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.

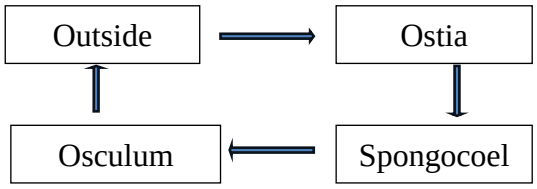


Fig. 1. Course of water current in the Asconoid canal system.

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.

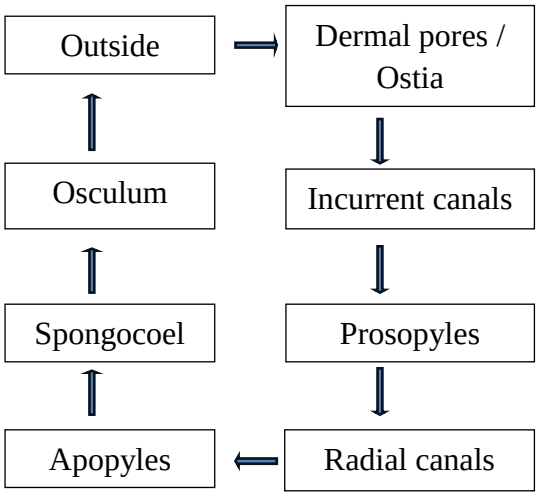


Fig. 2. Course of water current in the Syconoid canal system

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.

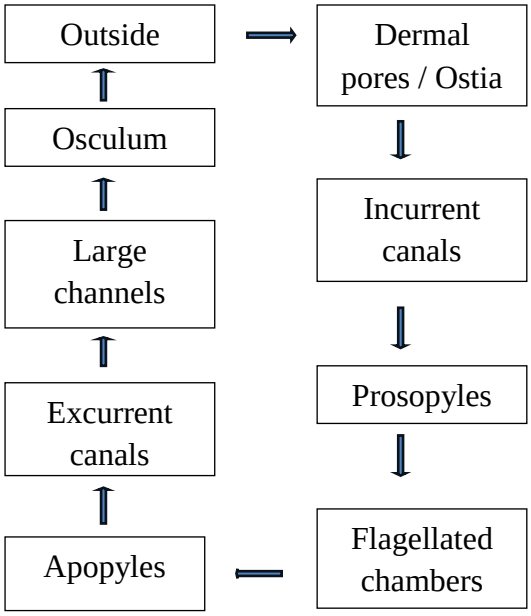


Fig.3. Course of water current in the Leuconoid canal system.

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

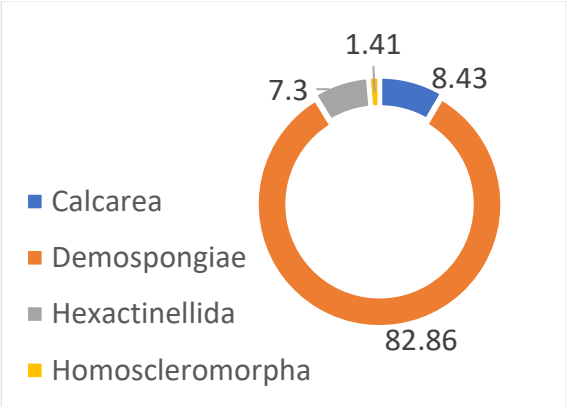
Sponges have the ability to reproduce asexually and sexually and most of them are hermaphrodites. Asexual reproduction is by fragmentation and budding wherein parts of the sponge body or buds get detached from the sponge body and carried away by water currents to different locations where they settle 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
	Gastrophanellidae
Epipolasida	Jaspidae
	Sollasellidae
	Tethyidae
Choristida	Ancorinidae
	Geodiidae
	Craniellidae
Carnosida	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 whn 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

Characteristicfeatures:

- 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

Characteristicfeatures:

- Colour: pale yellow when alive.
- Sponge composed of finger-shaped/flattened branches; surface with strong conules, conules prominent at growing tips.
- Osculesirregularlydistributed, terminal or marginal, rounded or elliptical, shallow andcompound; osculediameter 1to 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

Characteristicfeatures:

- Colour: brownishwithyellowtinge whenalive.
- Texture: hard.
- Sponge massive withsand 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,inthedermalpart.

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

References

Annandale, N. (1915) Indian Boring Sponges of the family Clionidae. *Records of the Indian Museum, Calcutta*, 11, 1–24.

Bergquist,P.R.(1978)*Sponges*.London,Hutchinson,268pp

Bowerbank, J.S. (1873) Report on a collection of sponges found at Ceylon by E.W. H. Holdsworth. *Proceedings of the Zoological Society of London*, 1873, 25–32.

Burton, M. (1928) Report on some deep-sea sponges from the Indian Museum collected by the R.I.M.S. "Investigator" part II Tetraxonida (concluded) and Euceratosa, *Records of the Indian Museum, Calcutta*, 30 (II), 109–138.

Burton, M. (1930) Addition of the sponge fauna of Gulf of Mannar. *The Annals and Magazine of Natural History Series*, Series 10, 5 (30), 665–676.

Burton, M. (1937) Supplement to the littoral fauna of Kurusadi Island. *Bulletin of the Madras Government Museum*, 1, 1–58.

Burton, M. & Rao, H.S. (1932) Report on the shallow-water marine sponges in the collection of the Indian Museum. *Records of the Indian Museum, Calcutta*, 34, 299–356.

Carter, H.J. (1880) Report on specimen dredged up from the Gulf of Mannar and presented to the Liverpool Free Museum by Capt. W.H. Cawne Warren. *The Annals and Magazine of Natural History Series*, 5 (30) & 6 (31), 437–457, pls. 18–19 & 35–61 + 129–156, pls. 4–8.

Dendy, A. (1887) The sponge fauna of Madras. A report on a collection of sponges obtained in the neighbourhood of Madras by Edgar Thurston Esq.*The Annals and Magazine of Natural History Series*, 5 (20), 153–165, pls. 9–12.

Dendy, A. (1889) Report on a second collection of sponges from the Gulf of Mannar. *The Annals and Magazine of Natural History Series*, 6 (3), 73–99, pls. 2–5.

Dendy, A. (1905) Report on the sponges collected by Professor Herdman, at Ceylon, in 1902. In: Herdman, W.A. (Ed.), *Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar. Vol. 3. Supplement 18*. Royal Society, London, pp. 57–246, pls. I–XVI, pp. 182–184.

Dendy, A. (1916) Report on the calcareous sponges collected by Mr. James Hornell at Okhamandal in Kattiawar in 1905–1906. *Report of the Government of Baroda, Marine Zoology*, Okhamandal Series, 2 (17), 79–91 + 93–146, pls.1–4.

Dendy, A. (1922) Report on the non-calcareous sponges collected by Mr. James Hornell at Okhmandal in Kattiawar in 1905–06. *In*: *Report of the Government of Baroda, Marine Zoology*, Okhamandal Series, Kattiawar, II, pp. 93–146, 4 pls.

Dendy, A. & Burton, M. (1926) Report on some deep sea sponges from the Indian Museum collected by the R.I.M.S. "Investigator". Hexactinellida&Tetraxonida (Pars). *Records of the Indian Museum, Calcutta*, 28 (I), 225–248.

de Voogd, N.J.; Alvarez, B.; Boury-Esnault, N.; Cárdenas, P.; Díaz, M.-C.; Dohrmann, M.; Downey, R.; Goodwin, C.; Hajdu, E.; Hooper, J.N.A.; Kelly, M.; Klautau, M.; Lim, S.C.; Manconi, R.; Morrow, C.; Pinheiro, U.; Pisera, A.B.; Ríos, P.; Rützler, K.; Schönberg, C.; Turner, T.; Vacelet, J.; van Soest, R.W.M.; Xavier, J. (2024). World Porifera Database. Accessed at https://www.marinespecies.org/porifera on 2024-01-30. doi:10.14284/359.

Hooper, J. N. A. 2000. 'Sponguide': Guide to sponge collection and identification. http://www.qmuseum.qld.gov.au/naturewelcome.[:sponges",(versionAugust2000).

Pattanayak, J.G. (1999) Annotated checklist of marine sponges of the Indian region. *In*: Hooper, J.N.A. (Ed.), *Origin and Outlook, Proceedings of the 5th International Sponge Symposium 1998*, *Memoirs of the Queensland Museum, Australia*, 44, pp. 439–455.

Schulze, F.E. (1902) *An account of the Indian Triaxonia collected by the Royal Indian Marine Survey Ship "Investigator" translated into English by R. von Lendenfeld.* Trustees of the Indian Museum, Calcutta, 113 pp.

Thomas, P.A. (1968) Studies on Indian sponges I–V. *Journal of the Marine Biological Association of India*, 10 (2), 245–268.

Thomas, P.A. (1970a) On some deep-sea sponges from the Gulf of Mannar with descriptions to three new species. *Journal of the Marine Biological Association of India*, 12, 202–209.

Thomas, P.A. (1979) Demospongiae of Minicoy Island (Indian Ocean) Part I. Orders Keratosida and Haplosclerida. *Journal of the Marine Biological Association of India*, 21 (1 & 2), 10–16. https://doi.org/10.1016/0025-326X(79)90263-7

Thomas, P.A. (1980) Demospongiae of Minicoy Island (Indian Ocean) Part II & III. *Journal of the Marine Biological Association of India*, 22, 1–20.

Thomas, P.A. (1984) Sponges collected aboard R.V. 'Skipjack' from the southeast coast of India. *Journal of the Marine Biological Association of India*, 26 (1), 95–102.

Thomas, P.A. (1986) Demospongiae of the Gulf of Mannar and Palk Bay. *In*: James, P.S.B.R. (Ed.), *Recent Advances in Marine Biology*. Today and Tomorrow's Printers and Publishers, New Delhi, 5, 205–365.

Thomas, P.A. (1989) Sponge fauna of Lakshadweep. *Bulletin of the Central Marine Fisheries Research Institute*, 43, 150–161.

Van Soest, R.W.M., Boury-Esnault, N., Vacelet, J., Dohrmann, M., Erpenbeck, D., De Voogd, N.J., Santodomingo, N., Vanhoorne, B., Kelly, M. & Hooper, J.N.A. (2012) Global Diversity of Sponges (Porifera). *PLoS ONE*, 7 (4), 1–23.

Venkataraman,K.andWafar,M.2005.Coastaland marinebiodiversityofIndia.*IndianJ.Mar. Sci.,*34 (1): 57-75.

Vinod, K., George, R.M., Thomas, P.A. &Manisseri, M.K. (2012) *Semperellamegaloxea*sp. nov. (Family: Pheronematidae): A new hexactinellid sponge from Andaman waters, India. *Indian Journal of Fisheries*, 59 (1), 33–36.

Vinod, K., George, R.M., Thomas, P.A., Manisseri, M. K. & Shylaja, G. (2014) Diversity and distribution of shallow water sponges (Porifera) in the coastal waters from Enayam to Kollam, south-west coast of India. *Indian Journal of Fisheries*, 61 (3), 52–57.