Comparative study of Abundance and Diversity of Ornamental Gastropods in the Intertidal waters of Gurgusum and Green Island

PRABHU. H. V.[1], Lakshmipathi M.T.[2] Atobrhan Solomon, Brhane Kflu and Tekie Angosom

1Department of Marine Biology and Fisheries, College of Marine Science and Technology, Ministry of Education, Massawa, Eritrea, N.E.Africa.
2 Corresponding author, Colleges of Fisheries, Mangalore, Karnataka, India.

Email: *hv_prabhu@yahoo.co.in, drlakshmipathi@gmail.com*

ABSTRACT

In the present study, the ornamental gastropods identification and distribution patterns in relation to sediment texture and nature of substrate in the intertidal area of Massawa coast was carried out in the two sites (Gurgusum and Green Island) for the months of February, March, and April, 2013.In the present study about 31 species of gastropods belong to sub-class of Prosobranchia (that are consider as ornamental gastropods) were identified. The study was done by transect method stretched from the lowest low tide towards the upper part of the intertidal area, and within the transect, a quadrat of 1m^2 was also lied down at a specific interval. From the sampling areas, gastropods and sediments were collected from randomly selected grids within the quadrat. From the result obtained, there was a variation in the distribution patterns of the gastropods within the sites (from upper to lower) and among the two sites and there was a difference in the sediment texture and substrate nature of the sites during the sampling period. The variation in distribution patterns of the organisms identified is largely correlated with the substrate nature and sediment particle size difference that exists among the two sites, which determines the habitat where the organism lives and the mode of feeding habit that it exhibits. The vertical distribution differences are also due to the availability of crevices and seaweeds abundance.

INTRODUCTION

The seven major taxa of living molluscs three classes are well known, the univalve (gastropoda), which includes the snail, conchs and periwinkles, the bivalves (bivalvia), which includes the clams, oysters and scallops, the cephalopods (cephalopoda), which embraces the squids, nautiluses and octopuses. There are four minor, although peculiarly distinctive, groups the chiton (scaphopoda) and the gastroverns (monoplacophora), and the aplacophora, the wormlike molluscs (Abbott, 1982).

Generalized mollusc is marine benthic animal, bilaterally symmetric, dorsoventerally depressed. The body is divided in to a small poorly defined anterior head, a large dorsal visceral mass and broad, flat ventral foot. The visceral mass contains the digestive, excretory, reproductive system, and the heart. The muscular head-foot often provides the major means of locomotion. In the more active group, the head region is well defined and carries sensory organ and brain (Russell *et al*.2008). The mantle covers the visceral hump like a cloak and serves for respiration and shell production. The outer surface of the mantle secretes the shell, adding to its thickness and circumference throughout the life. The inner surface is elaborated into gills (ctenidia) or a lung. By cilia or muscular pumping, the mantle maintains a flow of water through the mantle cavity, as needed for gaseous exchange and filter feeding as well as flushing away of wastes (Jessop, 1988).They are adapted for life on hard rock substrata, where it uses its rasp like radula to graze on the biofilm of microscopic algae and other small sessile organisms, they have several pairs of gills. (Beesley *et al*.1998).Molluscs include many familiar animals such as clams, oysters, mussels, snails, slugs, octopods and squids in seven living class. Despite of their obvious dissimilarities, these animals are all molluscs and share many basic features (Ruppert *et al*.2004)

Generalized molluscs are macrophages burrower, which uses its radula to scrape microscopic algae, other organisms and detritus from hard substrata. (Ruppert *et al.* 2004) In general, molluscs are soft-bodied animals that are usually produce an external shell composed of a limy material, calcium carbonate. The one feature unique to all molluscs is the presence of a fleshy mantle-foot lobe or pair of lope lining the shell-building material. Other anatomical characteristics however differ with the phylum (Abbott, 1982).

Of the entire invertebrate, molluscs probably have been and still are most valuable to man. They are food sources in many part of the world. Their shell provides a variety of products and the diverse and beautiful forms that these may take have let to molluscs becoming important element in the art, culture, and tradition of many races (Wu, 1999). The shells of molluscs have been highly valued by human since prehistoric times. Despite their importance, particularly in developing countries, they have received very little scientific attention compared with species valued as food (Ruppert *et al.* 2004)The ornamental shell trade includes shells exploited whole for their decorative value, rare and precious shells sought by shell collectors or conchologists, and those used in shell craft- shell collecting a favourite hobby in the nineteenth century has undergone a recent revival, largely because of growth in the tourism and leisure industries (Salm, 1978). These shells are widely collected for their beauty rarity and scientific interest.Most ornamental shells are gastropods, they are the largest and most diverse mollusc class. The gastropods are the snail and slugs and the taxon includes an enormous diversity of these animals. They originate in the sea, but have colonized fresh water and are the only mollusc found in terrestrial habitat.Estimate number of the species varies from 40,000 to 100,000 species, but there are probably around 60,000 described, extant gastropods and another 15,000 known fossil species. Gastropods are primarily benthic, become adapted to life on all types of bottoms, but some are adapted to pelagic life (Parkinson, 1982).

Three major groups of gastropods are present namely the prosobranchs, pulomnates and opisthobranchs. The prosobranchs are primarily benthic marine animals, where as the pulomnates have capitalized on the ecological possibilities of ariel respiration (Wells, 1981)Due to their great variety, it is difficult to describe generalized gastropods. The only characteristics common to all gastropods is torsion, which is a 180^0 counter clockwise rotation of the visceral mass with respect to the foot (Ruppert *et al*, 2004). Because of the diversity in form and colour of their shells, many gastropod species are valued in the ornamental shell trade. A wide range of attractive or rare gastropod collected for the international shell trade and for sale to tourists. Gathering desirable species of gastropods provides an income for many tropical, coastal communities, and many development programmes have encouraged this activity (Parkinson, 1982)

Gastropods retain the broad, flat creeping foot of the generalized molluscs but are much more active and mobile than the chitons and monoplacophorans. Locomotion is primary function of the gastropod foot, but it may also be responsible for activities such as prey capture, reproduction and defence. The surface of the sole of typical gastropod foot is broad, flat, and variously adapted for locomotion over a variety of substrata. most are hard bottom. Gastropods, terrestrial pulomnates, and even large soft bottom species move rapidly by propelling wave of muscular contraction that sweep along the sole of the foot (John, 1984).

Gastropods evolved on rocky marine bottoms, but have radiated into a wide variety of other habitat. Natural selection has resulted in close relation among shell type, locomotion and habitat. In general, shells with low spires are more stable and better adapted for carriage upside down or on the vertical surface of rocks and vegetations. Shells with long spires are carried horizontally or even dragged over soft bottom. Some prosobranchs and cephalaspid opisthobranchs that live on the soft bottom have become adapted for burrowing. A small number of gastropods are adapted for sessile existence firmly attached to the substratum. A few gastropod taxa have independently become adapted foe pelagic life (Ruppert *et al*. 2004).

Virtually every possible feeding mode found in gastropod, and the morphology of the digestive system varies widely. Gastropods may be microphagous burrowers, herbivores, carnivores, omnivores, scvavengers, deposit feeders, suspension feeders, cytoplasm suckers, and parasites (Caddy, 1989).

Objective of the study:

- To identify the ornamental gastropods in the intertidal waters of Massawa coast.
- To describe the distribution pattern of the ornamental gastropods around that area.
- To determine the habitat of ornamental gastropods in relation to type of the substratum and sediment texture.

Materials and Methods:

Sampling area: The Red sea is unique which remains warm to great depths, yet its surface water remains pleasantly cool. While biologically part of the great Indo-Pacific region, it has its own character. Many of its species are endemic that is they are found nowhere else. During summer, air temperatures in the region typically exceed 40°C, warming Red sea surface waters to 30°C. Strong evaporation creates high surface salinity which ranges from 42‰ in the north to 37‰in the south and 46‰ in the Arabian Gulf. The area gets only 6-60mm rain annually resulting in insignificant and usually episodic inflow from rivers. Tidal range is minimal, 0.5m in the north and 1.5m in the south (Lieske and Myers, 2004).

Massawa coast, which is part of the Eritrean coastline, is different from other coasts that surround the Red sea. The same as other parts of the Red sea, it gets little inflow of fresh water from the terrestrial areas. In the present study, two sites were selected can represent the intertidal coast around Masssawa, based on its accessibility under most weather condition.

- **Green Island**: This is a closed area located in15°36'N and 39º29'E towards southeast of Dahlak Hotel. Since it is a protected area, there is a little human activities and the wave action is less in the western side compare eastern side. The nature of the substratum is a soft bottom reaches to 5cm depth.
- **Gurgussum:** This area is located in 15°39'N, 39º28'E to the right (east) side of Gurgussum Beach Hotel. In this area there is a considerable wave actions and the substratum is hard toward the lower intertidal and becomes soft bottom (3cm deep) towards the upper intertidal zone. Human activities are more comparing to Green Island.

Data collection and analysis:

Samples were collected using transect and quadrat method from two sites namely, Green Island and Gurgussum. The sampling was done monthly for a period of three months that is February, March, and April 2013. It was conducted in the intertidal zone of each site. By determining the time of lowest of low tide of each site, a transect line was put at a distance of 100 meters starting from the lowest of the intertidal to the upper part of that area. Along with the transect method a quadrat of $1m^2$ (1m x1m) was used at every 25m interval in the transect line. With quadrats, some forms of stratified random sampling usually gave estimates that were closer to known values than simple random placement (Miller and Ambrose, 2000). The quadrat itself was divided in to 25 sub-sections (grids) of each $0.4m^2$. The number of sample to be taken can be determined based on the desire degree of inclusiveness or precision of the data (Brower and Zar, 1977).

Fig. 1. Study area and sampling station

Sediment collection and analysis:

Sediment samples were collected from each quadrat in every month during the sampling period. From each quadrat, sediment was collected from two randomly selected grids. And it was collected in polyethylene plastic bags and was brought to the laboratory for further scientific analysis. To determine the sediment particle size, the sediments were dried in air to remove the moisture content and 100g of sub sample were taken and soaked with hexameta-phosphate dispersant over night. 50% HCl was added into the sediment in order to dissolve the soft shells. Wet sieving was carried out using a sieve of mesh size 62.5µm to separate sand and allied particles from silt and clay, and later dried in oven at 60ºC. The clay components were separated from silt by standard pipette analysis method (Carver, 1971).

Gastropods collection and analysis:

The easiest method and the one which does not require equipment of some complexity is the collection of the larger invertebrate in the eulitoral the true tidal zone where the animal of the epifauna may be taken from the most varied types of substrate (including a stony and rocky substrate) at low tide and those living with in the sediment may be dug out with spade or fork

(Ziegelmeier, 1964). The different species of gastropods were collected by using scraper (scissor like tool) that skims the gastropods found in the selected grids, since almost all of the gastropods are not firmly attached to very hard substratum, it becomes easy to collect them manually using the scraper. For the small and burrower ones, a spade like small material and sieve of mesh size 62.5µm was used to separate them from the sediment particles. The gastropods were collected from two randomly selected grids of each quadrat lied in the 100m length transect line. The gastropods collected were kept in polyethylene plastic containers. To protect any external change on the shell and to avoid the putrid smell after death of the gastropods, 5% formalin solution, was poured into each container that holds live gastropods. Along with the collection of the sediment and gastropods, the presence of other organisms (plants and animals) and other important over all characteristics of each site during the sampling period was recorded.

RESULTS and DISCUSSION

Species identification

The commonest sea snails (gastropods) in the Red sea area contain representative of almost every major family of shells (Bement and Ormund, 1981). In the present study, 31 different species of gastropods were identified. All of them are member of the sub class Prosobranchia, which are commonly known by the presence of hard and diverse shell structure and operculum. Under this subclass, 4 orders were identified namely, Neogastropoda (which includes 15 species under ten families), Mesogastropoda (which contains 10 species under 4 families), Archaeogastropoda (which contains 5 species under 4 families), and Pyramidellomorpha (which comprises 2 species under one family) presented in Table 1)

Substrate nature of the study sites:

In the current study sites, there was a difference in the type of substrate and sediment texture. This difference is largely due to their geographical position in which they are located. In Gurgusum, the sediment texture is dominated by sand. Silt and clay were present in less quantity, although the percentage of silt is greater than clay percent (Table 2). Nature of the substrate is relatively hard with the deposition of sediment about 3-4cm depth. The deposit decreases towards the lower intertidal. This was due to the gentle slope of area and the presence of hard dead coral, which is dominated by seaweeds in the lower parts that protects from small currents and waves that affect the sediment particles.

In Green Island the sediment is dominated by silt and sand which have a closer percentage but the percentage of clay was very little (Table 2). The relatively protected nature of the area leads to have high deposition of sediment and a number of dead shells.

Table 1. The list of identified gastropods (sub class Prosobranchia)

ORDER	FAMILY	SPECIES NAME
NEOGASTROPODA	1 Melongenidae	*Volema pyrum*
	2 Nassaridae	*Nassarius concinnus*
	3 Terebridae	*Terebra babylonia, Terebra nebulosa*
	4 Turridae	*Xenoturris cingulifera,* *Xenoturris cingulifera erythrae*
	5 Conidae	*Conus vexillum* *Conus* spp.
	6 Olividae	*Oliva balbosa*
	7 Costellariidae	*Vexillum exaperatum* *Vexillum osirids*
	8 Coralliophilidae	*Coralliophilia costularis*
	9 Muricidae	*Chioreus vergineus*
	10 Thaididae	*Morula granulate* *Maculotriton cf.serriale*
MESOGASTROPODA	1 Cypraeidae	*Cypraea grayana* *Cyprae* microdon *Cyprae pantherina*
	2 Cerithidae	*Clypeomorus bifasciatus* *Cerithium* spp.
	3 Strombidae	*Strombus fasciatus* *Strombus tricornis* *Strombus metabilis*
	4 Potamididae	*Tereblaria palustris* *Batillaria* spp.
ARCHAEOGASTROPODA	1 Trochidae	*Tectus dentatus* *Polinces turridus*
	2 Neritidae	*Nerita polita*
	3 Littorinidae	*Littorina scabra*
	4 Naticidae	*Notice onca*
PYRAMIDELLOMORPHA	1 Pyramidellidae	*Pyramidellasp &Bulla.ampulla*

Table 2. The average percentage distribution of sand, silt, and clay in the sediment of Gurgussum and Green Island

.

Station	Gurgussum			Green Island		
	Sediment fractions (%)			Sediment fractions (%)		
Quadrant No	**Sand (%)**	**Silt (%)**	**Clay (%)**	**Sand (%)**	**Silt (%)**	**Clay (%)**
1	93.46	6.50	0.04	43.18	56.77	0.05
2	98.11	1.84	0.05	52.05	47.92	0.03
3	97.61	2.33	0.06	39.00	60.95	0.05
4	95.30	4.65	0.05	43.00	56.87	0.13

DISTRIBUTION PATTERNS:

In order to determine whether there exist a variance or not on the distribution patterns of the identified orders in the two sites, a statistical Analysis of Variance (ANOVA) was tested based on the data collected from the two sites during the sampling period (Table 3). Based on the calculation carried at 5% level of significance, there was a considerable variation among the two sites in the distribution patterns of the four orders of gastropods, however there was no significant difference among the orders with in the sites.

Table 3. Distribution patterns of gastropods with respect Gurgussum and Green Island of the intertidal areas of Massawa coast.

ORDER	**GURGUSSUM**				**GREEN ISLAND**				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	TOTAL
Neogastropoda	10	15	12	7	3	6	7	9	69
Mesogastropoda	5	5	10	12	13	7	20	11	83
Archaeogastropoda	6	8	3	4	30	30	17	31	129
Pyramidellomorpha	0	0	0	0	0	0	0	2	2
TOTAL	21	28	25	23	46	43	44	53	283

At 0.05 level of significance columns are variable

Table 4. Distribution of species in the Gurgusum and Green Island

N°	Species name	Gurgusum	Green Island
NEOGASTROPODA			
01	*Volema pyrum*	P	P
02	*Nassarius concinnes*	P	P
03	*Terebra babylonia*	P	P
04	*Tereba nebulosa*	P	A
05	*Xenoturris cingulifera*	P	P
06	*Xenoturris cingulifera erythrae*	P	P
07	*Conus vexillum*	P	P
08	*Conus* spp.	P	P
09	*Oliva balbosa*	P	A
10	*Vexillum exapertum*	P	A
11	*Vexillum osirids*	A	P
12	*Coralliophilia costularis*	P	A
13	*Chioreus vergineus*	P	A
14	*Morula granulata*	P	P
15	*Maculotriton cf. serriale*	P	A
	MESOGASTROPOD		
16	Cypraea grayana	P	A
17	*Cypraea microdon*	P	A
18	*Cerithium* spp.	A	P
19	*Cyprae pantherina*	P	A
20	*Clypeomorus bifasciatus*	P	A
21	*Strombus fasciatus*	P	A
22	*Strombus tricornis*	P	P
23	*Strombus metabili*	P	A
24	*Tereblaria palustris*	P	A
25	*Batillaria* spp.	P	A
	ARCHAEOGASTROPODA		
26	*Tectus dentatus*	P	A
27	*Nerita polita*	P	A
28	*Littorina scabra*	P	A
29	*Polinices turridus*	P	P

30	*Notica onca*	A	P
PYRAMIDELLOMORPHA			
31	*Pyramidella* spp *and Ampulla*	A	P

(Presence indicated by 'P' and absence by 'A')

Always the shape of the gastropods shell relates with their mode of movement as well as habitat, based on the study conducted on shells, those with low spires inhibited on the low vertical surface of rocks and vegetations. Whereas those having long spires shells are cored horizontally even penetrated over soft bottom. Spires may supply to shell strengthening, to protection, to stabilization in soft bottom. The significant variability in the distribution pattern of the different orders of gastropods in both sites is largely due to the difference in the shape of their shells, nature of the substratum of sites and sediment texture. Different species with different shells adapt up on different substrata with different sediment texture.

In Green Island, the substrata are inhibited by gastropods those prefer to burrow in relation to its soft bottom (silty and sandy). As a result, the families of Naticidae, Strombidae, Pyramidellidae, and Cerithdae, which prefer to live in a soft bottom, are dominantly inhabited in this area. Their presence is highly correlated with their shell shape and structure and the mode of feeding habit they exhibit. Since the Strombidae are deposit feeders, they have long spires and other shell projections that help them to burrow in soft bottom and to resist against any other physical factors that affects them and this structure is helpful in dragging over soft bottoms. Pyramidellidae and Cerithdae are carnivorous, their abundance in fine silt area with water depth greater than one meter depth, and they are correlated with presence of worms and crustaceans, which are their preferred food. As a result, they are exclusively found in Green Island. Naticidae are abundant in Green to Island. Their presence is due to the very large foot with which they are able plough up the soft silt of their habitat in search of gastropods and bivalves, which they consume through bored holes and also due to less wave action.

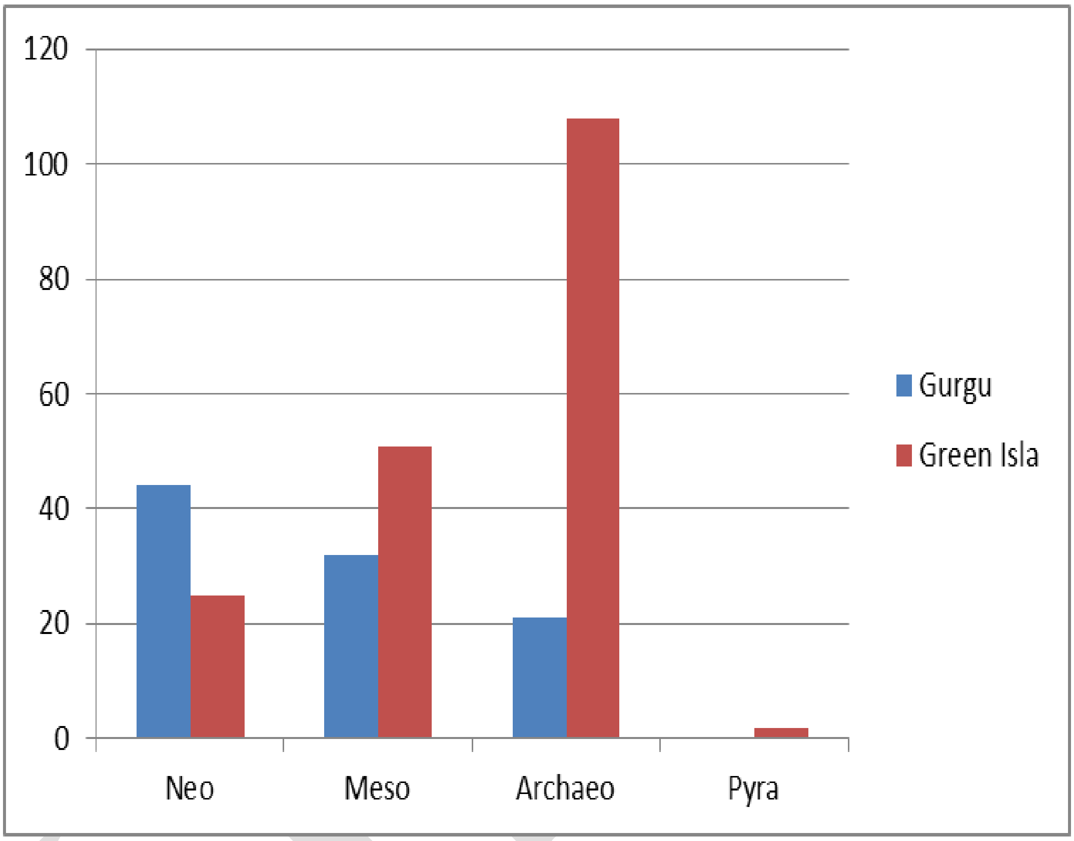
The members of gastropoda that are found in the hard substratum (Gurgussum) are mostly family of Terebridae, Costellariidae, Potamididae, and Littorinidae species. This hardness of substrata is not due to high wave action; it is mainly due to the presence of dead corals that extend from the upper to the lowest of the low tide of the intertidal area and the crevices present in the dead coral that provide shelter or home for many species of Cowries and Cones. They are active predators they creep about on rocks, most feeding on barnacles and bivalves in the intertidal zone. Seaweeds present here use for Terebridae as an attachment and supports different species of herbivorous animals that provide food for the carnivore families of

Matridae, Costellariidae, Cypraeidae and Conidia (Mehari, *et al* 2011). Since the shell structures are the main factor for distribution of gastropods, families that have low spires and lack shell projections are dominantly distributed over the hard substratum of Gurgussum.

The occurrence of each species is usually restricted to a particular horizontal band, due to a number of environmental factors such as degree of wave impact, the slope of the shore, nature of the rock substrate and the presence or absence of seaweeds and other animals (Abbot, 1982). Since the Terebridea and Potamididae have strong spirals, they are relatively dominant in Gurgussum, which has an intertidal sandy substrata nature. Their presence may correlate with their feeding habit, as they are scavengers. In addition, burrower creature occurs in accumulation of sand in rock crevices, where the bottom that is covered with sediment, most of the inhabitants lives within the deposit (Tait and Dipper, 1998) Thermal tolerance in intertidal gastropods is known to vary according to factors such as geography, season, and shore position (Clarke *et al*, 2000). Therefore, the sediment texture, distribution of seaweeds along the intertidal areas and crevices present are the main factors for the big variation in the distribution of gastropods in the two selected areas. As a result, the family of Cypraeidae, Conidia, Olividae, are distributed only in the lower part of the intertidal that has dead corals with crevices that provide shelter from exposure to environmental variation. The Naticidae, which are low competitive and well adapted to sun exposure. Their distribution is limited in the upper intertidal and on hard substrate for attachment. In addition to this, the commonly distributed family of Nassaridae and Melogenidae are dominantly found in the middle intertidal that have more sediment deposition and water pool that provide protection from environmental factors. The commonly known species which belongs to families of Cypraeidae, Conidae, and Olividae are carnivorous and their distribution are limited to the lower intertidal area.

The particle size or sediment texture of the bottom plays a great role in determining the distribution of gastropods that’s why all gastropods have been identified have soft bottom representatives. The modes of burrowing of many creatures are specialized in suitable only for certain grade of sediment (Trueman and Brown, 1992).

The abundance of species was more in Green Island comparing to Gurgussum. This is because of the type of the substrata compare to Gurgussum, which is a soft bottom, contains a comparative percentage of sand and silt sediments and it is a fully protected area from human activity. That is why it is dominated with few species but more abundance. In contrast, species diversity is high in Gurgussum. This is due to the type of substrate in Gurgussum is dominated by dead corals and the presence of seaweeds which serves as shelter and food for many species of Cowries, Cones, and Oliva species. This variety of habitat allows different species to be available based on their niche. The distribution and abundance of gastropod have been greatly affected by fishing pressure, which is common in shallow even intertidal (Browell and Stevely, 1981).



No/m^2

GROUPS

Fig.1. General Distribution patterns of the four orders of Gastropods with respect to the two sites in the intertidal waters of Massawa.

CONCLUSION:

Based on the study conducted for three months in the two sites around the intertidal area of Massawa, about 31 species of gastropods (sub-class of Prosobranchia) which belongs to the phylum of mollusca, have been identified. From the data analysed it can be concluded that, a number of gastropods species are present around the intertidal coast of Massawa. From the results obtained, the sediment texture in Gurgussum, is dominated by sand (> 93%), and in Green Island the sand and silt is found with closer percentage. The percentage of clay is very small (<1.00%) in the two sites (Gurgussum and Green Island). But, the different orders of gastropods among the two sites and within the sites themselves shows a variation in their distribution pattern during the sampling period, this variation is largely due to the difference in substrate nature and sediment texture of the areas, availability of seaweeds and crevices respectively, in the two sites.

REFERENCES:

Abbot, T.R (1982). The Kingdom of Sea Shells. Bonanza Books. 1,46p.

Barnes, D.R (1980).The Invertebrate Zoology Holt-Saunders International Edition.342p.

Beesely, P.,Ross GIB, and Well (1998).Mollusca. The Southern Synthesis, Fauna of Australia Vol.5; 123-125. CSIRO Publishing: Melbouna XVI. 567p.

Bement G, Ormund (1981). Red Sea Coral Reefs. Western Press Ltd. Kent 81-83 p.

Brower, J.E, and Zar JH, (1997).Field and laboratory methods for Ecology, Brown Dubuque. Iowa. 194p.

Browell, W.N, Stevely J.M (1981). The Biology, Fisheries, and Management of the Queen Conch, *Strombus Gigas*, Mar, Fish, Reu, 43:1-12.

Caddy, F.J, (1989). Marine invertebrate Fisheries: Their assessment and management.FOA.A Wiley- interscience publication. Rome, Italy.443p.

Carver, R.E (1971) Procedure in Sedimentary Petrology. Wily, New York 635

Clarke, A.P, Mill P.J, Grahame, J (2000).The Nature of heat coma in littorina littorea (Mollusca Gastropoda) Marine Biology.Vol. 137. P 147-451

Curtis, H (1979). Biology.Third edi.Worth publishing.Inc.NewYork USA. 444p.

Dance, P.S (1989). Sea Shells. Treasures press Michelin Huose. 85p.

Evans, M.S, Knowel G, Pye-Smith C, Scott R (1977).Conserving Shells in Kenya. Oryx 13(5): P480-485.Cambridge University Press. P147-160.Gigas, Mar, Fish, Reu, 43:1-12.

FAO (1980). Year Book of Fishery Statistics: Catches and Landing, Vol. 50.FAO Rome.

FAO (2002).FAO Species Identification Guide for Fishery Purposes: The Living Marine Resources of the Western Central Atlantic, Vol1.pp99.

Halsted, P.J, Halsted C.D (1980).The cowries of Zanzibar.Bull.East. Afr. His.Soc.7-8: p 67-69.

Hickman, O.C, Roberts L.C, Hickman F.M (1982) Biology of Animals. The CV. Mosby Company USA. 381p.

John. D (1984).Department of Marine Zoology In: Sharabati D (1984).Red Sea Shells. Routledge and Kegan Paul Plc, Boston, USA. 1p.

Jessop MN (1988) Zoology. S chaum's Outline Theory and Problems of Zoology.McGaw.

Hill.Inc. p 163

Johannes, E.R (1981). Making better use of Existing Knowledge in Managing Pacific Island. 245p.

Lieske, E, Myers F.R (2004). Coral Reef Guide of Red Sea: The definitive guide for Over 1200 Species of underwater life. Harper Collins Publisher. 6p.

Miller, W.A, Abrose F.R (2000). Sampling patchy distributions: Comparison of sampling Designs in rocky intertidal habitats. Mar. Ecol. Prog. Ser. Vol. 196:1-2

Miller, A.S, Harley P.J, (1994). Zoology.Wm. C.Brown communications in publication. Rome, Italy.443p.

Mehari, Mebrhatu and Merhawi,(2011) Senior Research Paper on ornamental molluscs (Unpublished).

Parkinson.B (1982). The specimen shell resources of Fiji. South pacific commission, New Caledonia.45p.

Prasad, S.N (1980). Life of Invertebrates.Vikas publishing House Pvt Ltd.New Delhi India

Ruppert E.E, Fox SE, Brnes DR (2004) Invertebrate Zoology. Thomson Brooks/Cole. 284-366p.

Russel, J.P, Wolfe, L.s, Hertz, E.P, Star C, Mcmillan B (2008) Biology. The Dynamics of Science, Thomson Higher Education Belmont. P.869 Biological Association, Ambleside, England's 160

Sharabati, D (1984). Red Sea Shells. Routledge and Kegan Paul Plc, Boston, USA.

Salm, V.R (1978).Conservation of Marine Resource in Seychelles. IUCN Report to the Government of Seychelles, Morges, Switzerland.

Tait, V.R, Dipper, A.F (1981). Elements in Marine Ecology. Boston University Press, Oxford, 251p.

Trueman, E.R, Brown, A.C (1992). The Burrowing Habit of Marine Gastropods. Advances in Marine Biology, 28:389-432.

Wells, S.M (1981). International trade in ornamental shells. IUCN conservation monitoring Centre. Cambridge , UK.p22

Wu, LW (1999). Molluscs in Cites. Academic Sinica and Council of Agriculture 44p.

Zieglmier, F (1964). Macrobenthos .In: Schliper, C (1972). Research Methods in Marine Biology. Siolgwick and Jasson. 118p.