immediate access to advanced health care, there will be greater potential for stingray injuries. A thorough understanding about the diversity of stingrays of marine and freshwater ecosystems and their injuries and envenomations would largely improve the public health community's ability to better manage and to prevent stingray injuries.

Although several books on hazardous marine animals are available, a comprehensive book on the venomous stingrays of the world seas and freshwater systems is overdue. Aspects such as biology and ecology of marine and freshwater stingrays; profiles of world's 220 species of marine and freshwater stingrays and stingray injuries; and their management and treatment are dealt with in this publication. For each species, its common name, global distribution, habitat(s), identifying features, food habits, reproduction, predators, parasites and IUCN's conservation status have been given with suitable illustrations.

It is hoped that this publication would be of great use for the students of fisheries science, marine biology, aquatic biology, and environmental

sciences; as a standard reference for libraries of colleges and universities; and as a guide for sea goers and divers.

I am highly indebted to Dr. K. Venkataramanujam, former Dean, Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Thoothukudi, India, for his valuable suggestions. I am grateful to all my international friends who provided me with certain fish photographs. I also sincerely thank Mrs. Albin Panimalar Ramesh for her help in secretarial assistance and photography.

CHAPTER 1

INTRODUCTION

CONTENTS

ABSTRACT

Stingrays (phylum: Chordata; subphylum: Vertebrata; class: Chondrichthyes; subclass: Elasmobranchii; order: Myliobatiformes) are members of the "cartilaginous fishes," which are characterized by cartilaginous skeletons. They have jaws, paired fins and nostrils, scales, and two-chambered hearts. The habitat and distribution of marine and freshwater stingrays along with their use to humans in terms of food, various products, and ecotourism are given in this chapter.

1.1 BIODIVERSITY AND DISTRIBUTION OF WORLD STINGRAYS

A total of 218 species of stingrays have so far been described including 177 species of marine stingrays with 19 genera and 41 species of freshwater stingrays with 7 genera. While marine stingrays have been found widely distributed throughout the coastal tropical and subtropical seas of the world, freshwater stingrays (family: Potamotrygonidae) inhabit the brackish waters, lagoons, and freshwater tributaries of some of the major tropical river systems of South America and Africa. Most myliobatoid rays are demersal and the eagle rays are pelagic (Michael, 2005). The dasyatid stingrays, on the other hand, are bottom-feeders in shallow brackish waters and near reefs.

Biodiversity and Distribution of World Stingrays

Family/genera	No. of species	Distribution
Dasyatidae (whiptail stingrays)		
Dasyatis	43[a]	Atlantic, Indian, and Pacific Oceans
Himantura	28[b]	
Makararaja	1[c]	
Neotrygon	5	
Pteroplatytrygon	1	
Pastinachus	5	
Taeniura	3	
Taeniurops	1	
Urogymnus	1	

Family/genera	No. of species	Distribution
Potamotrygonidae (freshwater stingrays)		
Heliotrygon	2[c]	Atlantic and Caribbean watersheds of South America and rivers in West Africa
Paratrygon	1[c]	
Plesiotrygon	2[c]	
Potamotrygon	24[c]	
Gymnuridae (butterfly rays)		
Gymnura	14	Worldwide in tropical and warm temperate (subtropical) seas; Atlantic (Black Sea), Pacific, and Indian oceans
Myliobatidae (eagle rays/manta rays)		
Aetobatus	3	Tropical and western temperate seas worldwide; Atlantic, Pacific, and Indian oceans
Aetomylaeus	4	
Myliobatis	12	
Manta	2	
Mobula	9	
Pteromylaeus	2	
Rhinopteridae (cownose rays)		
Rhinoptera	8	Circumglobal distribution (temperate and tropical continental seas)
Urolophidae (stingarees or round stingrays)		
Trygonoptera	6	Eastern Indian, western Pacific, eastern Pacific (from California to Chile), and western Atlantic ocean
Urolophus	22	
Urobatis	6	
Urotrygon	13	
Hexatrygonidae (sixgill stingrays)		
Hexatrygon	1	Off South Africa
Plesiobatidae (deepwater stingray)		
Plesiobatis	1	South Africa; Mozambique, Australia and Western Indian ocean; west-central Pacific ocean (from Japan to Philippines) and Hawaiian Islands

[a]Four species of *Dasyatis* and bseven species of *Himantura* are in freshwater habitats; [c]exclusively freshwater species.

Source: Schneider (1990).

1.2 FOOD USES OF STINGRAYS

Stingrays are of use to humans in terms of food, various products, and ecotourism. Proximate composition of several species of marine stingrays showed that they can be used as a food item like their counterparts, namely, bony fish. Among the marine stingrays, *Dasyatis americana*, *Dasyatis sabina*, *Dasyatis zugei*, and *Dasyatis pastinaca* are suitable for our daily diet. Among freshwater stingrays, *Potamotrygon orbignyi*, *Potamotrygon scobina*, *Potamotrygon motoro*, *Paratrygon aiereba*, and *Plesiotrygon iwamae* are mainly caught for food purposes. Although edible, stingrays are not considered as a high-quality food. They are consumed fresh, dried, and salted. Stingray recipes particularly with dried forms of the wings are most common throughout the world. Normally, the most prized parts of the stingray are the wings, the cheek (the area surrounding the eyes), and the liver. In Singapore and Malaysia, the stingrays are commonly barbecued over charcoal and served with spicy sambal sauce.

1.3 OTHER USES OF STINGRAYS

Among the stingrays, the freshwater species are preferred in the South American ornamental fish trade. While species such as *Plesiotrygon iwamae*, *Paratrygon aiereba*, *Potamotrygon motoro*, *P. orbignyi*, and *P. scobina* are used for ornamental and medicinal purposes, species like *Potamotrygon hystrix* and *P. schroederi* are employed mainly in the ornamental fish trade. The money generated by the freshwater stingray fisheries provides a precious supplementary income for the riverine people. The skin of the stingrays is used as a leather wrap in Japanese swords due to its hard, rough texture. Native American Indians used the spines of stingrays for arrowheads, while groups in the Indo-West Pacific used them as war clubs.

1.4 ECOTOURISM

In the marine sanctuary of the Belize, off the island of Ambergris Caye, divers and snorkelers often gather to watch stingrays. Many Tahitian island resorts regularly offer guests the chance to “feed the stingrays.” This consists of taking a boat to the outer lagoon reefs, where habituated

stingrays swarm around, pressing right up against tourists seeking food from their hands or that being tossed into the water.

KEYWORDS

- **cartilaginous fishes**
- **marine stingrays**
- **freshwater stingrays**
- **ecotourism**
- **ornamental fish trade**

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CHAPTER 2

BIOLOGY AND ECOLOGY OF MARINE STINGRAYS

CONTENTS

ABSTRACT

The ecology, morphology, and internal anatomy of marine stingrays along with their predators, threats, and conservation status are dealt with in this chapter.

2.1 ECOLOGY OF MARINE STINGRAYS

Marine stingrays prefer warm waters. They live in temperate and tropical ocean zones, including open bays and regions near coastlines. They may be divided into categories depending on the ocean depths they occupy. Pelagic stingrays, such as the manta ray, swim actively through open waters. More common, however, are benthic stingrays such as the southern stingray, which swim along the ocean floor and even hide in the sand.

2.2 BIOLOGY OF MARINE STINGRAYS

2.2.1 CHARACTERISTICS OF MARINE STINGRAY FAMILIES

2.2.1.1 FAMILY: DASYATIDAE (WHIPTAIL STINGRAYS)

The stingrays of this family are chiefly marine and some species are, however, found either in brackish waters or in freshwater systems. The side of the head in these fishes is continuous with the anterior margin of the pectoral fin. These fishes respire by drawing water through a small hole located behind the eye and expelling it through the gill slits on the underside of the disk. The dorsal fin is totally absent or indistinct, when present. The disk is about 1.2 times as broad as long. The eyes and spiracles are located on top of the head. The floor of the mouth is with fleshy papillae. Small teeth are present in many series forming bands along jaws. The nasal curtains are well developed and are continuous across narrow isthmus in front of the mouth and deeply fringed. There is no caudal fin. The tail is long and whiplike. Most species possess at least one long venomous spine on the tail. The dorsal surface is usually gray to dark brown, sometimes with darker or paler markings and the ventral surface is generally whitish. Largest species is about 4 m in length or width. These

fishes are live bearing (ovoviviparous) with fully developed young (ftp://ftp.fao.org/docrep/fao/009/y4160e/y4160e39.pdf).

2.2.1.2 FAMILY: GYMNURIDAE (BUTTERFLY RAYS)

These fishes are chiefly marine and are rarely seen in estuaries. The body of these rays is flattened and is surrounded by an extremely broad, rhomboid disk formed by the pectoral fins, which merge in front of the head. The eyes and spiracles are located on top of the head. Some species have spiracular tentacles. The snout is obtuse and angular. The nasal curtains are broadly expanded; continuous across narrow isthmus in front of mouth and are smooth edged (with rare exceptions). The mouth is slightly arched and it lacks papillae on its floor. The jaws bear many small teeth in bands. The dorsal fin and tail spines are present or absent. The pelvic fins are laterally expanded and are not divided into anterior and posterior lobes. The caudal fin is always absent. Some species have one or more long, serrated spines. The tail is short and threadlike with longitudinal folds on the upper and/or lower surfaces. The skin of the upper side is naked in most species, but with a variable number of tubercles in large individuals of other species. The dorsal surface is gray, light green, olive, purple, or dark brown, sometimes with a reddish cast, often marked with spots or lines. The ventral surface is white, sometimes with a bronze or rusty cast. These fishes range in body length from 31 cm to 4 m (ftp://ftp.fao.org/docrep/fao/009/y4160e/y4160e40.pdf).

2.2.1.3 FAMILY: MYLIOBATIDAE (EAGLE AND MANTA RAYS)

In the rays of this family, the head is elevated above disk. In the eagle rays, the jaws are powerful with large platelike crushing teeth in several rows. The eyes and spiracles are laterally placed on head. The tail is much longer than the disk. Venomous spine(s) is present in some species. The dorsal fin is small and the pectoral fins are reduced or absent. Some species are known for their leaping ability high into the air. All the species are viviparous with 2–6 fully developed young. The plankton-filtering manta ray species are among the largest fishes of this family but they are harmless.

2.2.1.4 FAMILY: RHINOPTERIDAE (COWNOSE RAYS)

These ray species are known for their odd-looking heads. Their whiplike tails are armed with one or more stings.

2.2.1.5 FAMILY: UROLOPHIDAE (STINGREES OR ROUND STINGRAYS)

The species of this family possess well-developed caudal fin. The tail is moderately long and outer anterior margins of the pectorals are continuous along the side of the head. Most species have one or more long poisonous spines on tail.

2.2.1.6 FAMILY: HEXATRYGONIDAE (SIXGILL STINGRAY)

The sixgill stingray (*Hexatrygon bickelli*) is the only extant member of this *family*. This flabby, heavy-bodied fish is with a long, thick, fleshy snout. The body coloration is dark violet-blue or brownish above and white below.

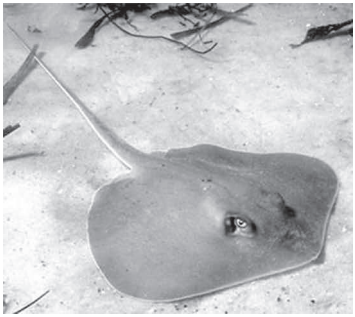
2.2.1.7 FAMILY: PLESIOBATIDAE (DEEPWATER STINGRAYS)

The deepwater stingrays are found on soft bottoms at depths between 44 and 680 m. They are large, dark rays with a rounded disk which ends in an angular pointed snout. These rays are viviparous and their reproductive characteristics largely resemble that of *Urolophidae*. They feed on a variety of fishes and invertebrates. They are not of very much interest to fisheries. Despite their venomous defensive sting, they do not pose any threat to humans (Nishida &Nakaya, 1990). Characteristics of some of the important groups of marine stingrays are given below:

Cownose ray: This stingray has a very broad disk and pointed wings. Its snout is indented in the middle to form two lobes, hence the name "cownose." Superficially, it resembles the eagle ray. The eyes are located in front, or anterior to, the beginning of the pectoral fins. Its maximum width and weight may be 2 m and 50 kg, respectively. It may be seen in large schools in sand flats and mudflats stirring up food on the bottom with its wings or pectoral fins.

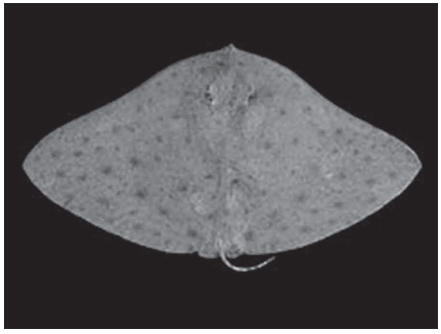
Southern stingray: This is an inshore species which spends much of its time in shallow areas of sand or mud in search of food. The diet of this ray consists of clams, crabs, shrimps, worms, and small fish. Its disk is rhomboid in shape but it is distinguished largely by its blunt or rounded snout. The tail is rather long and whiplike with a barbed spine near the base.

Atlantic stingray: This has a prominently pointed snout. Its dorsal surface is brown to yellowish-brown and its ventral side is whitish. It is a small species, growing to only 7 kg.



Smooth butterfly ray: This ray has a very broad disk which is much wider than long. The tail is very short with a keel on its top. The tail spine is absent. This ray is unique because it can change its color to match with

the sandy bottom of the sea. It can grow to 1.5 m in width and is found in shallow and deep waters. It is most often seen in late spring and summer in warm waters.



Spotted eagle ray: This has a wide, diamond-shaped disk with whitish, yellow, or green spots on the dorsal side. The ventral side is relatively light in color. One or more sharp barbs are present at the base of a very long, black, whiplike tail. It grows to a width of 2.5 m and a weight of 250 kg. These rays may be seen swimming alone, in pairs, or in schools. They have a shovel-shaped mouth with a wide, single row of teeth that allow them to dig up clams, oysters, and other organisms. Like some other large rays, they have been seen leaping clear out of the water and making loud, croaking sounds.

Atlantic manta: This is the largest ray reaching a width of 7 m, a length of 5 m, and a weight of about 2 t. It has two hornlike projections at the front of the head, which can help push food toward the mouth. These large

creatures may be seen basking near the surface of the water. While adult manta rays are known to feed on shrimp, mullet, and plankton, juvenile manta rays feed mainly on anchovies, shrimp, and copepods. Manta rays differ from most other rays in not having a stinging barb.

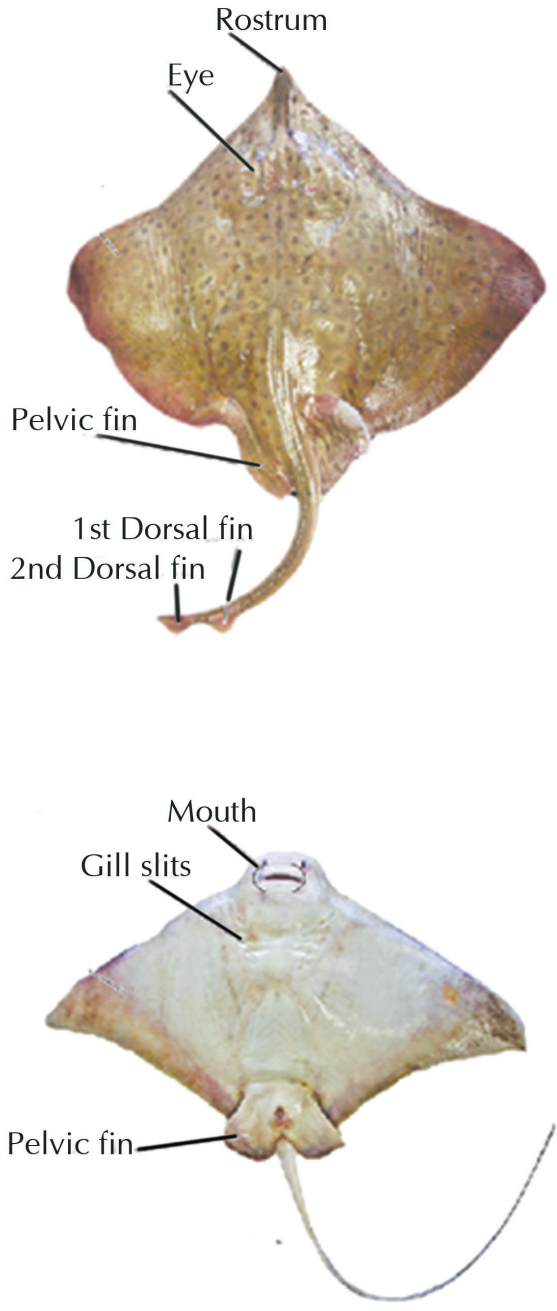
Devil ray: The devil ray resembles largely the manta ray. But it is considerably smaller, reaching 1.5 m in width.

Morphology: The marine stingrays are related to sharks, skates, and chimeras and are with skeletons made entirely of cartilage. Their body is normally dorsoventrally depressed or "flattened" from top to bottom and the flattened portion of the body is referred to as the "disk." The pectoral fins are large and expanded laterally, becoming thin toward the outer edges to form winglike structures. These fins not only give the ray its unique appearance but also help in locomotion. The pelvic fins are also expanded laterally with a convex lateral margin that is partially overlapped by the pectoral fins. While the dorsal and anal fins are absent, the caudal fin tapers into a filament. The eyes and spiracles are located dorsally. The nictitating membrane is absent and the cornea is attached directly to the skin around

the eyes. The gill openings and mouth (with usually protrusible jaws) are on the ventral surface of the body. Unlike bony fish, the stingrays do not have a gill covering. Instead, water flows over their gills through the gill slits. When stingrays are on the ocean floor, they use their spiracles to bring water in for distribution over the gills. These small openings allow the stingrays to breathe while buried in the sand or when in feeding. Some adult stingrays may be no larger than a human palm, while other species, like the short-tailed stingray, may have a body of 2 m in diameter, and an overall length of about 5 m. The smallest stingrays (stingrees or round stingrays) of the family Urolophidae have a body diameter of 30 cm or less. The giant dasyatid stingrays may have a body diameter of more than 2 m and body weight of over 300 kg. The myliobatid rays, especially the giant manta rays, may also have a disk size of up to 7 m with a weight of about 1350 kg. The coloration of stingrays may vary from gray to bright red in color and be plain or patterned (Schneider, 1990). The body of the stingrays is covered with dermal denticles which are the modified tiny placoid scales. While the benthic marine stingrays tend to ripple their fins to swim above the seafloor, pelagic rays flap their pectoral fins and fly through the water. While the benthic rays usually have a rounded or diamond-shaped body with barbs that are located near the middle of the tail, the epelagic rays have a batlike appearance and have barbs that are located nearer the pelvic/pectoral fins. The teeth of stingrays are also modified placoid scales, and like the dermal denticles, they are less pronounced than that of most of the shark species (Klimley, 2013).

Dorsal view of a marine stingray

Ventral view of a marine stingray



Body plan of a marine stingray (dorsal and ventral views)

2.3 INTERNAL ANATOMY

2.3.1 SKELETON

The internal skeleton of rays (or *endoskeleton*) lacks true bone and is instead made entirely of cartilage. Cartilage is a strong and durable material which is lighter and more flexible than bone, enabling elasmobranchs (which lack a swim bladder) to stay afloat and turn in a tighter radius than other fish. However, parts of the elasmobranch skeleton—such as the skull, the vertebrae, and dermal spines—are often strengthened by the deposition of calcium and salts, a process called *calcification*.

The vertebral centra rays are cylindrical and biconcave in shape and are generally divided into two primary types: precaudal and caudal vertebrae. The number of vertebrae a given individual will contain throughout its entire life is set during embryonic development, a period which also marks the beginning of vertebral calcification. Precaudal vertebrae generally begin forming before caudal vertebrae, and all vertebrae appear to grow throughout the lifespan of individual rays. This enables the use of vertebral centra for ageing. Age is determined in rays by counting vertebral rings that are deposited annually.

2.3.2 LIVER

The liver of rays is a large, soft, and very oily organ which occupies most of the body cavity and can comprise as much as 25% of the body weight. It consists of two large, pointed lobes that are greenish-gray to dark reddish-brown in color. The function of the liver in rays is twofold. First, as in all animals, the liver concentrates the fatty reserves and, therefore, provides for energy storage. Second, the liver acts as a hydrostatic organ by storing lighter-than-water (or low-density) oils. These oils counteract the sinking tendency of the rays by decreasing the density and increasing the buoyancy of the animal on a whole. Without such a large liver, rays would have difficulty staying off the bottom, as they lack the *swim bladder* characteristic of bony fishes.

2.3.3 DIGESTIVE TRACT

The second most noticeable structure in the body cavity of rays is the digestive tract which consists of two contiguous organs: the esophagus and the stomach. The anterior end of the stomach (also known as the *cardiac stomach*) is J shaped and saclike, and tapers into the posterior part of the stomach known as the *pyloric stomach*, which bends anteriorly. The pyloric stomach terminates at a constriction called the *pylorus*, which leads to the short *duodenum* and then to the larger *spiral valve intestine*, which is highly coiled and twisted internally. The function of the spiral valve intestine is to increase the surface area for digestion and absorption of food, while also conserving space in the body cavity for the large liver and for the development of embryos. The spiral valve, in turn, leads to the *rectum* and the *anus*, which opens into the *cloaca*, a cavity where the digestive, urinary, and genital glands open to the outside.

2.3.4 PANCREAS

The pancreas is a gland that helps in digestion by secreting digestive enzymes into the duodenum. It consists of two connected lobes: a ventral lobe, which contains a duct from which pancreatic secretions enter the duodenum, and a dorsal lobe. Both are usually pinkish in color.

2.3.5 SPLEEN

The spleen is a dark brownish organ, triangular or slightly elongate in shape, which lies against the stomach. However, it does not play any role in the digestive process. However, it is part of the lymphatic system, a system which is a major component of the immune system.

2.3.6 RECTAL GLAND

The rectal gland is a small, fingerlike organ that concentrates large quantities of excess salt from the bloodstream for final excretion through the anus. It secretes a colorless solution with about twice the concentration

of salt found in the blood plasma into the rectum via a small duct. This organ is very important to rays, whose livers produce large amounts of *urea*, thereby making these marine fishes slightly *hyperosmotic* to seawater).

2.3.7 KIDNEYS

The kidneys of rays are part of the urogenital tract and are involved in the manufacture and transport of urine as well as in the regulation of plasma urea concentrations. They are either semilunar shaped or ribbon-like, dorsoventrally flattened, dark red organs that are highly lobed and lie dorsally on either side of the spinal column outside of the body cavity. A tough membrane, called the *peritoneum*, separates the kidneys from the rest of the body cavity. The kidneys are drained into the cloaca by the ureters.

Food and feeding: The coral reefs are the favorite feeding grounds for the stingrays. The flattened bodies of these rays make them conceal themselves effectively in their environment. They have rows of sensory cells around their mouths called "Ampullae of Lorenzini" that are able to detect weak electric fields generated by prey items. Like sharks, they use these electroreceptors for sensing their prey. Most species of marine stingrays are opportunistic feeders, devouring prey items whenever possible. They feed primarily on small fish, snails, clams, and shrimps, and some other small sea creatures. Many rays are equipped with crusher plates that allow them to crush preys like crabs and shrimps. Some rays, like the manta rays, however, filter-feed on tiny planktonic crustaceans and fish with the help of their transverse gill plates called gill bars. The cephalic (head) lobes of the manta rays help to channel water into the mouth.

Dentition in a typical bluntnose stingray: The upper jaw of this ray protrudes slightly at symphysis, while the lower jaw is indented, leading to a slight overbite. A total of 36–50 rows of teeth are located in the upper jaw. The bottom of the mouth has a cross row of three wide papillae with a lone, small papilla on each side. Each tooth has a quadrangular base. During the mating season, adult male teeth develop wide, triangular cusps for grasping during copulation. Females and juveniles have rounded cusps (Florida Museum of Natural History—Ichthyology).

Segments of a tooth plate from the lower jaw of an eagle ray

Behavior: The stingrays, owing to their dorsoventrally flattened body, are well adapted for searching sea floors for food. With muscular wings, they are also hydrodynamically adapted for effortless cruising over long distances along sandy shore lines, often in schools or shoals. They remain motionless; drift along underwater currents; swim backward; and catapult themselves off wave tops, like flying fish. When not feeding or schooling, these rays bury themselves in soft sandy or muddy sea or river bottoms, with their dorsally placed eyes looking for potential prey items or predators. Some freshwater stingrays have been reported to emit electrical currents to stun their prey or predators. When provoked, most stingrays are very capable of defending themselves with their single or multiple tail spines.

2.4 REPRODUCTION (MANTA RAYS)

The reproduction of these fish possesses some similarities with sharks, their close relatives. Manta rays are large fish and just like other species, they develop within eggs; however, the mother does not release them;

it gives birth to live offspring. That is the manta rays are ovoviviparous animals. Fertilization is internal and involves sexual union of two individuals. The male enters one of its copulatory organs called claspers in the female cloaca to transfer its sperm and allow fertilization. It is believed that female manta rays take longer to reach sexual maturity than males. In *Manta alfredi* species, females mature from 8 to 10 years of age and males at 6 years of age, approximately, when the width of the disk is about 2.5–3 m in diameter. *Manta birostris* females also reach maturity between 8 and 10 years or to a later age, while members of the opposite sex mature when their disk's width is 4–4.5 m. The age of maturity varies from region to region. Females usually have 1 or 2 offspring maximum at a time. Manta rays deliver once about every 2–5 years and can have offspring for about 30 years. Of course, half of births may occur during the first 24 or 25 years.

2.4.1 COURTSHIP AND MATING

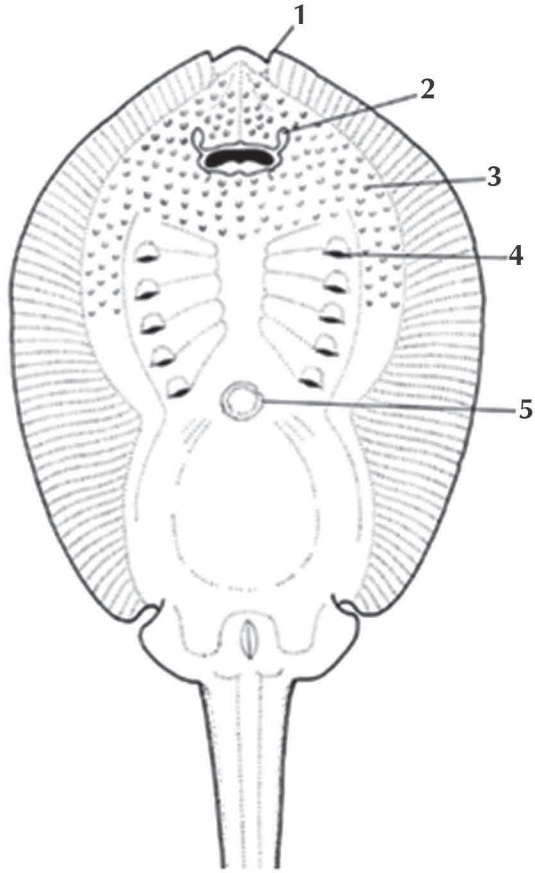
Mating takes place in warm waters and often around the cleaning stations. When males are in heat, they tend to "casually" wander in the localities in search of a receptive female; the latter releases sex hormones in the water to communicate its willingness to mating. The courtship process may take several days or weeks. Usually, several males (25–30) congregate around a receptive female and compete to mate with her. The female chooses a male and it bites its partner's left pectoral fin to hold her. Then, it positions itself so that bellies of both are bonded and inserts one of its claspers in the female cloaca. The coupling lasts seconds and usually the female stands still. After mating, the male goes away and never returns to take part in parental care.

2.4.2 INCUBATION

After fertilization, the offspring develop in eggs inside the womb. Inside the egg, embryos are fed by the yolk. The female takes care of the eggs for about 1 year until hatching occurs. Then, the young are born alive and independent from the first moment they leave the mother's body. Delivery usually occurs at night and in shallow water.

2.4.3 PATERNAL CARE

Small manta rays can measure more than 1 m in diameter, and since they have few natural predators, they do not need parental care as such. During the first year of life, babies tend to double in size. It is believed that these animals have a long life span which may be at least 40 years (Talwar & Jhingran, 1991; Thorson et al., 1983).



Ventral view of 1-month embryo

(1) Anterior tip of pectoral fin; (2) olfactory pit; (3) papilla; (4) gill opening; (5) point of attachment of yolk.

Predators and other threats: Though the marine stingrays have camouflage counter shading and a sharp barb on their tails, they still encounter a large number of predators. Hammerhead sharks (*Sphyrna* spp.) in particular are voracious consumers of many marine stingray species. The killer whales (*Orcinus orca*) also favor stingray flesh. Other predators include tiger sharks, bull sharks, and large carnivorous fish. Many recreational marine fishermen seek stingrays for their food throughout the world. The flesh of the stingray is often used as a replacement for more valuable fish and crustaceans in seafood salads and premixed seafood entrees.

IUCN conservation status: While most stingrays are relatively widespread and are not currently *threatened*, conservation status for several species (e.g., *Taeniura meyeni*, *Dasyatis colarensis*, *Dasyatis garouaensis*, and *Dasyatis laosensis*) is more problematic and is listed as *vulnerable* or *endangered* by IUCN. Further, the status of several other species of stingrays is poorly known and is listed in the category of "*Data Deficient*."

Conservation strategies for stingrays: The basic conservation objectives for the stingrays are as follows:

1. Securing the biodiversity of stingrays for the future and
2. ensuring the wise, equitable, and sustainable use of stingrays.

Conservation recommendations for stingrays

1. Recognition and protection of aquatic ecosystems of special significance;
2. closed or restricted access to aquatic areas where multiple priority species occur;
3. education of fishers in correct handling and release procedures for priority species;
4. enacting legislation to protecting priority species;
5. assembling the basic biological information for the conservation of genetic diversity;
6. raising awareness, at all levels, of the importance of ecosystems and genetic resource conservation; and
7. training staff to implement the objectives listed above.

KEYWORDS

- **marine stingrays**
- **ecology**
- **morphology**
- **internal anatomy**
- **parental care**
- **threats**
- **conservation**

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