

Diversity of marine sponges

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Sponges which belong to the Phylum Porifera are also commonly called 'pore bearers' are asymmetrical or radially symmetrical metazoans characterized by a porous body and an internal system of canals. These primitive animals have cellular grade of organization i.e. the sponge body is formed of loose aggregation of cells, without tissues and organs. The body is perforated by numerous openings, called ostia or incurrent pores through which water enters into the body of the animal, besides few larger pores through which water goes out of the body; the phylum Porifera gets its name from this feature (L. porous = opening, fere = to bear). The sponges are also characterized by an elaborate system of canals for the circulation of water and the transport of food and oxygen. The body encloses a central cavity called spongocoel. Water enters the spongocoel through the ostia (small pores) and passes out through the osculum (large pores). The animal is devoid of mouth and digestive system. Lining the spongocoel and the canal system are a unique type of flagellated cells or collar cells called the choanocytes. The body wall of sponges consists of a gelatinous matrix, supported by spongin fibres and spicules. The spicules are small bristle-like structures, formed of either silica or calcium carbonate. The sponges are known to have high regeneration potential. Reproduction is both by sexual and asexual means. Asexual reproduction is by fragmentation and budding, while sexual reproduction involves a flagellated and free-swimming larva (Parenchymula, Amphiblastula).

The sponges are sessile aquatic organisms. They occur in marine and freshwater ecosystems; though higher diversity of these poriferans is found in marine habitats. The marine forms are found both in inshore as well as in deeper waters. They are presumed to be the earliest-branching metazoan taxon and therefore have immense significance in the reconstruction of early metazoan evolution. The sponges are the oldest Parazoans still extant and their continued existence in vast numbers is closely linked to the apparent adaptability to changes in the environmental characteristics and competing biota (Bergquist, 1978; Muller 2003).

The sponges are important components of coral

reefs having ecological, commercial and biopharmaceutical importance. Their biomass and ecological tolerance often exceed that of the reef-building corals (Reutzler, 1978). They are also known to be effective filter feeders with an ability to filter four to five times their own volume every minute (Allen, 2000). Some species of sponges are also capable of bio-eroding as well as consolidating reef structures (Hooper, 2000). Some specialized sponges are bio-eroders in coral reefs, coralline bottoms and oyster beds and may compete with other sessile organisms such as corals. Some species are also capable of binding unconsolidated substrate such as coral rubbles, gravels and pebbles to form stable surfaces. Many fossil sponges and a small group of Recent sponges are also capable of extensive reef formations that shape the contours of the benthos, in some places. Some of the megabenthic species may form high-density aggregations in many shelf edge and sea mount regions playing significant roles in deep-sea ecosystems.

The sponges have great commercial demand as some species are good sources of bath sponges used in cosmetic industries. They have also become the focus of biochemical studies due to the presence of novel compounds and bioactive secondary metabolites which can be used for curing many diseases, including cancer. Some sponges like *Aplysina fulva* and *Mycale microsigmatosa* have been found to have potential to prevent marine biofouling (Pereira et al., 2002). This renewed interest in sponges has accelerated the discovery and documentation of species in all the oceans. It is believed that the extant fauna may be twice as diverse as that currently described species (Hooper & Levi, 1994).

Classification of sponges

The Phylum Porifera is divided into three classes, based largely upon the chemical composition and structure of the supporting skeleton. These classes are Calcispongiae or Calcarea, Demospongiae and Hyalospongiae or Hexactinellida.

Class I: Calcispongiae or Calcarea

Calcispongiae are calcareous sponges whose spicules are formed entirely of calcium carbonate. They are the most primitive of all sponges and are generally inhabitants of

shallow coastal waters of seas all over the world. The members of Calcarea are small and simple; they are either solitary or colonial. The body is cylindrical or vase-like and the osculum are often fringed with bristles. The spicules are monaxonic (single-rayed) or tetraxonic (four-rayed) and are formed entirely of calcium carbonate. The choanocytes of species of this class are relatively large.

Class II: Demospongiae

Demospongiae is the largest group of sponges and encompasses more than 80% of the known species. The members of this class are most widely distributed and are the most highly organized of all sponges. They are large-sized and are either solitary or colonial. With the exception of the Family Spongillidae, all members are marine. The species of class Demospongiae are compact, mostly massive and brightly coloured. The spicules are made up of silica, but never of calcium carbonate. The spicules are monaxonic or tetraxonic and are differentiated into large spicules, also called megascleres and smaller ones called microscleres. In some of the forms, skeleton is absent.

Class III: Hyalospongiae or Hexactinellida

The members of Hyalospongiae are predominantly deep-sea forms, found at depths ranging from 300 to 8,000 metres. They are generally solitary forms, with cylindrical or funnel-shaped bodies, having structural complexity. The outer layer and inner flagellated layer of the body wall are syncytial rather than cellular. The spicules are glass-like and siliceous, and are four rayed or six rayed (hence the name Hexactinellida).

The members of this group have a simple canal system. The canal system is a unique feature encompassing a system of pores, canals and cavities through which water enters the body from outside, circulates within the body and passes out. The canals are lined by flagellated cells, also called collar cells and the beating of collar cells helps to maintain a constant circulation of water which is required for nutrition, respiration and excretion in sponges. Based on the canal system, sponges are classified into three types namely Asconoid, Syconoid and Leuconoid.

Type I: Asconoid

This is the simplest type of canal system consisting of a simple wall and a complete and continuous lining epithelium of choanocytes, interrupted only by the inner ends of the porocytes. The asconoid types of sponges are

generally radially symmetrical with a vase-like body. The body wall is thin and encloses a cavity called spongocoel which opens at the summit through a narrow opening called osculum. The movement of the flagella of choanocytes produces water current which passes through the incurrent pores (ostia) into the spongocoel and escapes out through the osculum.

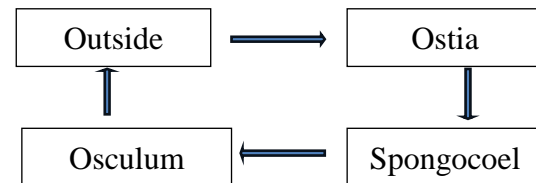


Fig. 1. Course of water current in the Asconoid canal system.

Type II: Syconoid

The Syconoid type of canal system is slightly advanced and a modified form of Asconoid type. The wall of these sponges is pushed into finger-like projections called radial canals, at regular intervals. In simpler forms, the radial canals are free projections and water surrounds the entire length. But in advanced forms, the walls of the radial canals are fused together, leaving tubular spaces between them called incurrent canals. The incurrent canals are lined with epidermis and they open to the exterior through ostia or dermal pores.

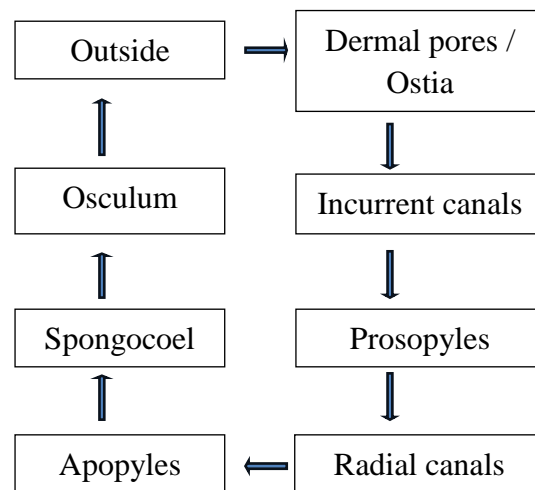


Fig. 2. Course of water current in the Syconoid canal system

The wall between the incurrent and the radial canals is pierced by numerous pores called prosopyles. The radial canals open into the spongocoel through the internal ostia or apopyles.

Type III: Leuconoid

The leuconoid type of canal system is more complex and advanced than the asconoid and syconoid type of canal systems. It is a modification of the syconoid structure in which the choanoderm of the radial canal evaginates forming clusters of small rounded or oval flagellated chambers, replacing the elongated radial canals seen in the syconoid type of canal system which involves an increased outward folding of choanoderm and thickening of the body wall. The dermal pores or ostia lead into incurrent canals that branch irregularly through the mesenchyme. The incurrent canals lead into small round flagellated chambers through prosopyles.

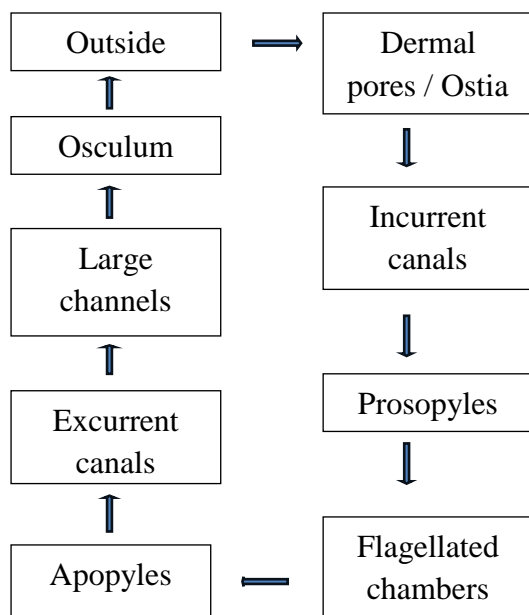


Fig.3. Course of water current in the Leuconoid canal system.

Water from the flagellated chambers enters the excurrent channels through openings called apopyles. The excurrent channels unite to form large tubes leading to the osculum through which water goes out.

Reproduction and propagation

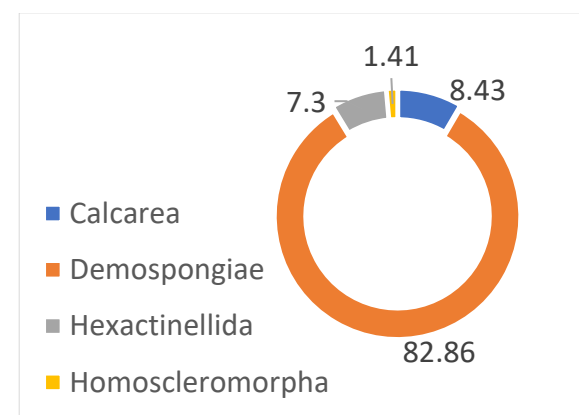
Sponges have the ability to reproduce asexually and sexually and most of them are hermaphrodites. Asexual reproduction is by fragmentation and budding wherein parts of the sponge body or buds get detached from the sponge body and carried away by water currents to different locations where they settle on a hard substratum and develop into an adult sponge. Some of the sponges also form gemmules which are commonly found in freshwater species.

Sexual reproduction takes place when the male releases the gametes into the water which moves in the water column and thereby captured by female choanocytes leading to internal fertilization. The larvae are then released into the water which uses their cilia to propel through water and settle down on a substratum to develop into an adult sponge. The sponges thus take role changes on male and female during every reproductive cycle.

Diversity of marine sponges

The sponges are found distributed in both tropical and temperate waters. Currently, a total of 9,637 valid species of sponges are enlisted in the World Porifera Database (de Voogd et al., 2024); however, it is believed that there could be more species. The World Porifera Database (WPD) is the database of all recent sponges ever described, and is a part of the World Register of Marine Species (WoRMS), a global initiative to arrive at a register of all marine organisms. Table 1. Accepted described species numbers extracted from the World Porifera Database (2024).

Class	Total No. of accepted species
Calcarea	812
Demospongiae	7,985
Hexactinellida	704
Homoscleromorpha	136
TOTAL	9,637



The coral reef areas in the Indian waters are rich in sponge fauna and a total of 486 species of marine sponges were described from the Indian

waters (Thomas, 1998). The highest diversity was recorded in the Gulf of Mannar and Palk Bay (319 species), followed by Andaman & Nicobar Islands (95 species), Lakshadweep Islands (82 species) and the Gulf of Kachchh (25 species). A total of 34 species of coral boring sponges have also been reported – 20 from the Gulf of Mannar and Palk Bay, five from the Andaman & Nicobar Islands and 18 species from the Lakshadweep reefs. Venkataraman and Wafar (2005) in their review on coastal and marine biodiversity of India, has mentioned a total of 451 species of sponges that belong to 169 genera and 65 families. Intensive field surveys in the hitherto unexplored areas may result in the discovery of many new species that were not reported earlier.

Studies on the taxonomy of sponges in India dates back to the nineteenth century with the pioneering studies of Bowerbank (1873), Carter (1880), Dendy (1887, 1905, 1916, 1922), Schulze (1902), Annandale (1915), Burton (1928, 1930, 1937), Dendy & Burton (1926), Burton & Rao (1932) and Rao (1941). Efforts by Thomas (1968, 1986) have led to the discovery of many new species of sponges. Pattanayak (1999) brought out the first checklist of sponges. Studies on the sponge fauna of east of India were more (Dendy, 1905; Burton, 1930, 1937; Thomas, 1968, 1986) when compared to the west coast of the country (Dendy, 1916, 1922; Thomas, 1979, 1980, 1989).

Taxonomic studies in sponges – Approaches

Specimen collection

The sponges from the intertidal region can be collected by wading while the sub-tidal specimens can be collected by diving or dredging. The specimens that come as bycatch in trawl or the specimens that get entangled in bottom-set gill nets can also be collected when fresh. The deep-sea sponges can be collected using epibenthic or hyperbenthic sledges in the bathyal and abyssal zones.

Coding and preservation

The specimens are to be given codes, and photographs of the whole specimen need to be taken before their preservation. The specimens should be examined for their morphological features like growth forms, shape, surface ornamentation, colour, consistency and faunal associates. The surface of the specimen needs to be examined for oscules, conules etc. with the help of a hand lens. For taxonomic purposes, the specimens can be preserved in 70% ethanol, while a small portion of the specimen can be

preserved in absolute alcohol for molecular taxonomy studies.

Histology

Most of the species belonging to the Class Demospongiae and Hexactinellida contain both soft tissues and mineral skeleton and hence require clearing of tissues to view the spicules. The subclass Keratosa and Verongimorpha of Class Demospongiae lack mineral skeleton and hence require clearing of tissues to view the spongin fibres and soft tissues. The members of the Class Calcarea have soft tissues and calcitic spicules and hence require tissue clearing to view the spicules. Thin sections of specimen are placed in containers having saturated solution of phenol crystals in xylene or any other histological clearing agent overnight. The sections can then be mounted on microscope slides using any viscous mounting medium. The slides are kept in oven at low heat overnight to set the mounting medium.

Spicule preparation

For sponges belonging to the class Demospongiae, a small portion of specimen is removed using a razor blade. This is placed in a test tube and a few drops of concentrated nitric acid is added to the test tube. This will digest all the organic material and only the siliceous spicules remain. Subsequently, three to four washings are given to remove the acid completely from the test tube and the spicules are removed and stored in vials with water. In the case of calcareous sponges, bleach is used instead of nitric acid.

Species identification

After gathering the morphological details, the architecture of the skeleton is observed under microscope. The geometry and size of the spicules are very crucial in the identification of sponges to the species level. Some species of sponges have only one type of spicule, while some have several types of spicules and there are few which do not have any spicules. The extracted spicules, both megascleres and microscleres, are observed under a compound microscope at different magnifications ranging from 4x to 100x, to ensure that all spicules that are present are recorded. The different types of spicules are measured using Image Analysis software. The keys and illustrations given in 'Systema Porifera' by Hooper and Van Soest (2002) is suggested for identification of specimens to the species level.

Table 2. Important Orders and Families of the most dominant Class Demospongiae

Order	Family	
Keratosida	Spongiidae	
	Dysideidae	
	Aplysillidae	
	Halisarcidae	
Haplosclerida	Haliclonida	
	Desmacidonidae	
	Adociidae	
	Callyspongiidae	
Poecilosclerida	Phorbasidae	
	Coelosphaeridae	
	Taprobaneidae	
	Plocamiidae	
	Myxillidae	
	Tedaniidae	
	Psammascidae	
	Raspailidae	
	Microcionidae	
	Ophlitaspongiidae	
	Amphilectidae	
	Halichondrida	Axinnellidae
		Halichondriidae
Hymeniacidonidae		
Monathidae		
Hadromerida	Spirastrellidae	
	Suberitidae	
	Placospongiidae	
	Clionidae	
Epipolasida	Gastrophanellidae	
	Jaspidae	
	Sollasellidae	
Choristida	Tethyidae	
	Ancorinidae	
	Geodiidae	
Carnosida	Craniellidae	
	Halinidae	
	Plakinastrellidae	
	Chondrillidae	
	Chondrosiidae	

Examples of some Demospongiae sponges and their spicule characteristics

1) *Sigmadocia carnosa*

Class: Demospongiae
Order: Haplosclerida
Family: Adociidae

Characteristic features:

- Colour: pale yellow when alive.
- Texture: compressible with good resiliency.
- Sessile, lamellate or encrusting; marginate in lamellate specimens.
- Oscules terminal and compound, diameter 1 to 2mm.

- Dermal skeleton a well developed unispicular reticulation.

Spicules:

- Oxeas: 0.10-0.13x0.003-0.009 mm.
- Sigmas: chord 0.034-0.038mm.

2) *Petrosia similis*

Class: Demospongiae
Order: Haplosclerida
Family: Adociidae

Characteristic features:

- Colour: purplish blue when alive.
- Texture: hard and incompressible.
- Spongethick, surface irregularly ridged.
- Oscules scattered; oscule diameter 0.5 to 2.0mm.
- Pores minute.
- Surface hispid due to the presence of terminal parts of the main fibres.

Spicules:

- Oxeas: size 0.2-0.34x0.011-0.027mm.
- Strongyles: size 0.2-0.3x0.02-0.03mm.

3) *Callyspongia fibrosa*

Class: Demospongiae
Order: Haplosclerida
Family: Callyspongiidae

Characteristic features:

- Colour: pale yellow when alive.
- Sponge composed of finger-shaped/flattened branches; surface with strong conules, conules prominent at growing tips.
- Oscules irregularly distributed, terminal or marginal, rounded or elliptical, shallow and compound; oscule diameter 1 to 4mm.

Spicules:

- Oxeas: straight or slightly curved, tips abruptly pointed, size 0.08-0.11x0.002-0.007mm.

4) *Myxilla arenaria*

Class: Demospongiae
Order: Poecilosclerida
Family: Myxillidae

Characteristic features:

- Colour: brownish with yellow tinge when alive.
- Texture: hard.
- Sponge massive with sand grains heavily incorporated.

- Oscules scattered; oscule diameter 0.5 to 1.0mm.
- Pores not traceable.
- Surface rough and uneven.
- Dermal skeleton tangential, stongyles and micro scleres are irregularly scattered.
- The main skeleton consists of an agglutination of sandgrains united by films of spongin.
- Spicules:
 - Strongyles: size 0.10-0.14 x 0.002-0.004 mm.
 - Acanthostyles: size 0.06-0.069x0.003-0.006mm.
 - Isochelas: size 0.015-0.03mm chord.
 - Sigmas (mediumsize): chord, 0.013-0.034mm.
 - Sigmas (large): chord,0.051-0.057mm

5) *Clathria frondifera*

Class: Demospongiae
 Order: Poecilosclerida
 Family: Ophlitaspongiidae

Characteristic features:

- Maximumheightofspecimen:67mm.
- Colour:brick-redwhenalive.
- Texture:firmandcompressible.
- Spongeconsistsofaclathrousmassofflattened orroundedtrabeculae.
- Osculesandporesarenottraceable.
- Skeletonisareticulationoffibrescoredandechinatedbystylesandacanthostyles.
- Two typesof subtylostylesare present,the largeroneinterstitiallyandsmaller,inthedermapart.
- Spicules:
 - Styles: size 0.164-0.338x 0.003-0.010mm.
 - Acanthostyles:size0.104-0.115x0.011mm;moremagnified(bottom).
 - Subtylostyles:size0.09-0.23x0.005-0.013mm.
 - Isochelas,palmate:chord,0.012-0.016mm.
 - Toxas(hair-like):notseen

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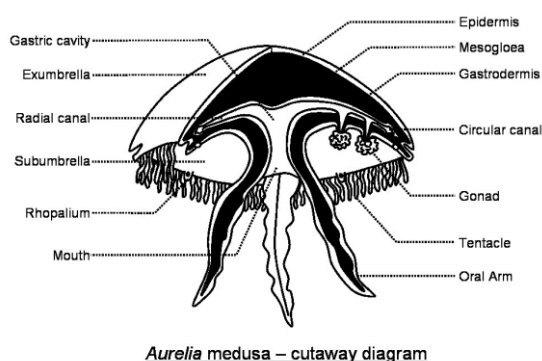
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Diversity of jellyfishes

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Jellyfish is a common term used for any gelatinous animal in marine waters. These include a wide variety of stinging and non-stinging jellyfishes. Jellyfish are the oldest animal on planet Earth, dating from the pre-Cambrian period, and have passed through 500 million years of natural selection. The word "jellyfish" is usually used for a group of jelly-like zooplankton that includes planktonic members of the phylum Ctenophora, Salps and Pyrosomes, and medusae from the phylum Cnidaria (scyphomedusae, hydromedusae, cubomedusae, and siphonophores). The true jellyfish come under the three Cnidarian classes, viz., Hydrozoa, Scyphozoa, and Cubozoa, and seasonally swarm in the coastal waters. Among the three classes, representatives of Scyphozoa and Cubozoa jellyfish range in size from 2 mm to 2 m in bell diameter, however, most of the hydrozoan jellyfish are smaller than 2 mm in bell diameter and belong to the mesoplankton. The biodiversity of pelagic scyphozoa jellyfishes and cubozoan jellyfishes is largely ignored in India, other than a few works in this line. The first work on scyphozoa medusae was published way back in 1930, in which the scyphomedusae of Madras were described with illustrations (Menon, 1930). Subsequent to this publication, the above author has brought out the scyphomedusae of Kurusadai Island (Menon, 1936). These are the two classic works that describe the taxonomic features and distribution of scyphomedusae along the south-east coast of India. Since then, there has been a long gap in the study of scyphomedusae in India. The scyphomedusae available in India were listed as 34 by Chakrapany (1984). The Medusae of the Travancore waters was studied by Nair (1951)

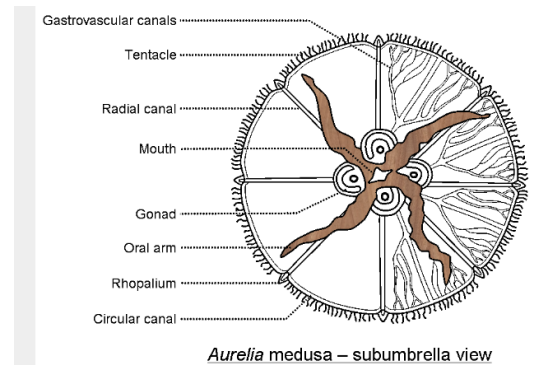


Aurelia medusa – cutaway diagram

and assessed for its impact on fisheries.

Morphometric features of Jellyfishes

Jellyfishes are simple organisms with three layers of tissue, viz., endoderm, ectoderm, and mesoderm. The body is composed of over 90 percent water. The umbrella shaped body, which is called the bell, and the underside are covered with oral arms, or tentacles. In jellyfish, differences in the bell margin are used as a differentiating characteristic between different



Aurelia medusa – subumbrella view

(Image based on: <https://cronodon.com/BioTech/Jellyfish.html>)

groups. The members of the order Semaestomeae have tentacles on the bell margin, whereas the members of the order Rhizostomeae have tentacles on the tip of their oral arms. Jellyfish are 97% water and are semi-transparent.

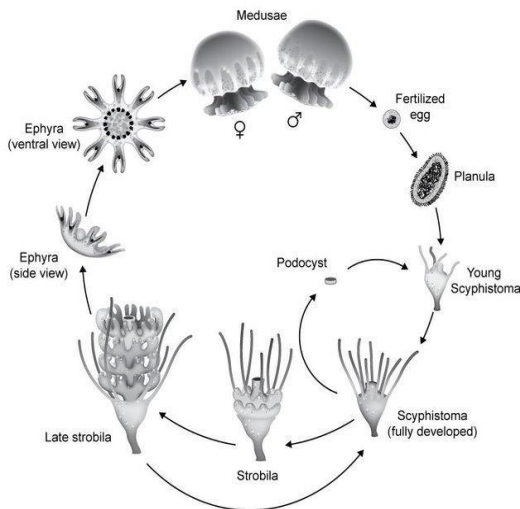
Jellyfish have two body layers: the outer layer, the epidermis and the interlayer, the gastrodermis. Between both layers is a thick layer of mesoglea, which consists of fibres embedded in a hydrated matrix that contains cells. These layers of tissues make up the umbrella of the jellyfish, which is usually bell-shaped; thus, the umbrella is also known as the bell. The scyphozoa jellyfish are tetra-radially symmetrical, meaning they have many structures in multiples of four. It contains a simple gastrovascular cavity that acts as the stomach. They are also characterised by having gastric filaments in the stomach. Some scyphozoa jellyfish, such as Semaestomeae, contain an opening, or mouth, at the subumbrella. There are four to eight oral arms near the mouth, which function as arms to capture and transport food to the gastrovascular cavity. Jellyfish lack

eyes but possess many sensory receptors capable of detecting light, pressure, temperature, and gravity. These sensory receptors are concentrated in the marginal sense organ that contains the rhopalium (Nakanishi, 2015). Not all jellyfish possess tentacles. For Semaestomeae jellyfish, tentacles can be found at the margin of the bell or at the subumbrella, whereas tentacles are absent from the Rhizostomeae jellyfish. Jellyfish contain a network of canals that usually anastomose with each other and form various patterns.

Life cycle and biology

Cnidarian jellyfish, also called medusae, have complex life cycles that often involve a benthic stage: the polyp and the pelagic stage: the medusae or jellyfish. This bipartite life cycle alternates between an asexual, benthic polyp and a sexual, pelagic medusa. Medusae typically are produced asexually in abundance and grow rapidly in seasons (Russel, 1970).

Life cycle of the cannonball jellyfish



Stomolophus meleagris based on Calder (1982)

Diversity and distribution of jellyfishes in India

Class Scyphozoa is ascribed to four orders, namely Stauromedusae, Coronatae, Semaestomeae, and Rhizostomeae, with 65 genera and over 187 species globally. The diversity of scyphozoan jellyfish along the Indian coastal waters has been reported at 29; however, given the poor research attention given to this group, there may be more species to be recorded in the coming years.

Order Semaestomeae

The order Semaestomeae composed of three families, four subfamilies, 18 genera and 56 species (Kramp, 1961). Semaestomeae jellyfish are characterized by four oral arms around the mouth. Tentacles are found at the umbrella margin. (Arai, 1997). The two important families of Semaestomeae are Cyaneidae and Pelagiidae.

Order Rhizostomeae

The order Rhizostomeae is composed of two suborders, 10 families, 25 genera, and approximately 89 species (Kramp, 1961). Rhizostomeae jellyfish are characterised by having a bell margin cleft into a lappet, with no tentacle on the bell margin, without a central mouth, and with eight oral arms extended from the subumbrella, where each oral arm bears numerous secondary mouths. A network of canals is found beyond the stomach. (Kramp, 1961; Arai, 1997). The important orders of this family are Mastigiidae, Versurigiidae, Lychnorhizidea, Catostylidae, Lobonematidae, and Rhizostomatida.

List of Scyphozoan jellyfishes Occuring in Indian waters

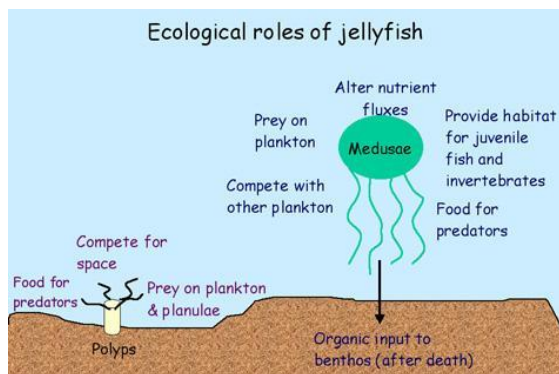
- *Atollawylliei* Haeckel, 1880
- *Nausithoe punctata* Kölliker, 1853
- *Periphylla periphylla* (Péron & Lesueur, 1810)
- *Cyanea nozakii* Kishinouye, 1891
- *Pelagia noctiluca* (Forsskål, 1775)
- *Aurelia aurita* (Linnaeus, 1758)
- *Acromitus flagellatus* (Haeckel)
- *Acromitus maculosus* Light, 1914
- *Catostylus mosaicus* (Quoy & Gaimard, 1824)
- *Crambionella orsini* (Vanhöffen)
- *Crambionella annandalei* Rao, 1931
- *Lobonemasmithii* Mayer, 1910
- *Lobonemoides robustus* Stiasny, 1920
- *Lobonemoides sewelli* Rao, 1931
- *Lychnorhizamalayensis* Stiasny, 1920
- *Rhopilemahispidum* (Vanhöffen, 1888)
- *Cassiopea andromeda* (Forsskål, 1775)
- *Cassiopea amachana* Bigelow 1892
- *Cephea cephea* (Forsskål, 1775)
- *Marivagiastellata* Galil & Gershwin, 2010
- *Netrostomacoeruleus* Maas, 1903
- *Netrostomasetouchianum* (Kishinouye, 1902)
- *Mastigias papua* (Lesson)
- *Versuriga anadyomene* (Maas)
- *Phyllorhiza punctata* Lendenfeld, 1884
- *Thysanostomatoriferum*
- *Thysanostomathysanura* Haeckel, 1880

List of Cubozoan Jellyfishes occurring in Indian waters

- *Alatinaalata* (Reynaud, 1830)
- *Alatinamadraspatana* (Menon, 1930)
- *Tamoyagargantua* Haeckel, 1880
- *Chiropsalmusquadrumanus* (F. Muller, 1859)
- *Chiropsoides quadrigatus* (Haeckel, 1880)
- *Chiropsoidesbuitendijki* (van der Horst, 1907)
- *Chironexindrasaksajiae*Sucharitakul, 2017

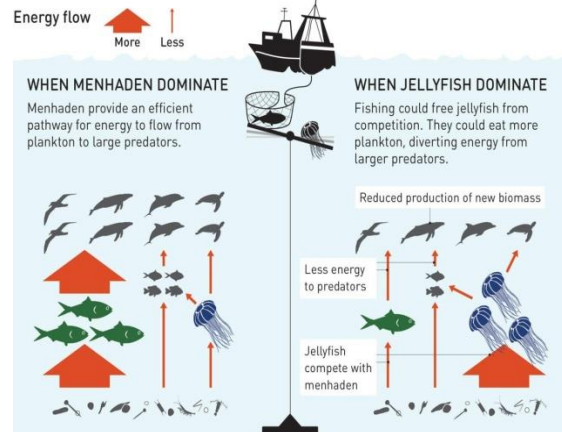
Ecosystem importance of Jellyfishes

Jellyfishes are distributed globally and often form swarms under favourable conditions that last for weeks to months before they collapse. Though jellyfish population swarms occur in many places at an increasing trend, the lack of time series data on their distribution and abundance along the Indian coast prevents us from concluding their population dynamics. Establishing time series data around the Indian subcontinent and



island territories on jellyfish abundance is difficult due to the fact that, in most cases, these jellyfish get damaged in bottom trawls and zooplankton tows and are not properly recorded. Jellyfish directly interfere with many human activities (reviewed by Purcell et al., 2007; Richardson et al., 2009), specifically through stings (beach closures, tourism impacts, injuries, deaths), clogging intakes (coastal power and desalination plants, mining and military operations, shipping, aquaria), interference with fishing (clogged and split nets, spoiled catch, stung fishers, damaged gear, capsized boats), aquaculture (fish deaths, pens fouled by polyps), and marine biological surveys (interference with trawls and acoustic surveys). Jellyfish also have ecosystem impacts with indirect effects on fisheries resources that are difficult to quantify, such as their roles as predators of zooplankton, fish eggs, and ichthyoplankton, as vectors for parasites, as food for fish, and as refugia and food for some species of juvenile fish.

Invasive species of jellyfish are reported in 21 of 45 LMEs. For the most part, invasive species were not responsible for the observed increases reflected in the results; however, the widespread detections demonstrate that jellyfish are truly global invaders of significant concern. Thriving populations of invasive jellyfish in systems like the Mediterranean and Black Seas should serve as warnings for other ecosystems around the



Potential ecosystem shifts due to fishing- From fish dominated to jellyfish dominated (Robinson et al. 2015)

Gut content studies of Jellyfishes

In order to study the gut content of jellyfish, their gastric pouches are excised, opened, and the contents rinsed through a 100- μ m mesh sieve. This is a common procedure for concentrating gut contents and handling samples of large medusae. The collection of jellyfish for gut content studies should be preferably done in the night. All medusae should be studied within 35 minutes of collection, which is less than published prey digestion times (Arai 1997).

Global jellyfish Fisheries

Dried jellyfish is considered a delicacy in many Asian countries. Jellyfish are also purported to have beneficial medicinal properties and are traditionally used to treat ailments such as arthritis, hypertension, and back pain (Hsieh et al., 2001). Jellyfish have been harvested off the coast of China for more than 1700 years (Omori & Nakano, 2001).

Only jellyfish belonging to the order Rhizostomeae are harvested for food. The rhizostomes are preferred because they are typically larger and have more rigid bodies than other scyphozoan orders. When processed, the rhizostomes produce a product that has a desirable, almost crunchy texture. Some species considered to be edible are:

Cepheidae	<i>Cephea cephea</i>
Catostylidae	<i>Catostylus mosaicus</i> , <i>Crambione mastigophora</i> , <i>Crambionella</i> <i>orsini</i> , <i>Crambionella</i> <i>annandalei</i>
Lobonematidae	<i>Lobonema smithi</i> , <i>Lobonemoides gracilis</i>
Rhizostomatidae	<i>Rhopilema esculentum</i> , <i>Rhopilema hispidum</i> , <i>Rhizostoma pulmo</i>
Stomolophidae	<i>Stomolophus meleagris</i> , <i>Stomolophus nomurai</i>

Indian Jellyfish fisheries

There are active jellyfish fisheries along Kerala, Gujarat, and Andhra Pradesh, and four species support jellyfish fisheries in India, viz., *Crambionella annandalei*, *C. orsini*, *Catostylus perezii*, and *Rhopilema hispidum*, which are processed and exported to overseas markets.

Guidelines for Jellyfish studies

Preservation Method

Scyphozoans are typically preserved for morphological analyses in a solution of 4% formalin in seawater with the appropriate label (i.e., 4 parts formalin [37% w/v] and 96 parts seawater). Place the jellyfish in a plastic container with a label (waterproof paper) and pour formalin until the organism is completely covered.

If you are using a plastic bag, place the organisms in a bag, fill it with formalin, twist the bag, and use a rubber band to wrap the plastic bag. When it is tight enough, fold the tip of the plastic bag, and with the last part of the rubber band, secure the folded part of the bag. An excess of 4% formalin solution is used, and it can be renewed after two weeks to ensure successful fixation.

Tissue storage for DNA studies

1. Flush the oral arms or bell margin with tap water. Repeat several times to displace all the debris.
2. Using clean forceps or scissors, cut a half-fingernail-sized piece of tissue from the oral arm or bell margin.
3. Preserve the tissue in one vial of preservative. (Make sure there is excess preservative; guard against diluting the preservative with too much water.)

4. With forceps, hold a piece of oral arm and cut it with clean scissors or razor blades.

5. Place the piece of tissue in a vial with 95% ethanol.

Specimen Information to be collected

- Geographic location
- Depth
- Date (of collection)
- Collector (e.g. your name)
- Photograph
- Whole jellyfish preserved? (yes/no; where)
- Conditions

Photograph of the following features

Bell

Differences in the bell margin can be useful to distinguish orders of medusae. For example, the semaeostomeae, in contrast to the rhizostomeae, have tentacles on the bell margin.

Canal

Canal structure inside the bell

Cnidae

In jellyfish, most cnidae are located in and around the tentacles and/or oral arms. Their shape is used for identification.

Mouth-arms

Differences in the form of the mouths distinguish orders of scyphomedusae. The Rhizostomeae have many small mouths distributed over their oral arms in contrast to semaeostomes, for example, which have a single, much larger, central mouth. The form and distribution of mouths over the oral arms can also be useful for distinguishing taxa within the Rhizostomeae.

Rhopalia

Rhopalia (singular rhopalium) are the most obvious sensory structures of scyphozoan jellyfish. They include specialised structures for sensing light (eyespots) and movement or direction with respect to gravity (statoliths).

Table .1 Checklist to study the Morphological features of Scyphozoan and Cubozoan Jellyfishes

1	Tentacles present on umbrella (on margin or underside) (or) Tentacles lacking on umbrella	
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2	Umbrella almost spherical (or) Umbrella not spherical	
3	Umbrella without prominent white spots(or) umbrella with numerous prominent white spots	
4	Mouth-arms with stout finger-like appendages (or)Mouth-arms with long and slender filaments basally	
5	Tentacles on underside of umbrella (or) Tentacles on margin of umbrella	
6	Tentacles in a wide band around underside of umbrella; medusae large (or) Tentacles in 8 U-shaped clusters on underside of umbrella	
7	Colour of the Umbrella	
8	Umbrella cuboid or not cuboid	
9	Umbrella higher than a hemisphere (or) Umbrella decidedly flattened.	
10	Tentacles round noodles like or pasta like flattened	

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