Project Report

MOLLUSCAN DIVERSITY IN THE INTERTIDAL ROCKY REEF AREAS OF THIRUMULLAVARAM COAST, KOLLAM

Dissertation submitted to the University of Kerala in partial fulfillment of the requirements for the award of the degree of

Bachelor of Science

in

ZOOLOGY

Submitted by

Sl. No.	Name of candidates	Candidate code
1	AMINA S.	250 141 42001
2	RAMSY A.	250 141 42005
3	SHERNA SALIM	250 141 42008
4	BRINCY BABU	250 141 42019
5	CHANDNI R.	250 141 42020
6	MUHAMMED BILAL	250 141 42023
7	AKHIL A. SALAM	250 141 42012

DEPARTMENT OF ZOOLOGY

TKM COLLEGE OF ARTS AND SCIENCE

KOLLAM-5

March - 2017

MOLLUSCAN DIVERSITY IN THE INTERTIDAL ROCKY REEF AREAS OF THIRUMULLAVARAM COAST, KOLLAM

Dissertation submitted to the University of Kerala in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF SCIENCE

IN

ZOOLOGY

Submitted by

Sl. No.	Name of candidates	Candidate code
1	AMINA S.	250 141 42001
2	RAMSY A.	250 141 42005
3	SHERNA SALIM	250 141 42008
4	BRINCY BABU	250 141 42019
5	CHANDNI R.	250 141 42020
6	MUHAMMED BILAL	250 141 42023
7	AKHIL A. SALAM	250 141 42012

DEPARTMENT OF ZOOLOGY
TKM COLLEGE OF ARTS AND SCIENCE, KOLLAM-5

March - 2017

CERTIFICATE

This is to certify that the dissertation entitled **Molluscan diversity in the intertidal rocky reef areas of Thirumullavaram coast, Kollam** is an authentic record of the work done by ..... with Reg. No: ..... under my supervision as partial fulfillment of the requirements for the Degree of *Bachelor of Science* in Zoology and this report has not been submitted earlier for the award of any degree or diploma or any other similar titles anywhere.

21/03/17

Dr. Sirajudheen T.K.

(*Supervisor*)

Asst. Professor & Head

Dept. of Zoology

Certified bona fide:

Head of the Department 21/03/17

Dr. SIRAJUDHEEN. T.K
Asst. Professor & Head
Dept. of Zoology
TKM College of Arts & Science
Kollam, Kerala - 691 005.

DEPARTMENT OF ZOOLOGY • T.K.M. COLLEGE OF ARTS & SCIENCE • KOLLAM.5

EXAMINERS:

1. 11/5/2017

2.

DECLARATION

I do hereby declare that this dissertation entitled **Molluscan diversity in the intertidal rocky reef areas of Thirumullavaram coast, Kollam** is a bona fide report of the project work carried out by me, under the supervision and guidance of Dr. Sirajudheen T.K., Asst. Professor & Head, Department of Zoology, TKM College of Arts and Science, Kollam as partial fulfillment of the requirements for the award of the Degree of Bachelor of Science in Zoology.

Student

AMINA S

RAMSY A

SHERNA SALIM

BRINCY BABU

CHANDNI R

MUHAMMED BILAL

AKHIL A SALAM

Karicode

27.03.2017

ACKNOWLEDGEMENT

I have got many people to thank for their encouragement and support to accomplish the objectives of my work.

First I would like to thank my supervisor, Dr. Sirajudheen T.K., Asst. Professor & Head in the Department of Zoology, TKM College of Arts and Science, for his expert guidance, valuable suggestions, constructive criticism and incessant encouragement.

I am grateful to the Principal of our college Prof. Hashimuddin A., for his support and encouragement.

I would also like to place on record my appreciation and thanks to all my beloved teachers in the college for their great encouragement.

Thanks are due to Mr. Ravinesh, Dept. of Aquatic Biology, University of Kerala, for rendering his expertise in identifying the molluscan specimens.

Finally but immensely I remember with sincere gratitude, all my classmates and parents for their cooperation, love and concern without which this work would not have been materialized.

Student

CONTENTS

DEDICATED TO MY PARENTS AND TEACHERS....

Mollusca constitute invertebrate animals inhabiting marine, freshwater as well as terrestrial habitats. They enjoy second largest phylum in animal kingdom next to Arthropoda in terms of the number of species. The Phylum Mollusca comprises of six living classes -Monoplacophora, Polyplacophora, Gastropoda, Scaphopoda, Bivalvia and Cephalopoda (Bouchet and Strong, 2010). There is one extinct class Aplacophora.

Most of the Molluscs represented by Gastropods; they are soft-bodied, torted, asymmetrical molluscs, bearing a characteristic spirally coiled shell. Most of the gastropod species will be dextral (right handed) or sinistral (left-handed) (Hyman, 1967). The shell of the gastropod is secreted by mantle and is composed of layers of crystalline calcium carbonate separated by thin sheets of protein forming a crossed lamellar structure (Currey and Kohn, 1976). Shells protect the organism from abrasion by sand, moving stones or predators, besides protecting it from desiccation and impact of salinity (Hughes, 1986).

Bivalves, the second largest class comprises bilaterally symmetrical and laterally compressed aquatic molluscs, elongated in anterior-posterior direction. They are provided with shell consisting of two wholly or partly calcified shells lying on the left and right side of the body. The valves (except some cases) are connected dorsally by calcified, elastic structure called ligament and open and close by hinging along an axis. Animals are lack of head, radula, jaws and cephalic sensory organs. Foot is an extensile structure in bivalves serves mainly for burrowing. They form an important element of the benthonic fauna, abundant in the sub littoral zone.

The phylum Mollusca is one of the most successful inhabitants of our planet, occupying almost every ecosystem. Molluscs are successfully invade almost all habitats like marine, fresh water and terrestrial biotopes (Hyman, 1967). Marine molluscs especially gastropods are found to inhabit diverse coastal and marine habitats like mangroves, coral reefs, rocky coasts, sandy beaches, sea grass beds and ocean depths (Khade and Mane, 2012). Gastropods are found in all seas at all latitudes and depths (Ruppert and Barnes, 1994).

Significance of molluscs

Being a part of whole aquatic community, Molluscs play an important role in aquatic ecosystems. Molluscs are considered to be a suitable indicator group for local invertebrate biodiversity. The planktonic larvae of gastropods play an important role in maintaining the stability of biotic population and form a key component of food chains. Not only many aquatic animals thrive on them but they also serve as food for human in many parts of the country. They play very unique roles in ecology as efficient grazers, scavengers and carnivores (Sturm *et al.,* 2006). Molluscs play an important ecological role in interacting actively with other species and thereby influencing benthic community structure (Venkataraman and Wafar, 2005). Molluscs such as Bivalves filter large volumes of water daily, they ingest suspended particulate matter from the water column, while bioaccumulating nondigestible metals and compounds in their tissues. Many molluscs such as Gastropods are very good bioindicators of aquatic health. A progressive increase in their number with increasing pollution load indicates

that they possess great tolerance against the contaminants present in water and flourish well in their presence.

The molluscs directly as well as indirectly form economically very important group for human being. Gastropods constitute about 2% of the total molluscan catches across the world and the major share comes from America followed by Asia and Oceania, Africa and Europe (Leiva and Castilla, 2002). They have been used in all parts of the world as food, ornament, money, utensils of war and home since prehistoric times (Ganong, 1889).

Molluscs are considered as an important food source in many regions of the world and they stand next to finfish and crustaceans in their nutritive value (Kamboj, 1999). The cut, sundried and oil fried pieces of chank meat and the extracted boiled meat of *Umbonium vestiarium, Cellana radiata,Turbo intercostalis, Strombus* spp.and *Thais* spp. are suitable for consumption (Appukuttan and Ramadoss, 2000). The nutritive meat of gastropods is also used in the preparation of stews, appetizers, salads, pickles etc (Patterson and Ayyakannu, 1997).

Bioactivity of many molluscs has been studied by Babar *et al.,* 2012. Among molluscs, gastropods are found to be biologically active against various microbes. Gastropods are found to be sources of structurally and pharmacologically important substances that possess antimicrobial, antitumour and anti inflammatory properties (Bhadury and Wright, 2004). The powdered chank shells mixed with water was considered as an effective medicine for diseases such as rickets and asthma. Chank ointment was used for eye ailment. Varatika Bhasma

a traditional ayurvedic medicine produced from money cowry *Cypraea moneta,* has been used in the treatment of diseases such as duodenal ulcer, loss of apetite, malabsorption, tuberculosis, ottorhoea and ophthalmic diseases (Mallick, 2013).

Sea shells have been a subject of interest for the naturalists, amateurs and shell collectors well before the period of Linnaeus (Bouchet and Strong, 2010). Molluscan shells and shell products with attractive shape and colours are gaining importance day by day. They were widely used in the preparation of traditional Indian ornaments. Freshwater mussels, pearl oysters, turban and top shells are sources of mother pearl. They also form basic raw material for shell Button Industries.

Many species of gastropods and bivalves landed in trawl bycatch are used in ornamental shell trade in Kerala. Species like *Tibia curta, Bursa spinosa, Babylonia spirata, Babylonia zeylanica, Turritellaattenuata, Rapana bulbosa, Turbinella pyrum, Conus glans* and *Umbonium vestiarium* are used in shell handicraft centres in Tamil Nadu for manufacturing curios (Appukuttan and Ramadoss, 2000).

The sacred chank *Turbinella pyrum* was the royal emblem of the Travancore Cochin state. Chanks were also embossed as images on coins and stamps (Appukuttan *et al.,* 1980). They were also used as souvenir items, home decors and other ornaments (Floren, 2003). Gastropod meat has been used in the preparation of a number of value added products (Appukuttan and Ramadoss,

2000). Many gastropod species were used as knives, pigtroughs and instruments for cleaning and shaping claypots by the people of Brooker Island, Papua New Guinea (Kinch, 2003). Sea shells are also used in the manufacture of lime and as bait in fishing (Patterson and Ayyakkannu, 1997). Two species of cowries, money cowry (*Cypraea moneta)*and gold ring cowry (*Cypraea annulus)* were used as currencies in ancient times (Rao, 2003).

However, as vectors they are instrumental in the transmission of many diseases in livestock and human. For instance, they are the intermediate host of many trematodes and many larval bivalves are parasitic on gills of fishes. Some freshwater snails are vectors of disease, serving as the intermediate hosts for a number of infections for which humans or the livestock are definitive hosts. Twenty seven species of cone shells are found to have poisonous effect by virtue of the conotoxin emitted by their poisonous dart. Conotoxins derived from cone snails acts by blocking muscular and neural receptors and are used in the treatment of pain, cancer, neuromuscular and psychiatric disorders (Cruz and White, 1995). Neurological research has proved the effectiveness of *conus* venom in human beings and the venom molecules can be easily synthesised owing to their small size (Concar, 1996).

World molluscan taxonomy

The taxonomy of molluscs has been well studied and most of them have been aimed at studies pertaining to distribution and detailed levels of taxonomic resolution (Terlizzi *et al.*, 2005). About 30,000 existing species has been described

so far and there are fossil records dating upto Cambrian Era (Samuel *et al.*, 2005).

The history of molluscan taxonomic studies all over the world was contributed by many authors. Some of them are reviewing here for instance. Melvill and Standen (1901) from Persian Gulf, Caroline and Solomon Island, Higo *et al.* (2001) from Japan, Wilson (1994) from Australia, Kilburn (1972) from South Africa, Neilsen (1976) from Thailand, Tan and Chou (2000) from Singapore, Aziz *et al.* (2001) from Malaysia, Thach (2007) from Vietnam and Dayrat *et al.* (2014) from Indo-West Pacific.

Taxonomic studies on Indian Molluscs

Various taxonomic surveys have been carried out around Indian seas comprising of Bay of Bengal, Arabian Sea and Andaman Sea. Smith (1904) studied the Mollusca of Bay of Bengal and Arabian Sea. The marine molluscs of south India and Sri Lanka have been studied by Winckworth (1936). The habits, ecology and economics of the edible gastropods of Indian coasts have been studied by Hornell (1951). Satyamurti (1952) published descriptions of a number of commercial gastropods.

Philip and Appukuttan (1995) recorded the occurrence of 29 species of gastropods associated with the trawl by-catch of shrimp trawlers from southwest coast of India. Menon (1996) studied the by-catch landings of trawlers in the southern states of Karnataka, Kerala and Tamil Nadu. According to Rao (1998), the estimated number of gastropod species reported from India includes 3,619 species, with 2,000 species of marine gastropods belonging to 340 genera and

140 families. Apte (1998) described the taxonomic characters and distribution of common Indian molluscs in his book of Indian sea shells, among which 262 species were gastropods. Rao (2003) reported 15 species belongs to 4 genera of family Terebridaefrom different locations of Indian coast.

Recently, there are many studies on marine molluscs of India. A survey on the spatial distribution of molluscan fauna in Minicoy Island, Lakshadweep, India by Susan *et al.* (2012). A survey conducted by Thomas *et al.*(2014) to assess the distribution and seasonal variation of gastropods in the trawling regions off Konkan Malabar region in Arabian Sea recorded 35 species of gastropods belonging to 18 families and 5 orders. Bijukumar *et al.* (2015) published a report on the molluscan fauna of Lakshadweep included under various schedules of Wildlife Protection Act of India.

Molluscan diversity in Kerala

Taxonomic studies on Molluscan diversity of Kerala coast are mainly started during 20th century. Philip and Appukuttan (1995) prepared a detailed checklist of gastropods landed at Sakthikulangara and Neendakara harbours of Kollam district. Kurup *et al.* (2003) recorded the presence of 65 species of gastropods in the discards of bottom trawlers from Kerala coast.

Sary *et al.* (2013) studied the diversity of gastropod shells along Vizhinjam coast of Kerala. Ravinesh and Bijukumar (2013) carried out a comparative survey on the faunal diversity of natural rocky shore and artificial sea wall at Vizhinjam. The diversity of Cone shells along Kerala coast was revealed in a study conducted

by Sary *et al.* (2014). Recently Preetha (2016) studied the taxonomy and diversity of gastropods of whole Kerala coast.

Despite all these extensive surveys, site specific taxonomic surveys on intertidal molluscan diversity are rather limited along Kerala coast of India. This prompted the study with the objective of conducting a taxonomic survey of Molluscs in intertidal rocky reef areas of Thirumullavaram, Kollam coast.

Objectives of the study

- to conduct a taxonomic survey on diversity of molluscs in study area.
- to identify and document available species from the study area.
- to understand status of molluscan diversity and ecosystem in the study area and to recommend required conservation measures.

A taxonomic survey on molluscan diversity of intertidal rocky reef ecosystems were conducted during December 2016 to February 2017. The methods used in the study are detailed below.

Study Area

Kollam is a major port city of Kerala on the Lakshadweep Sea coast. Thirumullavaram coastal area (Fig. 2.1) is renowned intertidal rocky reef ecosystems, located about one kilometer west of the Kollam city, Kerala. The area support high biodiversity including many fauna and flora. Intertidal rocky reef areas serves as a shelter for many invertebrate animals including Echinoderms, Annelid worms, Arthropods, Platyhelminthes, Coelenterates and Mollusca.

The survey

Field surveys were conducted in the study area during December 2016 to February 2017. Specimens of various animals coming under the Phylum Mollusca were collected. The fresh specimens were cleaned, washed and photographed using digital camera. Representative specimens of each species collected were preserved in 5% formaldehyde after noting the colouration and other characters.

Taxonomic Studies

Each specimen was identified up to species level using text books, monographs, reprints and online databases. The standard identification keys used included those of Preetha (2016) and online databases (WORMS, Indo-Pacific Molluscan database and Biosearch). Shells with confusing taxonomic characters were

identified with the help of experts in the field Mr. Ravinesh R. from Dept. of Aquatic Biology & Fisheries, University of Kerala.

All scientific names were finalized following World Register of Marine Species (http://www.marinespecies.org/).

Statistical Analysis

Graphical representation of various aspects related to the taxonomy of Molluscs in the intertidal rocky reef areas of Thirumullavaram coast was done by using Microsoft Office Excel.

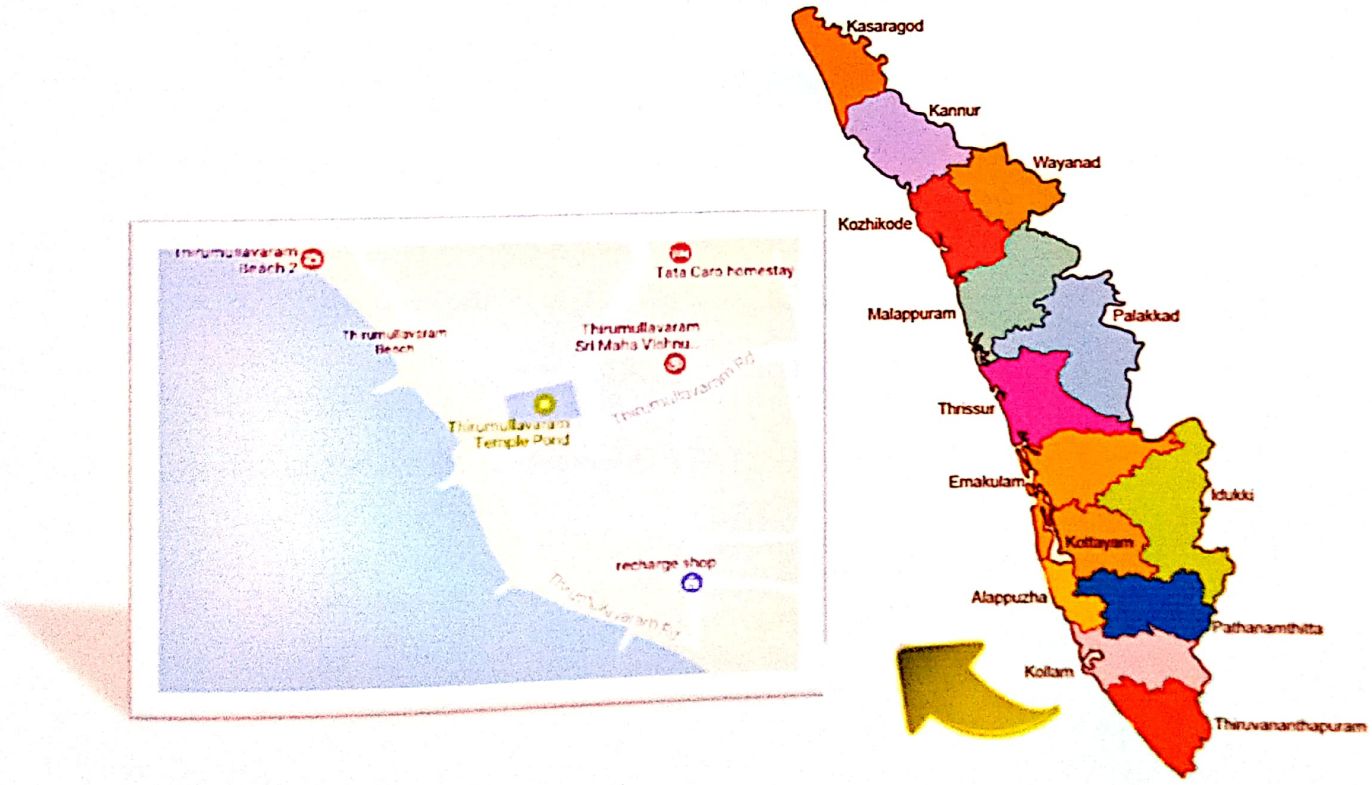


Fig. 2.1: Map of Kerala showing the study site.

The taxonomic survey conducted to realize the diversity of molluscs in the intertidal rocky reef areas of Thirumullavaram coast of Kollam realized the following findings.

The study revealed presence of 19 species Molluscs in the rocky reef areas of Thirumullavaram coast of Kollam. The whole species classified under three classes, seven subclasses and sixteen families (Table 3.1). The class Gastropoda represented the most diverse molluscan class in the area with a species diversity of 14 species followed by Bivalvia (4 species) and Polyplacophora (1 species) (Fig. 3.1). The species-rich molluscan subclasses were Caenogastropoda and Vetigastropoda with five species each followed by Heterodonta (4 species), Neritimorpha (2 species), Neoloricata, Patellogastropoda and Heterobranchia (one species each) (Fig. 3.2). Out of the 16 families reported, three families namely Ostreoidae, Fissurellidae and Planaxidae represented two species each whereas rest of the families were represented by single species (Table 3.2).

Table.3.1: Taxonomic list of Molluscan species collected from Intertidal rocky reefs of Thirumullavaram coast, Kollam.

Sl. No,	Taxonomy & Species	Common name	Figure No.	Accession No.
1	Class: Polyplacophora Subclass: Neoloricata Family: Mopaliidae ***Plaxiphora tricolor* Thiele, 1909**	Chiton	3.3	05/024
2	Class: Bivalvia Subclass: Heterodonta Family: Veneridae ***Gafrarium dispar* (Holten, 1802)**	Nil	3.4	05/013
3	Family: Ostreoidae ***Ostrea* sp**	Flat oyster	3.5	05/022
4	***Saccostrea cucullata* (Born, 1778)**		3.7	05/026
5	Family: Plicatulidae ***Plicatula australis* Lamarck,**	Southern kitten paw	3.6	05/025

	1819			
6	Class: Gastropoda Subclass: Patellogastropoda Family: Nacellidae ***Cellana radiata* (Born, 1778)**	Radiate patellid limpet	3.8	05/006
7	Subclass: Vetigastropoda Family: Fissurellidae ***Clypidina notata* (Linnaeus, 1758)**	Nil	3.9	05/009
8	***Scutus unguis* (Linnaeus, 1758)**	Hoof shield Limpet	3.10	05/027
9	Family: Chilodontidae ***Euchelus asper* (Gmelin, 1791)**	Four-keeled Margarite	3.11	05/012
10	Family: Trochidae ***Trochus radiatus*Gmelin, 1791**	Radiate Top Shell	3.12	05/031
11	Family: Turbinidae ***Turbo intercostalis* Menke, 1846**	Ribbed Turban	3.13	05/032
12	Subclass: Neritimorpha Family: Neritidae ***Nerita albicilla* Linnaeus, 1758**	Blotched Nerite	3.14	05/020
13	Family:Cerithiidae ***Cerithium* sp**	Nil	3.15	05/007
14	Subclass: Caenogastropoda Family: Planaxidae ***Planaxis sulcatus* (Born, 1778)**	Tropical Periwinkle	3.18	05/023
15	***Supplanaxis niger* (Quoy & Gaimard, 1833)**	Black Brown Planaxis	3.16	05/029
16	Order: Littorinimorpha Family: Cypraeidae ***Mauritia arabica* (Linnaeus, 1758)**	Arabian Cowry	3.17	05/019
17	Order: Neogastropoda Family: Columbellidae ***Anachis terpsichore* (G.B.Sowerby II, 1822)**	Dove Snail	3.19	05/003
18	Family: Muricidae ***Tenguella granulata* (Duclos,1832)**	Granulated Drupe	3.21	05/030
19	Subclass: Heterobranchia Family: Siphonaridae ***Siphonaria funiculata* Reeve,1856**	Nil	3.20	05/028

Table.3.2: Family wise diversity of Molluscs collected from Intertidal rocky reefs of Thirumullavaram coast, Kollam.

Sl. No.	Family	sps	Sl. No.	Family	sps	Sl. No.	Family	sps
1	Mopaliidae	1	7	Chilodontidae	1	13	Cypraeidae	1
3	Ostreoidae	2	9	Turbinidae	1	14	Columbellidae	1
4	Plicatulidae	1	10	Neritidae	1	15	Muricidae	1
5	Nacellidae	1	11	Cerithiidae	1	16	Siphonaridae	1
6	Fissurellidae	2	12	Planaxidae	2			

Fig. 3.1: Class wise Diversity of Molluscs collected from Thirumullavaram coast.

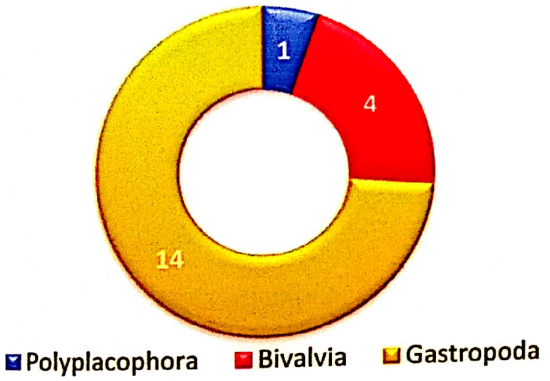
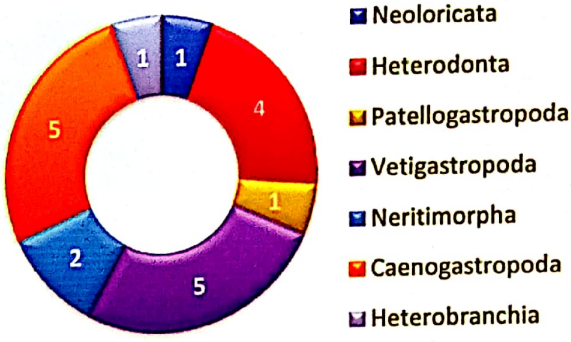


Fig. 3.2: Species composition of Molluscan subclasses collected fromThirumullavaram coast.



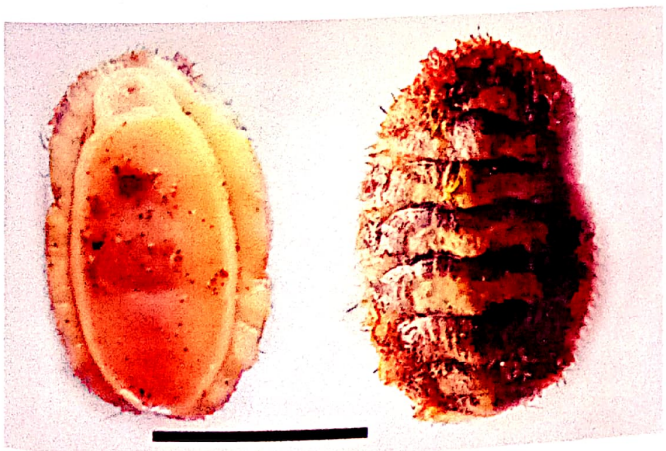


Fig. 3.3: *Plaxiphora tricolor*

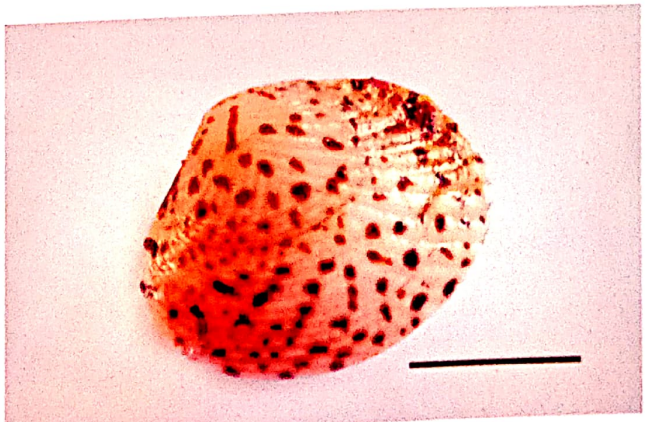


Fig. 3.4: *Gafrarium dispar*

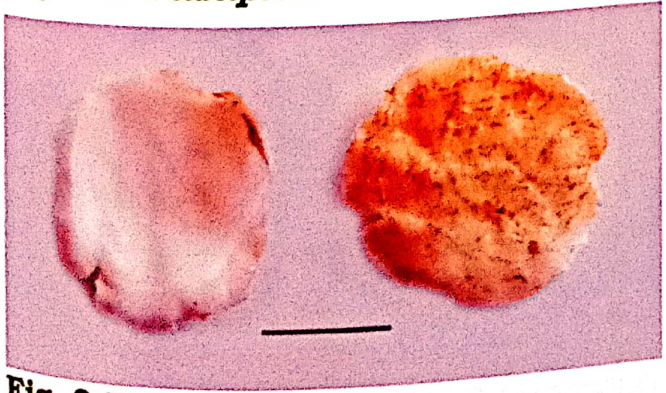


Fig. 3.5: *Ostrea* sp

Fig. 3.6: *Plicatula australis* ——1cm

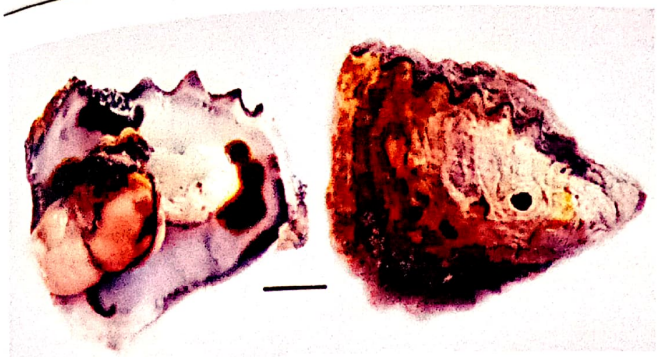


Fig. 3.7: *Saccostrea cucullata*

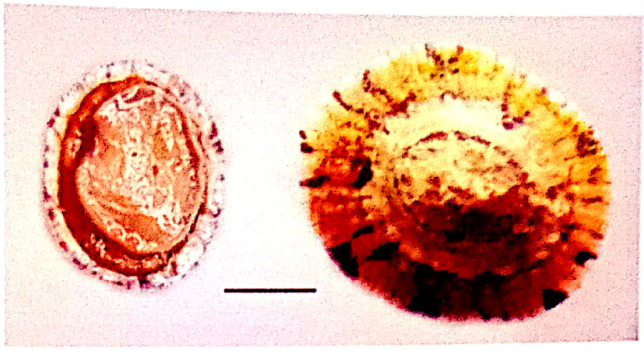


Fig. 3.8: *Cellana radiata*

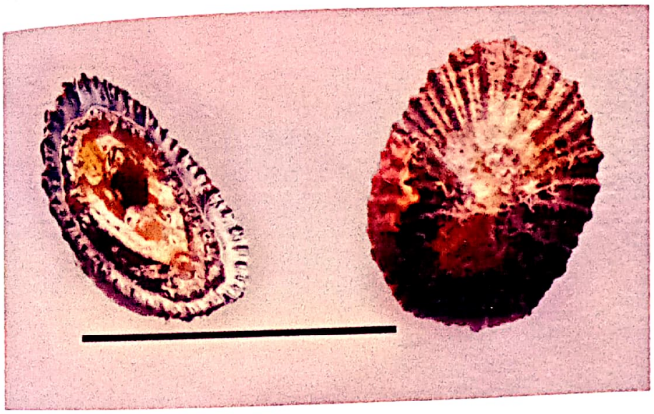


Fig. 3.9: *Clypidina notata*

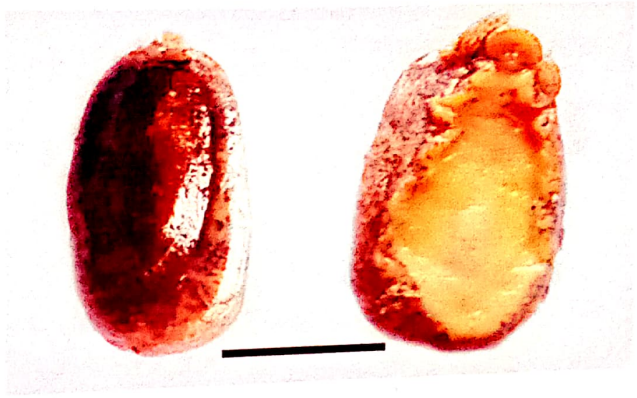


Fig. 3.10: *Scutus unguis*

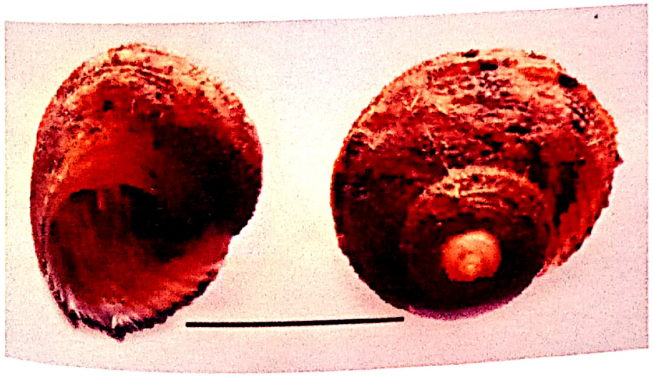


Fig. 3.11: *Euchelus asper*

Fig. 3.12: *Trochus radiatus*

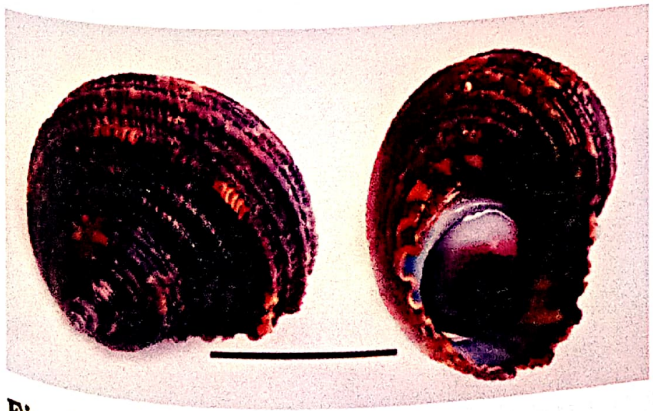


Fig. 3.13: *Turbo intercostalis*

Fig. 3.14: *Nerita albicilla* — 1cm

Discussion

The results of current study give basic information on the taxonomy and diversity of marine molluscs in the intertidal rocky reef areas of Thirumullavaram coast of Kollam. Many taxonomic studies are available from different regions in local, national and international level. Most of them are reviewed in the introduction part. Since the present study represent only a small duration of the year, it cannot be comparable with some of the previous works. Anyway, current results comply with most of them especially the recent listings of Rao (2003), Bijukumar (2012), Ravinesh and Bijukumar (2013) and Franklin and Laladhas (2014) which are mainly concentrated on molluscan diversity of different regions in east and west coasts of India.

According to Tripathy and Mukhopadhyay (2015), approximately 2,300 species of marine molluscs, including gastropods are represented in Indian coastal and marine biodiversity. A compilation of published literature shows that about 707 species of gastropods were recorded from the west coast of India, including 35 species endemic to the region (Tripathy and Mukhopadhyay, 2015).

The taxonomic survey conducted at intertidal rocky reef areas of Thirumullavaram coast recorded the presence of 19 species of Molluscs classified under three classes, seven subclasses and sixteen families. These include one species of chiton, four species of bivalves and fourteen species of gastropods. Gastropoda, the largest group of mollusca have undergone many taxonomic revisions. Ponder and Lindberg (1997) subdivided gastropods into two subclasses: Eogastropoda and Orthogastropoda. The monophyletic group Eogastropoda

included extant Patellogastropoda, comprising of true limpets and their extinct ancestors. The traditional system of classification considered them as specialized group of Archaeogastropoda, and presently they are considered as a sister-group of all other gastropods (Oliverio, 2008).

Caenogastropoda forms the most dominant group of marine gastropods in terms of species numbers, habitat diversity and ecological importance (Colgan *et al.*, 2007). They are represented by about 136 extant and 65 extinct families and thousands of genera coming under 41 superfamilies (Bouchet and Rocroi, 2005). Five species classified under three families represented the class Caenogastropoda in the present study. Another recent study done by Preetha (2016) recorded nine species under the order Caenogastropoda.

Another important finding in the current study was the presence of species under the order Neogastropoda. Neogastropods consists of a highly diverse group of predatory carnivorous gastropods with more than 16,000 living species and is adapted to all marine habitats (Bouchet, 1990). They include cone snails (Conidae), balers (Volutidae), purple dye murex snails (Muricidae), augers (Terebridae), and whelks (Buccinidae) (Ponder *et al.*, 2008). Occurrence of Neogastropods in the rocky reef areas revealing the presence of complex food web in this unique ecosystem of Kerala coast. Bijukumar (2012), Ravinesh and Bijukumar (2013) and Preetha (2016) were also reported the occurrence of many species of Neogastropods from different localities along Kerala coast.

In the marine ecosystem molluscs occupy almost all habitats starting with supralittoral zone to the deepest areas of the ocean trenches. Their varying morphological features, protective calcareous covering and biological adaptations

coupled with strong defensive features permit them to occupy all the marine realms (Ruppert and Barnes, 1994). The group ranges from almost microscopic forms less than one millimetre in adult size, to giant squids of the genus Architeuthis, which can reach over 15 m in size and hundreds of kilos in weight. The majority of molluscs, however, are smaller than one centimetre (Mollusca Base, 2016). Results of present study comply with the above report in that most of species recorded in this study are smaller ones living in intertidal rocky reefs.

The study also recorded the presence of commercially valuable species by virtue of their religious, economic, medicinal, edible and aesthetic values. Medicines prepared from powdered chank shells and cowries are used in the treatment of various ailments (Appukuttan and Philip, 1994). *Mauritia Arabica,* one species of cowry shell belongs to the family Cypraeidae recorded in this study is economically important species by virtue of their aesthetic beauty. Apart from this many species of molluscs obtained in the previous studies (Bijukumar, 2012, Ravinesh and Bijukumar, 2013 and Preetha, 2016) from Kerala coast were also possess great economic interest and demand.

Tripathy and Mukhopadhyay (2015) opined that Kerala can be considered to be a molluscan hotspot. The diverse coastal marine habitats support higher marine biodiversity. The extensive coast line of Kerala stretching along various ecological habitats such as rocky patches, intertidal zones, sandy beaches, sea weed ecosystems, mangroves and estuaries accounts for the molluscan diversity (Preetha, 2016). The results of this study, which documented 19 species from a single locality, further contribute to the biodiversity database of Kerala coast.

Furthermore, this study is supported by the following statements. The steep environmental gradation existing at intertidal rocky reefs create multiple ranges of micro-habitats with feasibility of supporting highly adapted and diverse assemblages of marine flora and fauna (Thompson *et al.*, 2002). The intertidal zone is a highly productive coastal habitat and recent studies done in many parts of the world (Worm and Lotze, 2006) including India (Ravinesh and Bijukumar, 2013) have recorded greater diversity of molluscs along these habitats.

The study revealed that many of the species reported during the period were rare species imparting major roles in coastal and marine ecosystem and food web. It is widely accepted that the factors such as global warming and habitat destruction may lead to stock depletion in wild and loss of biodiversity. Therefore, further studies are essential for the conservation and sustainable utilization of these resources.

Results of taxonomic survey conducted to realize the diversity of molluscs in the intertidal rocky reef areas of Thirumullavaram coast of Kollam, Kerala are summarized below.

- The study revealed presence of 19 species Molluscs classified under three classes, seven subclasses and sixteen families in the rocky reef areas of Thirumullavaram coast of Kollam.

- These include one species of chiton, four species of bivalves and fourteen species of gastropods.

- Class Gastropoda represented the most diverse molluscan class in the area with a species diversity of 14 species followed by Bivalvia (4 species) and Polyplacophora (1 species).

- Caenogastropoda and Vetigastropoda with five species each represented the species-rich molluscan subclasses followed by Heterodonta (4 species), Neritimorpha (2 species), Neoloricata, Patellogastropoda and Heterobranchia (one species each).

- Out of the 16 families reported, three families namely Ostreoidae, Fissurellidae and Planaxidae represented two species each whereas rests of the families were represented by single species.

- *Mauritia Arabica,* one species of cowry shell belongs to the family Cypraeidae recorded in this study is economically important species by virtue of their aesthetic beauty.

- Apart from this many species of valuable molluscs may occur in the area. So further studies are essential for the conservation and sustainable utilization of these resources.

REFERENCES

Appukuttan, K. K., Mathew, J., Thomas, K. T. and Prabhakaran, T. N. 1980. Chank fishing of Kerala with special reference to long line fishery. *Marine Fisheries Information Service, Technical and Extension Series*, 24: 10-14

Appukuttan, K. K. and Philip, B. M. 1994. Gastropods - an emerging resource in the by-catch of shrimp trawlers at Sakthikulangara - Neendakara area. *Seafood Export Journal*, 25 (21): 5-18.

Appukuttan, K. K. and Ramadoss, K. 2000. Edible and ornamental Gastropod resources. In, Marine Fisheries and Research and Management (V. N. Pillai & Menon N.G. eds.), Central Marine Fisheries Research Institute, Kerala. 525 – 535.

Apte, D. A.1998. *The Book of Indian Shells*. Bombay Natural History Society, Mumbai, 115pp.

Aziz, A., Japar, S. B. and Mutahara, Z. 2001. Checklist of shallow water intertidal vertebrates of Pulau Redang. Proc. National Symposium on Marine Park and Terengganu Islands, 12-13, February, 2001, Dept of Fisheries, Malaysia, 12-18.

Babar, A. G., Pande, A. and Kulkarni, B. G. 2012. Bioactive potential of some intertidal molluscs collected from Mumbai coast,West coast of India. *Asian Paicfic Journal of Tropical Biomedicine*, 2(2):1060-1063.

Bhadury, P. and Wright, P. C. 2004. Exploitation of marine algae: Biogenic compounds for potential antifouling applications. Planta, 219: 561-578.

BijuKumar, A. 2012. *Kerala Theerathe Kadal Jeevikal* (Marine Animals of Kerala coast- A Field Guide). Kerala State Biodiversity Board, Thiruvananthapuram, Kerala, 304 pp. (In Malayalam).

Bijukumar, A., Ravinesh, R., Arathi, A. R. and Idreesbabu, K. K. 2015. On the molluscan fauna of Lakshadweep included in various schedules of Wildlife (Protection) Act of India. *Journal of Threatened Taxa* 7(6): 7253–7268.

Bouchet, P. 1990. Turrid genera and mode of development: the use and abuse of protoconch morphology. *Malacologia* 32: 6977.

Bouchet, P and Rocroi, J. P. 2005. Classification and Nomenclature of gastropod families. *Malacologia*. 47(1-2): 1-397.

Bouchet, P. and Strong, E. E. 2010. Historical name bearing types in marine molluscs: An impediment to biodiversity studies? *Systema Naturae*, 250: 63–74.

REFERENCES

olgan, D. J., Ponder, W. F., Beacham, E. and Macaranas, J. M. 2007. Molecular hylogenetics of Caenogastropoda (Gastropoda: Mollusca). *Molecular hylogenetics and Evolution*, 42: 717–737

oncar, D. 1996. Doctor snail—Lethal to fish and sometimes even humans, cone nail venom contains a pharmacopoeia of precision drugs. *New Scientist.*

ruz, L. J. and White, J. 1995. Clinical toxicology of Conus snail stings. In: *Clinical Toxicology of Animal Venoms.*(J. Meier and J. White, eds) CRC Press, Boca Raton 117-128,

Currey, J. D., Kohn, A. J., 1976. Fracture in the cross-lamellar structure of Conus shells. Journal of Materials Science. 11, 1615–1623.

Dayrat, B., Goulding, T. C. and White, T. R. 2014. Diversity of Indo-West Pacific Siphonaria (Mollusca: Gastropoda: Euthyneura). *Zootaxa*, 3779 (2): 246–276

Floren, A. 2003. The Philippine shell industry with special focus on Mactan, Cebu. *Coastal Resource Management Project of the Department of Environment and Natural Resources.* United States Agency for International Development. 50 p.

Franklin, J. B. and Laladhas, K. P. 2014. *Marine Gastropods of Kerala.* Kerala State Biodiversity Board, Thiruvananthapuram, India, 186pp.

Ganong, W. F. 1889. Economic molluscs of Acadia. *Natural History Society of New Brunswick Bulletin*, 8: 1–116.

Higo, S., Callomon, P. and Goto, Y. 2001. *Catalogue and Bibliography of the Marine Shell-bearing Mollusca of Japan. Type Figures.* Elle Scientific Publications, Yao, Osaka, 208 pp

Hornell, J. 1951. Indian molluscs. *Journal of the Bombay Natural History Society* 1-96.

Hughes, R. N. 1986. A Functional Biology of Marine Gastropods. Croom Helm, London, 245 pp

Hyman, L. H. 1967. The invertebrates Mollusca I, Vol. VI,. Mc Graw-Hill, New York. 792pp

Kamboj, V. P. 1999. Bioactive Agents from the Ocean Biota. In: Ocean Science Trends and Future Direction. (Somayajalu, B.L.K. ed.), Indian National Science Academy, New Delhi, India, 197-227 .

Khade, S.N. and Mane, U.H. 2012. Diversity of Bivalve and Gastropod Molluscs from selected localities of Raigad district, Maharashtra, West coast of India. *World Journal of Science and Technology*, 2 (6): 35-41.

Kilburn, R. N. and Aiken, D. W. 1972. Notes on two endemic South African Cypraea. *Veliger* 15: 125–126.

Kinch, J. 2003. Marine mollusc use among the women of Brooker Island, Louisiade Archipelago, Papua New Guinea. *SPC Women in Fisheries Information Bulletin*, 5-14pp

Kurup, B. M., Premlal, P., Thomas, J.V. and Anand, V. 2003. Bottom trawl discards along Kerala coast: A case study. *J. Mar. Biol. Ass. India*, 45: 99-107.

Leiva, E. G and Castilla, J. C. 2002. A review of the world marine gastropod fishery: evolution of catches, management and the Chilean experience. *Rev. Fish boil. Fislr*, 11: 283-300.

Mallick, A. 2013. Ayurvedic drugs from Marine originates. *International journal of Pharmaceutical research and Development*, 5 (01): 011-020.

Melvill, J. C. and Standen, R. 1901. The mollusca of the Persian Gulf, Gulf of Oman and Arabian sea as evidenced mainly through F. W. Townsend, 1893 - 1900, with 453

Menon, N.G., 1996. Impact of bottom trawling on exploited resources. In, *Marine Biodiversity, Conservation and Management* (N.G. Menon and C.S.S. Pillai, eds.), Central Marine Fisheries Research Institute, Cochin,97-102.

Oliverio, M. 2008. Coralliophilinae (Neogastropoda: Muricidae) from the southwest Pacific. *Mémoires du Muséum National d'Histoire Naturelle*, 196: 481-585.

Patterson, J. K. and Ayyakannu, K. 1997. Pickled product from a gastropod *Babylonia spirata*. *Fishery Technology* 34 (1): 45 - 48.

Philip, B. M. and Appukuttan, K. K. 1995. A checklist of gastropods landed at Sakthikulangara - Neendakara area. *Mar. Fish.Infor.Serv.T&E.Ser.*,38:9-10.

Ponder, W. F. and Lindberg D. R. 1997.Towards a phylogeny of gastropod molluscs: an analysis using morphological characters". *Zoological Journal of the Linnean Society*, 119(2): 83-265.

Ponder, W. F., Colgan, D. J., Healy, J. M., Nützel, A., Simone, L.R.L. and Strong, E.E., 2008. Caenogastropoda. In, *Evolution and Phylogeny of the Mollusca*, (W.F.

Ponder, and , D.R. Hindberg, eds.), University of California Press, Los Angeles, 331-383.

Preetha Karnaver 2016. Taxonomy and Diversity of Gastropods (Mollusca: Gastropoda) of Kerala Coast. PhD Thesis. University of Kerala. 492pp.

Rao, S.N.V. 1998. Mollusca. In, *Faunal Diversity in India,*. Zoological Survey of India, Envis Centre, Calcutta, 103-117.

Rao, S. N. V. 2003. Indian Sea shells (Part-I): Polyplacopora and Gastropoda. *Occ Paper. Rec Zool Surv India*, 19 : 2-416.

Ravinesh, R. and Bijukumar, A. 2013.Comparison of intertidal biodiversity associated with natural rocky shore and sea wall: A case study from the Kerala coast, India. *Indian journal of geo-marine sciences*, 42(2): 223-235.

Ruppert, E. E., and Barnes, R. D. 1994. Invertebrate Zoology. Saunders College Publishing, Harcourt Brace and Company, Orlando, Florida. 1100 pp

Samuel, D.V., Chacko, D. and Patterson, J. K. E. 2005. Preliminary study on the molluscan diversityof —the lost worldl- Dhanushkodi, East coast of India. *SDMRI Res. Publi.*,.9: 54-58.

Sary, P.S., Kiran, P.R.B. and Kumar, B.A. 2013. Diversity of Gastropod Shells (Mollusca: Gastropoda) of Vizhinjam Bay, Southwest Coast of India. Proc. Multidisciplinary national Seminar, November 4-6, 2013, P. M. Sayeed Calicut University Centre, Androth, 39-41pp.

Sary, P.S., Kiran, P. R. B., Balasubramanian, N.K. and Kumar, B. A. 2014. Diversity of Cone Snails (Mollusca: Conidae) along Kerala Coast. *Journal of Aquatic Biology and Fisheries*, 2:619 – 622.

Satyamurthi, T. 1952. The Mollusca of Krusadai Island. 1- Amphineura and Gastropoda. *Bull. Madras Govt. Mus. New. Ser.*, 1(2): 267

Smith, E. A. 1904. Natural history notes from H.M. Indian Marine Survey Steamer "Investigator" On Mollusca from the Bay of Bengal and Arabian Sea. *Annals and Magazine of Natural History of London*, 14: 1-14.

Sturm, C. F., Pearce, T. A., Valdes, A. 2006. The Mollusks: A Guide to Their Study, Collection, and Preservation. Universal Publishers, Boca Raton, FL, USA, 460 pp.

Susan,V.D., Pillai, N.G.K. and Satheeshkumar, P. 2012. A checklist and spatial distribution of molluscan fauna in Minicoy Island, Lakshadweep, India. *World Journal of Fish and Marine Sciences* 4 (5): 449-453.

Tan, K. S. and Chou, L. M. 2000. *A Guide to Common Seashells of Singapore.* Singapore Science Center, Singapore. 168 pp.

Terlizzi, A., Scuderi, D. Fraschetti, S. and Anderson, M. J. 2005. Quantifying effects of pollution on biodiversity: a case study of highly diverse molluscan assemblages in the Mediterranean. *Mar. Biol.*, 148: 293-305.

Thach, N,N. 2007. Recently collected shells of Vietnam. Ancona, Italy: L'Informatore Piceno. 384

Thomas, S., Babu, A.P.D. and Geetha, S. 2014. Gastropod resource distribution and seasonal variation in trawling grounds off Konkan Malabar region, eastern Arabian sea. *Indian Journal of GeoMarine sciences*, 43 (3): 384-392.

Thompson, R. C., Crowe, T. P. and Hawkins, S. J. 2002. Rocky intertidal communities: past environmental changes, present status and predictions for the next 25 years. *Environmental Conservation*, 29(2):168-191.

Tripathy, B. and Mukhopadhyay, A. K. 2015. Marine Molluscan Diversity in India. In: Venkataraman, K. & C. Sivaperuman (eds.). Marine Faunal Diversity in India: Taxonomy, Ecology and Conservation. Academic Press, London.pp. 39–74.

Venkataraman, K. and Wafar, M. 2005. Coastal and marine biodiversity of India. Ind.J.Mar.Sci., 34 (1) : 57-75.

Wilson, B. R. 1994. *Australian Marine Shells. Prosobranch Gastropods*, Part Two (Neogastropods). Odyssey Publishing, Kallaroo, Western Australia. 370 pp, 53 pls

Winckworth, R. 1936. Marine Mollusca from South India and Ceylon. *Proc. Molac. Soc. London.*, 22: 16-23.

Worm, B. and Lotze, H. K. 2006. Effects of eutrophication, grazing, and algal blooms on rocky shores. *Limnology and Oceanography*, 51: 569–579.

Websites used

Biosearch. Accessed at http://biosearch.in

Mollusca Base. Accessed at http://www.molluscabase.org

World Register of Marine Species (WoRMS). Accessed at http://www.marinespecies.org/