GASTROPOD DIVERSITY ALONG THE INTER-TIDAL COAST OF KOLLAM, KERALA

DISSERTATION
Submitted to the University of Kerala
in the partial fulfilment of the requirement for the
BACHELOR OF SCIENCE
IN
ZOOLOGY

Department of Zoology
TKM COLLEGE OF ARTS AND SCIENCE, KOLLAM

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2017- 2020

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CERTIFICATE

This is to certify that the project entitled ***"Gastropod diversity along the inter-tidal coast of Kollam, Kerala"*** is an authentic record of the group work carried out by **Adithyasankar S (25017142001), Fathima Navas (25017142004), Nithin Raj (25017142010), Salima S (25017142012), Akshay Krishnan GS (25017142015), Anila MA (25017142019), Erfana Fathima N (25017142023), P Aparna (25017142029) and Saranya S (25017142036)** Department of Zoology, TKM College of Arts and Science, Karicode, Kollam, as a part of University of Kerala in partial fulfilment of the Degree of Bachelor of Science in Zoology under my supervision and guidance and it has not been submitted anywhere else for any other degree, diploma, or title.

Dr. JASIN RAHMAN
Head of Department

Dr. Mumthas Y
(Supervising Teacher)

DECLARATION

I, Jyothi Peter., hereby declare that this project entitled ***"Gastropod diversity along the inter-tidal coast of Kollam, Kerala"*** is an authentic record of original project work carried out by us under the guidance of Dr. Mumthas Y, Department of Zoology, TKM College of Arts and Science, Karicode, Kollam and submitted to the University of Kerala in partial fulfilment of the requirements of the Degree of Bachelor of Science in Zoology.

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INTRODUCTION

Marine and Coastal environments are among the most ecologically and socio-economically important habitats. Marine and coastal habitats have huge socio-economical value through food production, nutrient cycling, recreation and gas regulation (Harley et al., 2006). Coastal ecosystems are subjected to a variety of stressors which may interact to produce combined impacts on biodiversity and ecosystem functioning. Fluctuations in the conditions, nature and characteristics of aquatic systems affect benthic community composition, function, diversity and production. A report issued by the UN Environmental Program (2010) identified many pressures on marine biodiversity and the outlook for particular habitats, along with some steps being taken to ameliorate the causes.

Benthic fauna act as connecting link between the biotopes of substratum and water column in the aquatic ecosystems and their distribution highly depends on physical nature of the substratum, nutritive content, degree of stability and oxygen content. The low hydro dynamism (Danulate et al., 2002) and generally poor oxygenation of water column (Garcia and Gomez. 2005) lead to a limited diversification of benthic communities (Estacio et al., 1997). Tolerant or opportunistic species tend to dominate stressed assemblages and less tolerant species tend to became increasingly rare or disappear. Therefore both these species can serve as stress indicators (Belan., 2003). A significant disturbance will however introduce changes in the species composition their abundance and biomass. Such succession changes in the benthic community structure are often predictable and with increased pertuberation, the diversity, abundance and biomass will show a general decline (Pearson and Rosenberg., 1978). The spatio-temporal variation of benthic invertebrates will have impacts on other trophic levels which in turn will determine the fate of energy and nutrient flow in the coastal waters.

Most marine organisms that live benthically as adults have a life cycle that involves a larval stage that is pelagic. The adaptiveness of the life cycle is

debated (Strathmann 1985, 2007). So the conditions of the pelagic realm affect the benthic biota since they spend a part of their life cycle away from the sea floor. Hence physical and chemical environment has shaped and affected the benthic organisms. Many pelagic larval forms contribute much to plankton communities which in turn is consumed by pelagic fishes. Macrobenthos in marine sediments plays a vital role in ecosystem processes. They perform sediment reworking by feeding, burrowing and construction activities. Benthos comprises the critical link in the marine food web by acting as food for many fishes, birds and other marine invertebrates. Thus estimation of benthic production is useful to assess the fishery production of that area. Benthic fauna are key indicators of aquatic environmental pollution and stress and are used in many monitoring programs to assess the overall health of oceans and estuaries.

The coastal waters of the maritime states are under constant threat of pollution from a number of sources. The relatively long shoreline of India (6000km) is no exception either. More so in the case of Kerala. Kerala is now a developing state and on her way towards being an industrialized one by the year 2020. Most of her industries and urban areas are located on the coastal regions. In addition, the offshore area of the coast is a busy shipping lane. These two phenomena make the intertidal and offshore areas of the coast of Kerala interesting for scientific studies.

Consequent upon the rapid growth of human population near the coast, the use of marine environment for different purposes like exploration and exploitation of living and non-living resources, marine transport, dumping of domestic, industrial and agricultural waste and developmental activities for the settlement recreation and aesthetic purposes have greatly multiplied. Such intensified use of marine biosphere with footprints of man almost everywhere, has brought considerable changes leading to the loss of biodiversity and damage to coastal ecosystem. Therefore protection of marine biosphere from the menace of

pollution at local, regional and global scales have been strongly urged upon to ensure the sustainability of marine resource.

Studies on the marine life of the coastal waters and estuaries of Kerala have resulted in considerable knowledge of the fishes and plankton (Easa and Shaji., 2003). However, information about the marine benthic invertebrates of Kerala is limited even though they are critical components of an aquatic system. It is important to establish a baseline for tropical regions and improve our understanding of biodiversity in marine environment. The present study aims at addressing the above problems by filling up the existing lacunae on the diversity of benthic fauna with special reference to gastropods along the inter-tidal coast of Neendakara, Kollam.

Gastropods are among the few groups of animals to have become successful in all three major habitats: the ocean, fresh waters, and land. A few gastropod types (such as conch, abalone, limpets, and whelks) are used as food, and several different species may be used in the preparation of escargot. Very few gastropod species transmit animal diseases; however, the flukes that cause human schistosomiasis use gastropods as intermediate hosts. The shells of some species are used as ornaments or in making jewellery. Some gastropods are scavengers, feeding on dead plant or animal matter; others are predators; some are herbivores, feeding on algae or plant material; and a few species are external or internal parasites of other invertebrates.

From earliest times, humans have used many snail species as food. Periwinkles (*Littorina*) in Europe and South Africa, queen conchs (*Strombus gigas*) in the West Indies, abalones (*Haliotis*) in California and Japan, and turban shells (*Turbo*) in the Pacific are the most frequently eaten marine snails. Occasionally limpets and whelks are used for food, but they are more commonly used as fish bait. Freshwater snails rarely are eaten. Land snails of the family Helicidae have been eaten in the Middle East and Europe since prehistoric times. Today many

tons of the European edible snails *Helix aspersa* and *H. pomatia* (the most common species used to prepare escargot) are raised on snail farms or collected wild. Several species of Otalaand Eobania from Morocco and Algeria are exported for food.

In some places, introductions of *Achatina* and *Helix* have resulted in damage to crops and gardens by these rapidly multiplying snails. On the other hand, habitat degradation, the introduction of predatory rats and land snails, and shell collecting by humans have caused the extinction of about 50 per cent of all *Achatinella* species in Hawaii. Eighteen of the remaining 19 native species have been pushed to the brink of extinction.

Shells of certain snails are highly prized by collectors. The operculum of some *Turbo* species is used in making earrings; cameos are cut from the shell of the Red Sea snail *Cassis rufa*. Abalone shells are used in many cultures for decorative purposes; the shell of the golden cowrie (*Cypraea aurantium*) served at one time as a badge of a chief in Fiji. Strings of shells have been used as money.

Serious medical problems are caused by the few freshwater snails (*Pomatiopsis, Bulinus, Biomphalaria*) that serve as intermediate hosts for flatworms that parasitize humans. Schistosomiasis is a disease caused by minute blood flukes (*schistosomes*). Both snails and flukes are most common in areas where fields are irrigated. *Schistosomes* also parasitize birds and mammals. A skin rash called swimmer's itch results from bird schistosomes trying, only partly successfully, to penetrate human skin. They die in the upper skin layers, and their decomposition causes local infection. Other health problems are caused by several snails and slugs (e.g., *Bradybaena, Angustipes, and Veronicella*) that serve as intermediate hosts for the rat lungworm. If an infected land snail or slug is inadvertently chopped up in a salad and eaten, the worm can migrate to the brain and encyst, causing moderate to severe damage.

Most gastropods, however, are useful to humans in that they help decompose dead plants and animals into substances that can be used by plants to manufacture new organic compounds.

Kollam is a coastal hamlet the economy of which mainly resides in the fishery sector- the source of livelihood for the fishing communities. The coast is unexplored as far as benthos is concerned. The present study explores the gastropod assemblages along the inter-tidal region of the coast. As benthos is key indicators of pollution and stress, the study will pave the way for Environmental Risk Assessment and monitoring of coastal waters of Kollam.

OBJECTIVES

- To provide information on the gastropod diversity along the intertidal coast of Kollam
- Analyzing the commercial value/ importance of these gastropods in trade.
- Create awareness for Environmental Risk Assessment and monitoring of the coastal waters of Kollam, Kerala.

REVIEW OF LITERATURE

K.P. Philip (1970) carried out studies of the intertidal fauna of the sandy beaches of Cochin and presented the results of his preliminary observations. Environmental factors such as wave action, grain size, temperature and salinity were studied. He found that salinity varies considerably owing to the heavy rainfall during the southwest monsoon. Major components of the fauna, constituted by the bivalves *Donax spiculum* and *Donax incarnates* and the sand crab *Emerita asiatica* occupy mid-tide and low-tide levels. The pattern of distribution and the seasonal abundance of different intertidal species were studied.

Qualitative and quantitative study of the benthic fauna, sediment characteristics and organic matter content were studied along southwest and southeast coast of India by Sarala Devi *et al.* 1999. It was found that number of species varied with stations and also with depths. Population density was very low in the southeast coast as compared to the southwest coast. Polychaetes formed the dominant group. Molluscs were more common along the southeast coast. Five types of substratum were noticed from different stations along southwest coast and also organic matter was high in silty clay substratum (3.15%) whereas in sandy substratum this varied between 0.07 and 1.38 percent. Rich benthic fauna in the nearshore region having riverine influence is mainly due to the influx of nutrient rich river water (Parulekr and Dwivedi, 1974).

A study was carried out by Wilber *et al.* (1998) on the effects of dredged material disposal on benthic macroinvertebrates in Galveston Bay, Texas, USA. There was no evidence that dredged material disposal had a detrimental impact on the benthic production. In fact, disposal sites yielded both the highest production estimates and species richness in both the upper and lower bay area two years after disposal. It was found that variation in animal benthic production estimates was 2 or 3 times greater than the variation in consumption estimates.Macro

benthic organisms are not consumed in direct proportion to their abundance or biomass in benthic habitats (Virnstein, 1977).

An attempt has been made to infer the impact of extreme flooding events and anthropogenic stresses on macrobenthic communities Cardoso *et al.* 2007. Interaction between extreme weather events and anthropogenic stressors on the dynamics of the macrobenthic assemblages and the socio-economic implications that follow were explored. The intensification of extreme flooding events had significant effects on the structure and functioning of macrobenthic communities, specifically a decline in total biomass, a decline in species richness and a decline in suspension feeders were observed.

Episodic events such as extreme rain events and flooding can result in the catastrophic deposition of fine segments with profound influences on the structure and function of macrobenthic communities (Norkko *et al*., 2002). Vijayakumar*et al*. (1991) studied the quantitative distribution of macro and meiofauna from Kakinada bay and backwaters. Polychaetes and crustaceans constituted the bulk of macro fauna in the backwaters while Polychaetes and molluscs were found in the nearshore bottom deposits. Nematodes, polychaetes, foramniferanes and turbellarians were the major groups constituting the bulk of meiofauna both in the backwaters and nearshore regions. Macro faunal diversity was higher in the nearshore regions. Impoverishment of fauna in the backwaters was related to lowering in salinity and poor oxygenation. The salinity act as a limiting factor in the distribution of living organism and its variations caused by distribution and evaporation influences the fauna most likely in the intertidal zone (Gypson 1982)

Biodiversity and seasonal variation of macrobenthic infaunal community in the inshore waters of the Parangipettai coast was studied by Saurav Kundu, *et al*.2009. They revealed the occurrence of 132 species representing 5 diverse

groups. Polychaetes were the dominant group (45%), followed by bivalves (31%) and gastropods (16%).

Mehrniz *et al.* (2012)under took a study to survey the impacts of bottom trawling on distribution and diversity of gastropods of the Bahrakan Fishing Area (BFA) of the northwestern coast of the Persian gulf. Biomass and gastropods declined after trawling and no recovery occurred after 3 months. Impacts of trawling were higher in shallow areas than that in deeper areas. The study suggested that gastropod population were removed by passing of trawl and was similar to the result reported by Morton (1996).

Feldstein *et al.* (2003) suggested that due to the economic and ecological importance as well as sedentary life, molluscs have been assumed as an important organism in monitoring contaminants in different ecosystems. Bivalves and gastropod molluscs are among the most useful organism for environmental monitoring (Boening 1999). Fresh water molluscs especially gastropods are important from the medical and veterinary public health point of view. About 100 species of freshwater gastropods are reported acting as intermediate host in the diagnostic trematode parasites and among prosobranchs members of the family Pilidae and Thiridae were recorded as harbourers of larval trematodes (Subba Rao, 1993)

Udhayanadha and Munsinghe (2009) proposed that none of the physiochemical parameters are responsible for the distribution of molluscs, faunal species. However it indicates that the contents of the substrate make a favorable contribution on the distribution pattern with a high abundance of faunal species recorded from the substrate with fine sand, silt and clay.

Shivadas, *et al.*2011 studied the ecological aspect and the potential threats to an intertidal gastropod, *Umbonium vestairium.* The study suggested that based on the size frequency, it may be consider that *U. vestairium* like other tropical fauna

recruit during monsoon.11 different colour patterns of *U. vestairium* were observed. The fastidious nature and the sporadic distribution of *U. vestiarium* make them vulnerable to natural and anthropogenic disturbances. Changes in the timing or intensity of monsoon may directly affect the reproduction and associated dispersal of benthic community (Pezrlawski, 2008).

Wei *et al.,* (2016) conducted a study related to macrobenthos in the central Arabian Gulf, characterized by extreme climatic variations in the region. It was found that variability in climates revealed low abundance, biomass and high turnover of species, resulting in insufficient primary production due to global warming.

Seth *et al.,* (2016) assessed the comparison between water masses, macronutrients and phytoplankton in the northern Bering and Chukchi Seas. Their observations revealed that biological ramifications restructured the shelf flows and varying nutrient fluxes; potentially predominant for primary production, secondary production, heat and pelagic production.

Kenneth *et al.,* (2017) analyzed the macrobenthic groups in Deep Bay, northwest Hong Kong and found drastic transformations at three polluted sites namely Victoria harbor, Tolo harbor and Deep Bay. The results also revealed a connection between the macrobenthos and its polluted zone with a reduction in nutrients in the eastern area of Victoria Harbour, which was the main reason for non-recuperation of benthic groups.

Salim etal., (2017) carried out a case study based on gastropod landing, utilization, and trade in Kollam, India. Their study revealed that molluscan production in India was comparatively insignificant in earlier times, it increased due to the demand for edible as well as ornamental gastropods from around the globe coupled with their importance in generating additional income as a bycatch. The Shakthikulangara and Neendakara landing centres of the Kollam district of Kerala ranks among the major gastropod landing centres along the

west coast of India. Based on the cost and earnings analysed from the primary data collected from Shakthikulangara and Neendakara area, various productivity ratios are analysed which indicates that the fishing for gastropods registered a shift in operations from harvesting as a by-catch resource to targeted fishing. The study reveals the scope of gastropod fishery in Kerala as well as the lack of shellcraft industry in the state. Also, the reduced availability of gastropods due to the extensive exploitation is investigated.

A H Klein etal (2019) carried out a study on Multi-omics investigations within the Phylum Mollusca, Class Gastropoda: from ecological application to breakthrough phylogenomic studies, summarizing the current design of useful data integrating tools and strategies for comparative omics studies in the future. Additionally, they discuss the future of omics applications in aquaculture, natural pharmaceutical biodiscovery and pest management, as well as to monitor the impact of environmental stressors.

A review and a meta-analysis on what can aquatic gastropods tell us about phenotypic plasticity was carried out by Bourdeau PE et al (2019). They discussed the role of costs and limits of phenotypic plasticity and environmental heterogeneity as important constraints on the evolution of plasticity. They also consider potential publication biases and discuss areas for future research, indicating well-studied areas and important knowledge gaps.

MATERIALS AND METHODS

Study Sites

Fig 1 Google earth map of Kerala showing study sites

Site I : The South Indian state of Kerala is rightly called as “God’s Own Capital” because of its immense beauty nestled in almost all the districts of Kerala. Neendakara is a village in Kollam district 9km North of Kollam city in Kerala, India. It is Kollam district’s intermediate fishing port. In Malayalam Neendakara means ‘a long bank’. Geographically Neendakara is commonly called as ‘Kochu America’.

Fig 2 Site I : Neendakara

Neendakara is one of the prime port locations in Kerala. It is a strategic small port located in the East West international sea route. Also Neendakara is famous for its Fishing Harbour and related Marine Export oriented businesses.

Fig 3 Site II : Vaddy beach

Site II: Vaddy beach is a famous fish auction centre near Kollam Port (2.8-kilometre-long) road, connects historic Port of Quilon (Kollam Port) and with acess to Kochupilamoodu in the city through Kollam Beach.

Fig 4 Site III : Thirumullavaram

Site III: Thirumullavaram is a part of Kollam. It is situated 6 km north of the city of Kollam. The beach is very famous for conducting the Karkidaka Vavubali rituals. Thousands of devotees arrive on the beach to perform the Vavubali

Tharpanam every year. It is one of the most attractive beaches located in South India. Thirumullavaram beach is one of the 16 best-kept beaches in India, topper from the state of Kerala of India (CMRFRI,2018).

Duration of the study

Sampling was carried out during the months of November and December, 2019.

Survey and Collection

The study site was covered completely on foot and all the gastropod shells were handpicked from the inter-tidal region. This protocol was repeated twice a month both in the morning and evening (Plate- I).

Laboratory Analysis

a) Sorting:

The handpicked samples from the site were brought to the laboratory in polythene bags, transferred to a large, white-bottomed tray, and the animals were hand sorted. After this preliminary examination, the whole sample was treated with 5% buffered formalin and kept for further analysis.

Large samples are then subdivided into sub-samples (live and worn out ones) of roughly equal size that could be sorted more comfortably. The sub samples were placed in different jars with preserving solution and were labelled properly. Fine sorting was performed under a dissection microscope.

b) Analysis of fauna:

Digital images were taken for each of the samples. The preserved fauna was identified to major taxonomic groups using appropriate keys (Fauvel, 1996, Olomukoro 1996; FOA 1998; Shanks 2001; Rao 2000; Modayil 2007; Venkataraman and Sivaperuman, 2014) and standard taxonomic references along with available expertise) (Plate- I).

RESULTS

A total of 52 species (51 identified + 1 unidentified) of Gastropods were obtained from the study sites (Table 1 and Plates II-VIII). Numerical abundance was recorded maximum at site I (80%) followed by site II (12%) and site III(8%).

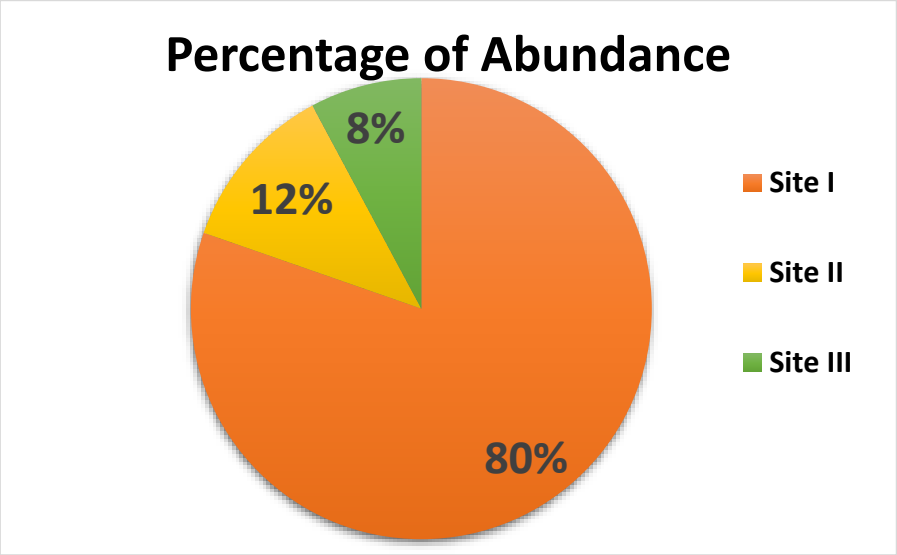

Fig 5 : Percentage of Numerical abundance along study sites

Among Gastropods, *Cerithium* species belonging family certhiidae is one of the common rocky intertidal gastropod was numerically abundant at site I whereas the least abundant species were *Bursa* sp, *Fusinus colus*, *Harpa major*, *Murex trapa*, *Nassarius cremates*, *Oliva* sp, *Pleuroploca filamentosa* and *Terebra crenulata*.

At site II, the dominant species were cerithidia sp and the least abundant species were *Babylonia spirata, Bufonaria sp, Cellana rota, Donax sp, Pirenella sp* and *Polinices mammilla.*

At site III, the numerically abundant species were *Tibia curta sowerby* whereas *Babylonia spirata, Bursa sp, Bufonaria sp, Chicoreus sp and murex sp.*

The systematic positon and their habitat, ecology and distribution are recorded in the following.

1. *Babylonia areolata (Link, 1807)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Buccinidae
Genus: Babylonia

Diagnostic characters: Shell rather thin but solid, elongate- ovate in shape, with a high spire. Whorls convex, distinctly shouldered below the sutures. Outer surface smooth and polished, under the prominent, velvety periostracum. Aperture large and ovate, somewhat pointed at posterior end, with a broadly open and short siphonal canal anteriorly. Outer lip rather thin, inner lip more or less thickened and calloused. Umbilicus deeply perforated, surrounded by a well-marked siphonal ridge. Operculum large and thick, with its nucleus near the anterior end.

Colour: Outside of shell white, with 3 spiral rows of large, squarish brown spots on body whorl, one row of such spots on spire whorls. Periostracum brownish. Inner side of the aperture purplish white, with the outer colour pattern showing through.

Size: Maximum shell length 6.5cm, commonly to 5cm.

Habitat, biology, and fisheries: On sand and mud bottoms. Sub littoral, mainly between depths of 10 and 20m. An economically important species in Thailand.

Distribution: Eastern part of the Indian Ocean, from the Andaman Sea to Indonesia; north to Taiwan province of China and south to southern Indonesia.

2. Babylonia zeylanica

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Superfamily: Muricoidea
Family : Babyloniidae
Genus : Babylonia
Species : B. zeylanica

Description:- Shell large upto 70mm in height, fusiform, less solid and with less inflated whorls, body whorl narrower than in Babylonia spirata, sutures not canaliculated, spire high ending in dark purple apex. Aperture dark, outer lip sharp and smooth, but not flexed at top, columella smooth with heavy broad callus posteriorly but narrow anteriorly, a strong parietal ridge almost close to the outer lip, umbilicus broadly open with a row of teeth on the outer margin, fasciole with aridge on the inner edge, anterior canal broad and deep, posterior canal not distinctsurface smooth, colour white with large brown blotches.

Threats:- Not reported

Remark:- The species is caught as a bycatch in shrimp trawlers at shakthikulangara and neendakara area. The meat and operculum of the species is commercially important. The species has been reported from coast of Kerala by Kurian (1953); Babu Philip and Appukuttan (1995); Rao (2003); Bijukumar (2012); and Franklin and Laladhas (2014).

Habitat:- Sandy, coastal

3. Babylonia feicheni (*Shikama, 1973)*

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Superfamily: Muricoidea
Family : Babyloniidae
Genus : Babylonia
Species : B. feicheni

Babylonia feicheni is a species of sea snail, a marine gastropod mollusk, in the family Babyloniidae

4. Babylonia spirata

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Family : Babyloniidae
Genus : Babylonia

Description:-Shell large upto 70mm in height, smooth and heavy, body whorl inflated, spire high and elongate, sutures deep and channelled. Shoulders prominent; whorls inflated; columella smooth and heavily calloused; umbilicus broad, deep, and heavily calloused, fasciole wide, anterior canal in the form of oblique notch at the base of aperture, posterior canal well developed, aperture large, ovate, outer lip sharp and strongly flexed at the top, interior of aperture smooth and thickened; Colour white with prominent light brown blotches, oblique streaks and spots; aperture ,outer lip and columellar callus white, fasciole orange brown, tip of apex and aperture tinged blackish; fresh shells covered by light brown periostracum

Threats:-Not reported

Remark:-The species has been reported from Kerala coast by Bijukumar (2012) and Franklin and Laladhas (2014). This species is commercially exploited in large quantities for meat export from sakthikulangara and Neendakara harbours of Kollam district Kerala. Operculum of the species is also commercially important.

Habitat:-Sandy

5. *Bursa bufonia (Gmelin, 1791)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Subclass: Caenogastropoda
Order: Littorinimorpha
Superfamily: Tonnidae
Family: Bursidae
Genus: Bursa

Bursa bufonia, common name the warty frog shell, is a species of sea snail, a marine gastropod mollusk in the family *Bursidae*, and the frog shells. The length of the shell varies between 23 mm and 101 mm. This species occurs in the Red Sea and in the Indian Ocean off Madagascar, Aldabra, Chagos and the Mascarene Bassin; and in the Western Pacific.

6. *Cellana rota*

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Superfamily: Lottioidea
Family : Nacellidae
Genus : Cellana
Species: C. rota

Description: Shell rather thin, of regular ovate outline, very low conical with apex slightly anterior to mid-length. External sculpture of numerous, fine, flat, somewhat granulose radial riblets.

color : Externally pale brown or yellowish with 8-10 sectors of dark brown mixed with blotches of the background color; inside translucent with external color showing through, except on the callus which is variously tinged with white and brown or pale orange.

Common size : 25-35 mm long; up to 37 mm in the Indo-Pacific.

Distinguishing characteristics: This species resembles some regularly ovate forms of the native Patella caerulea Linnaeus, 1758, but has the inside layer more translucent and never distinctly bluish. The pale blotches interrupting the dark sectors are not seen on all individuals, but when expressed they are diagnostic of Cellana with respect to all native Mediterranean patellids. Knobs on the radial sculpture do not occur on native Patella, with the exception of P. rustica Linnaeus, 1758 which is much taller, sturdier and cannot be confused.

Habitat : on rocks near sea level.

Distribution : Worldwide: Red Sea and Indian Ocean: Southern Arabia, Arabian Gulf, India; limits of distribution difficult to assess due to confusion with other species or subspecies of the Cellana radiata complex (Christiaens, 1986). Suez Canal (Tillier and Bavay, 1905, as Cellana radiata); common in Great Bitter Lake (Moazzo, 1939). Mediterranean: recorded first in 1961 from Akko, Israel (Christiaens, 1967); successively from Egypt (Giannuzzi-Savelli et al., 1994); Greece, Saronikos Gulf (Fountoulakis and Sabelli, 1999).

Establishment success: Remained rare during a long time but Fishelson (2000) has reported that it was common by 1999 dominating some rocky intertidal outcrops along Israeli shores. Near Ashdod Cellana has replaced completely Patella caerulea in the upper littoral (Mienis, 2002a). speculated reasons for success :

7. *Cellana rota*

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Superfamily: Lottioidea
Family : Nacellidae
Genus : Cellana
Species : C. rota

Cellana rota is a species of true limpet, a marine gastropod mollusc in the family Nacellidae, one of the families of true limpets

Diagnostic characters: Shell semi-translucent, rather thin, moderately elevated, with a variable shape. Outline rounded to elongate-ovate, sometimes broadly undulated. Apex subcentral or slightly anterior. External sculpture of numerous and generally unequal radial riblets, often underlain by distinct, broad radial folds. Interior smooth. Colour: shell coloration highly variable. Exterior basically cream or yellowish, with radial patterns of brown. Margin of the aperture often with alternating white and brown blotches. Interior with a silvery glaze, mainly whitish with a brown to orange apical region, sometimes centrally suffused with white.

Size: Maximum shell length 5 cm, commonly to 3.5 cm.

Habitat, biology, and fisheries: Common on rocky shores exposed to wave action, from mid-intertidal zone to shallow subtidal levels. Collected for food by villagers from the Southeast Asian area to eastern Polynesia.

Distribution: Widespread in the Indo-West Pacific, from Madagascar to eastern Polynesia; north to southern Japan and south to Queensland and New Caledonia.

7. *Clypidina notata*

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Superfamily: Fissurelloidea
Family : Fissurellidae
Genus : Clypidina
Species : C. notata

Clypidina notata, common name the black-ribbed false limpet, is a species of sea snail, a marine gastropod mollusk in the family Fissurellidae, the keyhole limpets

8.*Charonia tritonis tritonis (Linnaeus, 1758)*

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Subclass : Caenogastropoda
Order : Littorinimorpha
Superfamily: Tonnidae
Family : Ranellidae
Subfamily : Charonidae
Genus : Charonia

Diagnostic Features: Shell reaching a very large size (upto 45 cm in length), elongate with a tall spire, strongly inflated body whorl and short anterior siphonal canal. Whorls rounded, with slightly undulating suture and wide, smooth and rounded axial varices spaced about every 270^0 around the shell. Sculpture of broad flat spiral ridges with a single narrow cord in each interspace, and a row of rounded granules under the suture. Periostracum unconspicuous. Aperture large, elongate –ovate. Outer lip marked flaring, interiorly with paired teeth that are week to absent over central portion. Inner lip rather broad, slightly detached

anteriorly, bearing many prominent transverse folds with narrower interspaces over its whole length. Operculum thick, oval, with a central nucleus and completely concentric growth lines.

Colour: Outside of shell extremely glossy, with a crescent- shaped markings of purple brown on a cream to fawn background. Aperture cream, flushed with orange or pink interiorly. Inner lip with white transverse folds and dark brown interstices.

Size: Maximum shell length 45 cm, commonly to 30 cm.

Habitat, biology, and fisheries: In coral reef areas, low intertidal and shallow sub littoral zones, to a depth of about 30 m. Preys on large coral- eating starfish "**Crown –of- thorn**" *(Acanthasterplanci).* Actively collected in many areas since ancient times, both for its edible fish and large, highly decorative shell. Frequently over collected. Collections and sale of this species now banned in many countries with coral reefs, as an attempt to fight against the recent expansion of the "**Crown-of-thorn**" starfish, which has devastated many coral reefs.

Distribution: Widespread in the Indo- West Pacific, from east and South Africa, including Madagascar, the Red Sea and the Persian Gulf, to eastern Polynesia; north to Japan, Midway and Hawaii, and south to southern Queensland and northern New Zealand.

9.*Chicoreus brunneus (Link, 1807)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Muricidae
Genus: Chicoreus

Diagnostic characters: Shell moderately large, stout and heavy, roughly rhomboidal in outline, with a tall conical spire and inflated body whorl. About 3 strong and prominent, spinose axial varices per whorl, with a single broad axial nod between them, well-marked spiral cords and many fine, intermediate spiral threads. Spines of varices thick branched, leaf-like and close-set, about 6 in number on body whorl. Posterior most 3 or 4 spines rather long, progressively more dorsally recurved towards the anterior end of the shell, thus forming a gradual arc in that direction. Last 2 spines of body whorl straight. Aperture rounded ovate, with a deep and narrow notch at posterior end. Outer lip crenulate but without a tooth-like process, shortly lirate interiorly. Inner lip smooth almost completely adherent. Anterior siphonal canal broad and relatively short, narrowly open, slightly recovered distally, with 3 or 4 straight spines of which the basal one is bent dorsally.

Colour: Outside of shell usually brown with darker brown to almost black spiral cords and spines sometimes orange. Aperture white or light pink, with deep pink lips.

Size: Maximum shell length 11.5cm, commonly to 7cm.

Habitat, biology, and fisheries: Common in various shallow water habitats, rocks, coral reefs, or clean to muddy sand bottoms. Intertidal and sub littoral zones to a depth of about 20m. This common species is frequently collected by coastal people for food and shellcraft.

Distribution: Widespread in the Indo-West Pacific, from East Africa to western Polynesia; north to Japan and south to northern New South Wales and New Calidonia.

10.*Chichoreus torrefactus (Sowerby, 1841)*

Systematic position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Muricidae
Genus: Chicoreous

Diagnostic characters: Shell moderately large, solid, fusiform and moderately slender in outline, with a high, acute spire and large, elongate body whorl. Three spinose axial varices per whorl, with usually 2 or 3 axial nodes between them, and finally crenulated spiral cords interspersed with many fine spiral threads. Spines of varices short and branched, with smaller intermediate spines. About 5 major spines on body whorl, the shoulder spine and 2 anterior most spines strongest. Aperture broadly ovate, with a large and deep notch at posterior end. Outer lip crenulate but without a tooth-like process, shortly lirate inside. Inner lip adherent, calloused posteriorly, usually smooth. Siphonal canal moderately short, broad, narrowly open and slightly recurved, with 3 or 4 spines which are separated from the body-whorl spines by a spineless space.

Colour: Outside of shell usually brown, with darker spiral cords and spines. Aperture white, often with yellow to orange lips.

Size: Maximum shell length 14cm, commonly to 8 cm.

Habitat, biology, and fisheries: Among rocks or on muddy-sand bottoms, near rocks and under corals. Littoral and shallow subtidal waters. This common species is frequently collected for food and shell craft. In some localities, populations have been greatly reduced because of overcollecting.

Distribution: Widespread in the Indo-West Pacific, from south-east Africa to Micronesia and Melanesia; north to Japan and south to New Caledonia and Fiji Islands.

11.*Conus flavidus (Lamarck, 1810)*

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Family : Conidae
Genus : Conus

Maximum shell length 6 cm, commonly to 4 cm. Common on reef areas, usually under boulders and corals during the day. Mainly feeding on small coral fishes and shallow sub littoral zones to a depth of about 10m.Occasionally marketed in the northern Philippines. Widespread in the Indo-West Pacific, from East Africa to eastern Polynesia; north to Japan and Hawaii and south to northern Queensland and New Caledonia.

12.*Conus generalis (Linnaeus, 1767)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Conidae
Genus: Conus

Maximum shell length 9.5cm, commonly to 8 cm. In sandy bottoms. Intertidal and shallow sub littoral zones to a depth of about 10m.Locally collected for food. Widespread in the Indo- West Pacific, from East Africa to Melanesia; north to southern Japan, and to southern Queensland and New Caledonia. Indian Ocean populations generally considered as a distinct subspecies (*Conus generalis maldivus (Hwass, 1792*).

13. *Conus radiates (Gmelin, 1791)*

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Family : Conidae
Genus : Conus

Maximum shell length 8 cm, commonly to 6 cm. Common on sub littoral bottoms. Collected in fairly large quantities in the Philippines, mainly for shell trade. Restricted to the tropical West Pacific, from southern Japan and the Philippine Archipelago to eastern Melanesia.

14. *Conus tessulatus (Born, 1778)*

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Family : Conidae
Genus : Conus

Maximum shell length 6.5 cm, commonly to 5 cm. Found in coral reef areas, muddy sand and gravel flats of sheltered environments. Intertidal and sub littoral zones, to a depth of about 20m. Locally used as food. Widespread in the Indo-West Pacific, from East Africa to eastern Polynesia; north to Japan and south to Queensland and New Caledonia; also occurring in the tropical eastern Pacific, on the offshore islands and mainland from Mexico to Costa Rica.

15. ***Cymia lacera (Born, 1778)***

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Muricidae
Genus: Cymia

Diagnostic characters: Shell thick and heavy for its size, almost biconical in outline, with a moderately tall, conical spire and large, strongly angulated body whorl. Surface of shell with many narrow, irregular spiral cords all over, a sharply angular spiral ridge bearing spiny tubercles at periphery of each whorl. Some of the spiral cords may be stronger on body whorl and give rise to secondary spines on shoulder slope. Base of the body whorl with a prominent spiral ridge bordering the umbilical excavation. Posterior part of aperture often almost free from the body whorl. Outerlip strongly dentate posteriorly. Columella smooth and straight. Anterior siphonal canal short and deep, widely open.

Colour: Outside of shell pale grey, cream or yellowish brown, often with quadrangular brown mottling. Aperture flesh-coloured inside becoming pale cream to orange on margins.

Size: Maximum shell length 5cm, commonly to 4cm.

Habitat, Biology, and Fisheries: On muddy littoral rocks. Collected for food in Indo-West Pacific, notably in Indonesia, Indo-China and India.

Distribution: Indo-West Pacific, from India to Melanesia; north to Taiwan Province of China and south to southern Indonesia and New Caledonia.

16. Donax species

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Bivalvia
Subclass : Heterodonta
Order : Cardiida
Family : Donacidae
Genus : Donax

Donax is a genus of small, edible saltwater clams, marine bivalve molluscs. The genus is sometimes known as bean clams or wedge shells; however, Donax species have numerous different common names in different parts of the world. In the southeastern US they are known as "coquina", a word that is also used for the hard limestone concretions of their shells and those of other marine organisms.

Ecology : Species of Donax live, sometimes in high concentrations, vertically aligned in the sand on exposed beaches, on tropical and temperate coasts worldwide. When the waves wash these small clams out of the sand, they can dig back in again quite rapidly. They are filter feeders. Some species, such as Donax variabilis, migrate vertically and horizontally with changes in the tides. These coquina clams are found extensively on the east coast beaches of Trinidad (Mayaro) and widely available in Venezuela. They are called "Chip Chip" in Trinidad & Tobago and "Chipi Chipi" in Venezuela.

The empty small (15 to 25 mm) shells of Donax variabilis and Donax fossor may be found washed up on the beach, especially at low tide. The living animals can often be seen where the waves wash the sand around in the most shallow part of the littoral zone as the tidal level changes. These clams can use the action of waves to move themselves up and down the beach, quickly burrowing into a new location before they can be swept away (the so-called "dance of the coquina").

17. *Euchelus asper*

Systematic Position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Superfamily: Seguenzioidea
Family: Chilodontaidae
Genus: Euchelus
Species: E. asper

Description : The size of the shell varies between 6 mm and 35 mm. The thick, conoidal shell is imperforate in adult specimens. Its color is dull ashen, dotted with brown, rosy, and black. The 5½-6 convex whorls are separated by profound sutures, the first one eroded, the rest rough. They are ornamented with close, granulose, unequal cinguli (the colored bands or spiral ornamentation), with two on the upper, and 3 or 4 on the body whorl more prominent. The penultimate whorl has 12-15 lirae. The globose body whorl is rounded, descending, and convex beneath. The aperture is ovate-rounded, the margins nearly continuous, plicated finely all around. The columella is arcuate. The base of the shell is dentate.

This species is highly variable. It is also known under the form Euchelus asper quadricarinatus (Holten, H.S., 1802) (synonym: Trochus alabastrum Reeve, 1858), common name the four-keeled margarite. The size of the shell varies between 6 mm and 12 mm. It is found in the Indo-Pacific.

Distribution: This species occurs in the Indo-West Pacific.

18. *Ficus gracilis (Sowerby, 1825)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Ficidae
Genus: Ficus

Maximum shell length 20 cm, commonly to 13cm. On muddy- sand bottoms. Sub littoral and shelf zones, to depths of about 200m. Occasional by catch of shrimp trawlers. Central Indo-West Pacific from the Andaman Sea to eastern Indonesia; north to Japan and south to Indonesia.

19. *Fusinus colus (Linnaeus, 1758)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Fasciolariidae
Genus: Fusinus

Maximum shell length 20 cm, commonly to 15 cm. On sandy bottoms. Inter tidal and sub littoral zones to a depth of about 40m.Commonly collected in the area by shrimp trawlers, sometimes in large quantities. Widespread Indo-West Pacific, from East Africa to Melanesia; north to southern Japan and south to southern Queensland.

20. *Fusinus nicobaricus (Roding, 1798)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Fasciolariidae
Genus: Fusinus

Maximum shell length 18 cm, commonly to 11cm. On sandy bottoms. Sub littoral, from shallow sub tidal water to a depth of about 40 m. Incidental catch of shrimp trawlers. Widespread in the Indo-West Pacific, from Sri Lanka to Polynesia; north to Japan and Hawaii, and south to northern New South Wales.

21. *Harpa major (Roding, 1798)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Harpidae
Genus: Harpa

Maximum shell length 10 cm, commonly to 8.3cm.Commonly on sandy bottoms. Lower intertidal fringe and sub littoral to shell zones. Mainly collected for trade by shrimp trawlers. Widespread in the Indo-West Pacific, from East and South Africa, including Madagascar and the Red Sea, to eastern Polynesia.

22. *Lophiotoma indica (Roding, 1798)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Turridae
Genus: Lophiotoma

Maximum shell length 9.5 cm, commonly to 7 cm. Common on muddy bottoms. Shallow sub littoral zone and offshore to a depth of 50m.Incidentally collected in shrimp trawls. Indo-West Pacific from east Africa to eastern Melanesia; north to Japan and south to Queensland.

23. *Malea pomum (Linnaeus, 1758)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Tonnidae
Genus: Malea

Maximum shell length 8cm, commonly to 6 cm. On fine sandy bottoms, sub littoral, mainly between depths of 5 and 30m.Incidentally collected in fish traps and trawls, where common. Widespread in the Indo-West Pacific, from East Africa, including Madagascar and the Mascareign islands to eastern Polynesia; north to southern Japan and Hawaii, and south to southern Queensland.

24. *Murex ternispina (Lamarck, 1822)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Muricidae
Genus: Murex

Maximum shell length 12cm, commonly to 9cm. On soft sub littoral bottoms, from shallow water to a depth of about 60cm. collected and locally marketed for food and shell trade. Indo-West Pacific, from Sri Lanka to Melanesia; north to Japan and south to southern Indonesia and probably eastern Queensland.

25. *Murex trapa (Roding, 1798)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Muricidae
Genus: Murex

Maximum shell length 11.5cm, commonly to 10cm. Muddy sand-bottoms. Low tide and shallow sub littoral depths. Used locally as food, or collected for shell trade. Widespread in the Indo-West Pacific, from Madagascar Islands, India, Sri Lanka and the Andaman Sea, to the Philippines; north to southern Japan and south to southern Indonesia.

26. *Murex tribulus (Linnaeus, 1758)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Muricidae
Genus: Murex

Maximum shell length 10.5 cm, commonly to 8 cm. On clean or muddy sand, or coral-rubble bottoms. Sub littoral, mainly in shallow water between depths of 1 to 15 m. Used as food locally, the empty shell sold for collections. Indo- West Pacific, in south eastern Africa and Madagascar, and from the eastern most part of the Indian Ocean to Melanasia; north to southern Japan and south to northern Queensland and New Caledonia; also probably present in the Marshall Islands. Specimens from the Arabian region usually referred to this species actually belong to the distinct species *Murex forskoehlii Roding*, 1798.

27. *Nassarius cremates (Hinds, 1844)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Nassaridae
Genus: Nassarius

Maximum shell length 4cm, commonly to 3 cm. On fine sandy or muddy bottoms. Intertidal, sub littoral and shelf zones to a depth of 200m.Often occurring in rather large populations. Occasionally used as food. Shell utilized in shell craft. Widespread in Indo-West Pacific, from East Africa to Hawaii; north to Japan and south to central Queensland.

28. ***Natica vitellus (Linnaeus, 1758)***

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Naticidae
Genus: Natica

Diagnostic characters: Shell moderately thick, ovate-conic in shape and about as long as wide, with a short spire, convex whorls and well-defined suture. Outer surface smoothish, apart from the fine growth marks which tend to be stronger at the sutures of early whorls. Umbilicus large and deeply open, with an ill-defined, weak to nearly absent in internal rib, and slightly covered posteriorly by the thick and narrow callus of inner lip. Anterior end of aperture often slightly flaring. Operculum calcareous, with 2 spiral ridges alone its outer margin and finally serrated inner margin.

Colour: Outside of shell variable white or light brown to yellowish, with 1-3 usually broad and distinct spiral bands of darker brown on body whorl. Umbilical area whitish. Columellar side of the aperture often with brown shades.

Size: Maximum shell length 4.5 cm, commonly to 3 cm.

Habitat, biology, and fisheries: Sub littoral, from shallow subtidal levels to a depth of about 40 m. Used as food and for its shell. In Thailand, commonly collected by fishing nets from depth of 2-10 m.

Distribution: Indo-West Pacific, from Madagascar and the Persian Gulf to eastern Melanesia; north to Japan and south to Queensland and New Caledonia.

29. *Phalium glaucum (Linnaeus, 1758)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Cassidae
Genus: Phalium

Maximum shell length 12cm, commonly to 9 cm. Common on sandy bottoms, especially on exposed sand flats and close to dead coral areas. Intertidal and shallow sub tidal zones to a depth of about 100m. Feed on sea urchins of the "sand dollar" group. Egg capsules forming an irregular mass which is the result of several females spawning together. Collective for food and for shell trade. Widespread in the Indo-West Pacific, from East Africa, including Madagascar, to Melanesia; north to Japan and south to northern Queensland.

30.*Pleuroploca filamentosa (Roding, 1798)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Fasciolariidae
Genus: Pleuroploca

Diagnostic Characters: Shell moderately strong, reaching a large size (upto 15cm long), narrowly fusiform in shape, with a high pointed spire and moderately long siphonal canal. Whorls rounded to moderately shouldered in profile, sometimes slightly concave under the suture. Sculpture of numerous, thin spiral threads throughout the entire surface and a row of low to obsolete axial nodules at the shoulders.Aperture ovate, with many fine spiral threads inside the outerlip which has a slightly serrate, sharp margin.Columella with a

slight elbow at its basal end, bearing 3 oblique folds. Anterior siphonal canals straight and broadly open.

Colour: Outside of shell generally dark brown, sometimes orange- brown with lighter brown spiral lines and cream to nearly white irregular patches, mainly between the shoulder nodules. Interior of the outer lip orange cream, inner lip orangish brown with pale columellar folds.

Size: Maximum shell length 15cm, commonly to 12cm.

Habitat, biology, and fisheries: Common in coral reef areas and sandy bottoms. Sub littoral, mainly in shallow water. Sold in local markets of the northern Philippines.

Distribution: widespread in the Indo-West pacific, from East Africa, including the Red Sea, to Melanesia, north to the Philippines and south to Queensland and New Caledonia.

31.*Rapana bulbosa*

Systematic Position

Kingdom: Animalia.
Phylum: Mollusca.
Class: Gastropoda.
Family: Muricidae
Sub Family: Rapaninae
Genus: Rapana

This is a species of sea snail, a marine gastropod mollusc in the family *Muricidae*, the murex snails or rock snails. Its seashell is hard and heavy. It is also called the Turnip shell because of its shape. Its wide opening makes a favourite for listening to resonant ocean sounds. These seashells range between 1-3/4" to 2-1/4" long.

Distribution: The *Rapana bulbosa* is found on the ocean floor in the Indian and western Pacific Oceans, across the waters of Micronesia and Polynesia, the Coral

Sea and around the Philippines. Along the Australian Coast it is found from Northern New South Wales to northern Western Australia, and along the east coast of Africa including Madagascar. Found between depths of 10 and 40 meters (35–130 ft.), it is often associated with live coral colonies, such as the table-forming *Acropora*, either found on the reefs themselves or the sandy sea bottom nearby. Once common, it is now much less abundant due to shell collecting and the destruction of its habitat by such processes as dynamite fishing, especially in shallower areas. Carnivorous, the adult *Rapana bulbosa* eats coral and various invertebrates, while juveniles eat algae.

31. *Terebra areolata (Link, 1807)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Order: Neogastropoda
Family: Terebridae
Genus: Terebra

Maximum shell length 18cm, commonly to 13cm.On sandy bottoms. Low tide and sub littoral zone to a depth of about 20m.Mainly collected for its shell. Widespread in the Indo-West Pacific, from East Africa, including Madagascar and the Red Sea, to eastern Polynesia; north to southern Japan and Hawaii and south to Queensland.

32. *Terebra crenulata*

Systematic Position

Kingdom: Animalia.
Phylum: Mollusca.
Class: Gastropoda.
Order: Neogastropoda.
Family: Terebridae.
Genus: Terebra.

Colour creamy-pink, it possesses sharp white tubercles separated by narrow clear brown axial lines. It has two spiral alignments of brown spots equally distant and very far away from each other. It lives in the lagoon's shallow waters.

33.*Thais bufo (Lamarck, 1822)*

Systematic Position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Muricidae
Sub-family: Rapaninae
Genus: Thais

Maximum shell length 8cm, commonly to 6cm. On littoral rocks in sandy pools, and in estuaries. Preys on oysters and barnacles. Females usually gather for spawning, depositing the stalked egg capsules together in large sheets. Collected for food at low tide, where common. An important species in India. Widespread in the Indo-West pacific, from East and South Africa to Papua New Guinea; north to Japan and south to Queensland.

34. *Tibia curta*

Systematic position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Strombidae
Genus: Tibia

Tibia curta, a marine gastropod mollusc in the family *Strombidae*, the true conchs. This species occurs in southern India.

35. *Trochus radiates*

Systematic position

Kingdom : Animalia
Phylum : Mollusca
Class : Gastropoda
Order : Trochida
Superfamily: Trochoidea
Family : Trochidae
Genus : Trochus
Species : T. radiatus

Trochus radiatus, common name the radiate top shell, is a species of sea snail, a marine gastropod mollusk in the family Trochidae, the top snails.

Description : The thick, rather solid, trochoidal shell has a moderately elevated spire and is false-umbilicate. Its length varies between 17 mm and 40 mm. The color of the shell is yellowish whitish, tinged with green, and radiately striped with broad or narrow uninterrupted, axial, crimson flames. The base of the shell is white or pink, radiately marked or minutely speckled with red. The aperture, columella and umbilical area are pearl white. The spire has nearly straight outlines. The apex is acute, generally eroded and orange-colored. The about 7 whorls are planulate, sometimes a little concave in the middle. The body whorl has a sharply angled periphery. The shell upper surface is circled by irregularly beaded bands, 5 or 6 on each whorl, uneven in size, the upper row largest;. The bead in each whorl is larger on the upper row than those at lower rows, The base of the shell is nearly flat, concentrically lirate. These lirae are granulose, rather coarse, with broad interspaces, which are frequently occupied by revolving lirulae or striae. The oblique columella is strongly plicate above, its edge nearly smooth and shows blunt teeth. The large aperture is subrhomboidal, lirate within, and grooved. The basal lip thickened and crenate The umbilicus is wide and deep. The umbilical tract is funnel-shaped, rather broad, with a central rib. The parietal wall is scarcely callous, showing the color of the base, and with a white spiral rib in the middle.

Normally adult and large shells are encrusted with algae. Shells washed on beaches are usually clean, exposing the underlying pearly layer below the surface. This species feeds on encrusting algae.

The conspicuously radiate color pattern and the sculpture, consisting of coarse granulose lirae with interstitial lirulae both above and below, as well as the wide umbilical tract and eroded corneous or orange apex, will serve to distinguish this form.

Distribution: This species occurs on intertidal rock boulders in the Indian Ocean off Madagascar and in the Western Pacific.

36. *Turritella sp*

Systematic position

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Superfamily: Cerithioidea
Family: Turritellidae
Genus: Turritella

Turritella is a genus of medium-sized sea snails with an operculum, marine gastropod mollusks in the family Turritellidae. They have tightly coiled shells, whose overall shape is basically that of an elongated cone. The name Turritella comes from the Latin word turritus meaning "turreted" or "towered" and the diminutive suffix -ella.

DISCUSSION

The coastal marine ecosystem supports variety of habitats that consequently support high species diversity. In coastal areas, the intertidal zone is considered as most diverse and productive because with in the area of few meters' various kinds of flora and fauna are observed (Underwood, 2000). The intertidal zone has been studied extensively for its biodiversity in last two-three decades (Little and Kitching,1996). Vertical zonation is the most important process or phenomena observed on the rocky intertidal area in which from upper to lower intertidal area, different bands or zones containing different biodiversity are observed (Stephenson and Stephenson, 1949; Bandel and Wedler, 1987; Ellis, 2003).

Gastropods are the largest and most diverse class of mollusc and include species that are well studied within the areas of taxonomy, aquaculture, biomineralization, ecology, microbiome, and health. The variation in the distribution and abundance of organisms in different zones of intertidal zone has provided basis for so many ecological experiments and such complex patterns of variation have been studied well specially for the organisms of rocky intertidal area (Archambault and Bourget 1996; Blanchard and Bourget 1999; Trivedi et al., 2012).

Molluscan shells have been found important for various commercial purposes like poultry food, medicines, industrial raw material, fisheries, handicrafts, and interior decoration. The total coastal area covered by different kinds of marine habitats include 29 % of muddy flats followed by 28 % of sandy beaches, 22 % of marshy coast, and 21 % of rocky coast. Neendakara coast is very diverse in case of marine biota and studies on distribution and diversity of marine invertebrates have been carried out by many researchers (Venkatesh etal.,2015; Sajikumar, 2015; Salim et al,, 2017; Mumthas and Miranda, 2018). The commercially important gastropods are harvested extensively from various marine areas of India and their population is declining at alarming rate. So for

the conservation of the gastropod species, studies are required to carve the real picture of the population status of various species (Apte, 1998). Few studies have been done on the intertidal distribution of gastropod species along the coastal region of Kollam, Kerala (Venkatesh etal.,2015; Sajikumar, 2015; Salim et al,, 2017).

In the present study, fifty-two species of gastropods were obtained from the study sites. Numerical abundance was recorded maximum at site I (80%) compared to site II (12%) and III (8%). The greater abundance of gastropods along the coast of Neendakara in Kollam can be correlated to the slight increase in alkalinity in the coastal waters and the sandy silt sediments (Mumthas et al., 2016).

Miranda etal., 2012 also found dominance of Molluscs along the coast of Chavara in Kollam. Many of the gastropods obtained in the present study have ornamental value and are thus commercially important. Studies on age and growth are available for numerous species of gastropods, but such studies on *Trochus radiatus* is lacking, which is also commercially important species of South East coast of India.

In a study carried out by Sinu and Miranda (2013) along the coast of Arthungal in Kerala, higher abundance of Molluscs were recorded among the Macro faunal population. The configuration of immediate substrate of occupation, both as a refuge and more critically as a source of food is often the paramount factor governing the distribution of macro invertebrate fauna, and the bottom sediment of aquatic ecosystems are known to serve as shelter for macro benthic invertebrates and direct or indirect food source for detritus and grazers (Bishop 1973).

The ornamental gastropod is an emerging resource in Indian seas. However, as no shell crafting firms are located in Kerala. During the present study, among these gastropods many species are of economic importance, and most of them are edible, mainly as seafood and are exported to many countries (e.g., China, Indonesia, Japan, Taiwan, Thailand, and Vietnam etc.) Their shells are being

used in shell craft industry. Damaged shells are sent to Calcium carbide industry located in Tamilnadu. The gastropod shell is used to make attractive models, garlands, studs, rings, bangles, paper weights, curios, ash trays, door, and window curtains, sacred chanks, bathi stands, lamp shades, key chains, etc. The curios and other trinkets made out of shells are expensive articles as they have great demand in the home as well as foreign markets.

Gastropods are also used as bioindicators and biomonitoring. Their higher ability to accumulate metals in their bodies compared to other aquatic animals, so that gastropods can be used for environmental monitoring. *Littoraria scabra, Nassarius reticulatus, Nerita albicilla, Nucella lapillus, Gibberulus gibbosus, Terebralia palustris,* and *Telescopium telescopium* always use as biomonitoring metal pollution (Wolf, et al., 2001; Wolf and Rashid,2008). The main indicator that can be shown by gastropods is declining abundance and body size. Other indicators are as bioavailability of heavy metals in the soft tissues and shells. The ability of the heavy metal deposits is influenced by environmental factors, body size, weight, and gender. Heavy metals can affect hard, thickness, volume, and color of the shell (Samsi etal., 2017; Mumthas etal.,2018).

Some of the species like *B. ampulla* and *B. bufonia* are indicator species and are important in coastal Environment Risk Assessment Programs since they can be used as bio monitoring agents signalling coastal marine pollution. During the present study showed variations in the diversity status of gastropods. The information will be valuable in the practices for their conservation and the validation of the present findings to verify and gain more baseline data on gastropods in other coastal communities in the intertidal regions of Kollam coast

CONCLUSION

The gastropod diversity was documented along the inter-tidal region of the coast of Kollam. Fifty-two species of gastropods were obtained. The study is thus significant as it is an exhaustive preparation towards a biodiversity register of marine gastropods along the coast of Kollam in Kerala.

SUMMARY

A study was carried out to identify and document the diversity of gastropods, along the intertidal region along the coast of Kollam in Kerala. The site selected for the study included site I : Neendakara, Site II: Vaddy and site III : Thirumullavaram in Kollam.

The study period was for two months *viz* Sampling was carried out during the months of November and December, 2019. Gastropod shells were handpicked from the inter-tidal region twice a month in the morning and again in the evening. The samples were brought to the laboratory, sorted, preserved, and identified upto species level using standard keys. The handpicked samples from the site were brought to the laboratory in polythene bags, transferred to a large, white-bottomed tray, and the animals were hand sorted. After this preliminary examination, the whole sample was treated with 5% buffered formalin and kept for further analysis.

Large samples are then subdivided into sub-samples (live and worn out ones) of roughly equal size that could be sorted more comfortably. The sub samples were placed in different jars with preserving solution and were labelled properly. Fine sorting was performed under a dissection microscope. Digital images were taken for each of the samples. The preserved fauna was identified to major taxonomic groups using appropriate keys and standard taxonomic references along with available expertise.

A total of 52 species of Gastropods were obtained from the study sites. Numerical abundance was recorded maximum at site I (80%) followed by site II (12%) and site III(8%). Among Gastropods, Cerithium species belonging family certhiidae is one of the common rocky intertidal gastropod was numerically abundant at site I whereas the least abundant species were *Bursa* sp, *Fusinus colus, Harpa major, Murex trapa, Nassarius cremates, Oliva* sp, *Pleuroploca filamentosa* and *Terebra crenulata.* At site II, the dominant species were cerithidia sp and the least abundant species were *Babylonia spirata, Bufonaria*

sp, *Cellana rota, Donax* sp, *Pirenella* sp and *Polinices mammilla*. At site III, the numerically abundant species were *Tibia curta* sowerby whereas *Babylonia spirata, Bursa* sp, *Bufonaria* sp, *Chicoreus* sp and *Murex* sp. The study is thus significant as it is an exhaustive preparation towards a biodiversity register of marine gastropods along the coast of Kollam in Kerala and is useful for Environmental Risk Assessment of the coastal waters of Kollam.

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PLATE I

A) Sampling along the intertidal regions of the study sites

B) Sorting of Collected specimens

C) Identification of specimens

PLATE - II

Babylonia areolata

Bursa bufonia

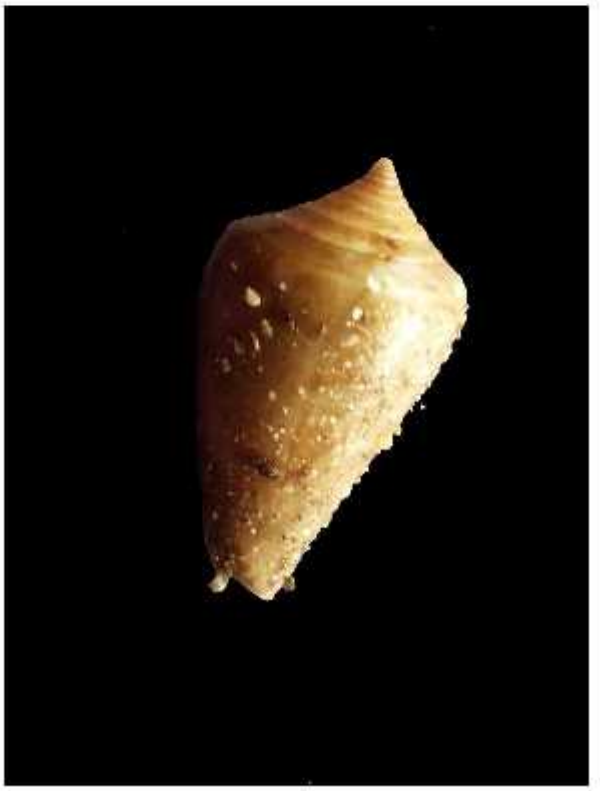
Charonia tritonis tritonis

Chicoreus brunneus

PLATE - III

Chicorus torrefactus

Conus flavidus

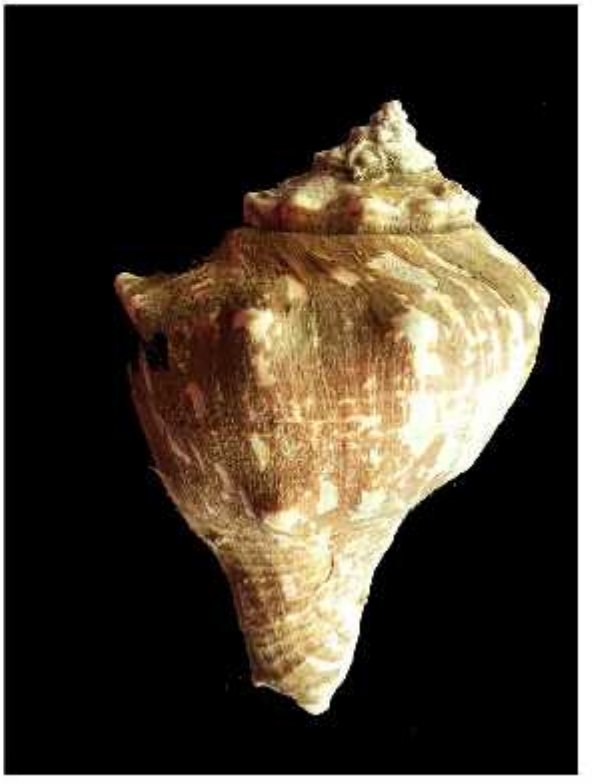


Conus generalis

Conus radiates

PLATE - IV

Conus tessulatus



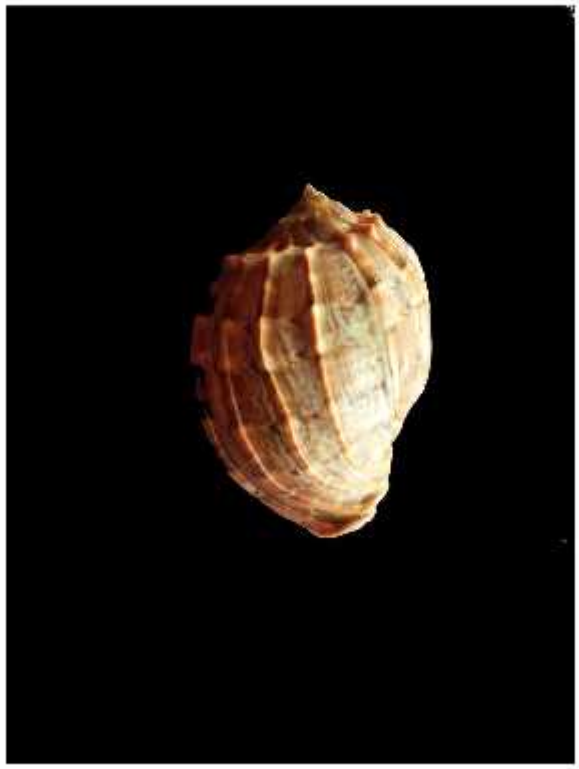
Cymia lacera

Ficus gracilis

Fusinus colus

PLATE - V

Fusinus nicobaricus



Cymia lacera

Lophiotoma indica

Malea pomum

PLATE - VI

Murex ternispina

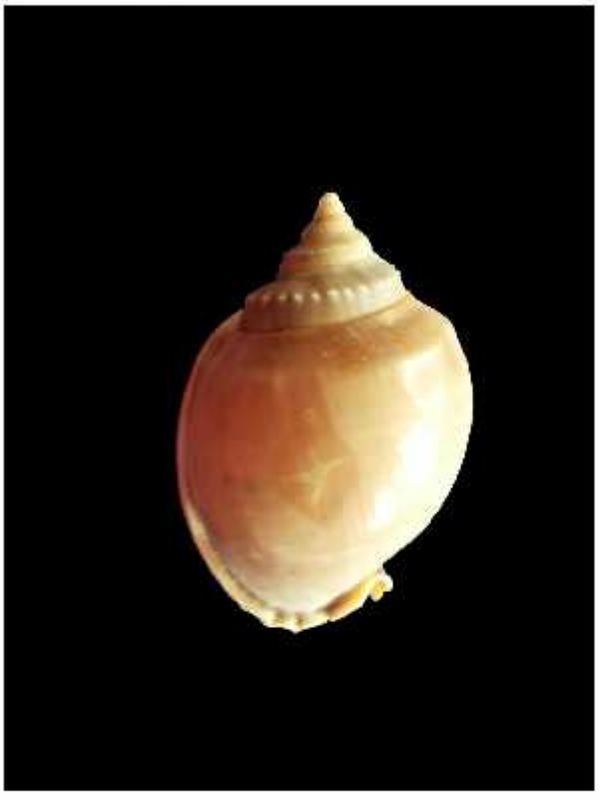
Murex trapa

Murex tribulus

Nassarius crematus

PLATE - VII

Natica vitellus



Phalium glaucum

Pleuropoca filamentosa

Rapana bulbosa

PLATE - VIII

Terebra areolata

Terebra crenulata zinnae

THAIS BUFO

TIBIA CURTA

PLATE – IX

Babylonia zeylanica

Babylonia feicheni

Babylonia spirata

Bursa spinosa

Cellana rota

Clypidina notata

PLATE – X

Charonia tritonis

Cymia lacer

Euchelus asper

Turritella sp

Trochus radiates

Cerithium sp