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THE MOST COMMON ROCKY SHORE INVERTEBRATE DWELLERS OF THE RED SEA COAST, EGYPT

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ABSTRACT

Along the Egyptian Red Sea Coast from Abu Darag on the Gulf of Suez southwards to Berenice, 19 species form the most common invertebrates that inhabit the widely distributed rocky shore niches. These species belong to Bivalvia, Gastropoda, Bryozoa, Annelida, and Cirripedia. They are all also recorded as fossils from the Pleistocene, some of them are dated back to the Pliocene. The recorded species have different modes of life: encrusters, clingers, crawlers, and byssate. Most of them tolerate the strong ecological stresses of the tidal zone especially desiccation and exposure to strong waves, few are not. The niches inhabited by them vary from nearly flat to slightly sloped rocky surfaces clean from sediments, others are covered by thin veneer of mud and/or sand, or vertically standing rocky walls, or even loose gravelly beaches. Population structure varies from one taxon to another. Also population structure changes within the same taxon from place to place according to shore level, wave exposure and microhabitat. The youngest raised coral reef, and the fine and coarse weathering products of the nearby sedimentary and basement rocks, as well as mangrove beaches are the main natural rocky shores present. Wastes of different solid objects offer local hard substrates that change community structures in non-rocky shore sites.

INTRODUCTION

The seashore gives most people their first taste of the diversity of life in the sea. The transition from a fully aquatic marine habitat to fully terrestrial conditions occurs within a few hundred meters at the most and often less than ten meters. Rocky shores are particularly suitable for research and education. They are essentially two-dimensional and are easily sampled non-destructively, without the need to dig and sieve which is so necessary on sandy and muddy beaches (Hawkins and Jones 1992).

The present work represents a part of the Ph.D. thesis carried out by the last author. It aims to: 1) detection of the most common invertebrate rocky shore dwellers that inhabit the sea shore today and have a geologic age dated back to the Pliocene, 2) reporting their modes of life, community structure, population densities, and associated fauna, 3) study of their microhabitat, and 4) the most effective autecologic parameters that affect their aerial distribution.

MATERIAL AND METHODS

Forty stations were selected to cover most of the Egyptian Red Sea Coast (*ca.* 800 km) from Abu Darag on the Gulf of Suez, in the north to Berenice in the south (Fig. 1)

Samples of living sea shells (bivalves, gastropods, amphinuras, barnacles, bryozoans, and annelids) were collected. Remarks and observations were reported on their habitat, abundance, diversity, community density, and community structure. Samples of the beach sediments or beach rocks or artificial substrates, as well as water samples, were also collected from the studied stations. Samples were collected by wandering along the shoreline, mostly from the high tide zone, the intertidal zone, and even below the low tide zone to a maximum of 1.5m. Unfortunately, it was impossible to collect samples below this limit owing to logistic,

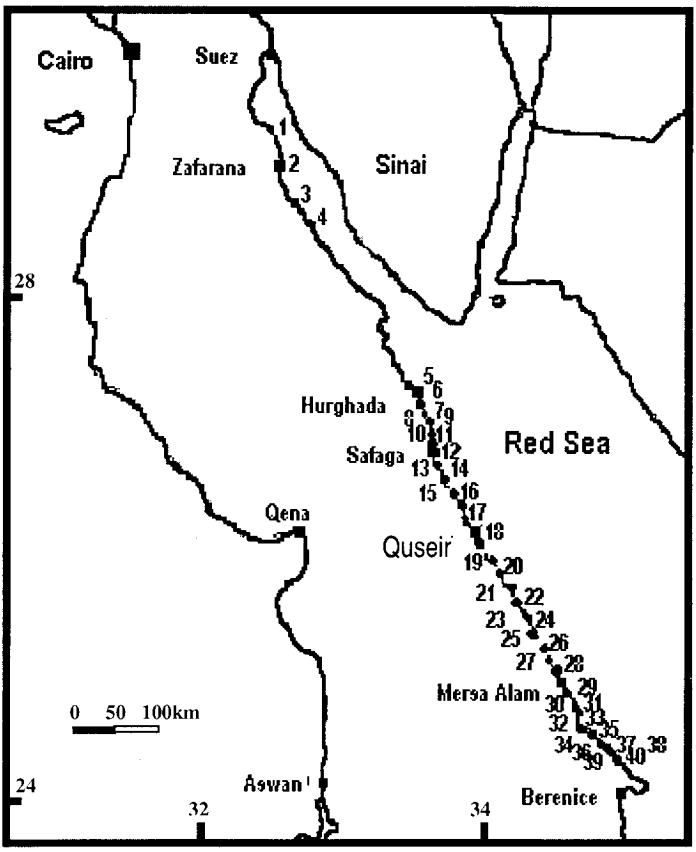

Fig. 1: Location map.

technical and financial problems.

All samples are deposited in the Museum of the Geology Department, Faculty of Science, Zagazig University, Zagazig, Egypt.

NATURE OF SHORELINES

The Red Sea coastal plain in Egypt, and consequently the beach and shoreline, varies from place to place in width, sediments, and topography. Along the west side of the Gulf of Suez, the coastal plain is a narrow strip of land, only few tens of meters in width except where the side western wadies open into the gulf, as in station 2 where Wadi Araba spelling opens into Zafarana. South of Gharib till Hurghada (stations 2-5), the plain averages 30 km. From Safaga and southward to Berenice (stations 6-40), the coastal plain becomes narrow again reaching less than 5 km.

The Egyptian Red Sea coastal plain is bordered by different lithostratigraphic units ranging in age from Precambrian to Recent. It is littered by different Carboniferous to Cretaceous rock units, which are exposed allover most parts of the western side of the Gulf of Suez. Miocene rock units cover a small area near Gharib and most parts from Hurghada and southwards (stations 7-40). Precambrian rocks littered the Miocene exposures and their weathering products

constitute considerable amounts of the beach sediments and beach rocks in many parts of the studied locations especially the wadi mouths. More details on the geology of the Red Sea coastal plain are found in Said (1962 & 1990), and Issawi *et al.* (1999).

There are also some man-made modifications in many parts of the studied stations, e.g. landfill and waste accumulation of different materials, shapes and sizes (plastic, wood, metals, concrete, tar balls and sheets). These wastes change locally the nature of the shoreline, as the presence of local hard substrates in a sandy shoreline affect the structure of the natural community.

According to the type of shore materials, the shoreline could be classified into the following types:

1- Reefal beaches

These beaches are composed of hard, massive algal coralline limestone of the youngest Pleistocene raised coral reef. Along the Red Sea Coast, most of the tourist villages and resorts were built above this unit. Reefal beaches are found in two forms. The first form consists of walls facing the sea, 0.5-9m height (Pl. 1/1), clean from sediments and sea water reaches during high tide. They are vertical or strongly sloped (60-90º) and represent a suitable substrate to some invertebrate dwellers that tolerate desiccation and strong waves e.g. *Balanus*, *Chiton*, some gastropods and green algae as in stations 5, 6, 14, 17, 21 and 40. The second form is low, flat coral heads up to 2m width, of different scleractinian species and sea water covers these beaches during high tide (Pl. 1/2). Such beaches are locally covered by thin veneer of mud and/or sand. They represent the substrate for many dwellers e.g. *Patella* and *Chama* as in stations 20, 25, 26 and 35.

2- Gravelly beaches

Beaches formed of non-consolidated pebbles to cobbles of different origin (rhyolite, basalt, porphyritic dacite or even of sedimentary origin). These clasts are transported to the shore from the hinterland "mountains" (Pl. 1/3). Sea water covers these beaches during high tide. Such clasts act as a suitable substrate for some clingers of gastropods e.g. *Planaxis* as in Zafarana area. In Safaga area, encrusting bryozoans, serpulids and vermetids are fixed above the clasts in the supratidal zone.

3- Sandy beaches

These beaches are mostly present along the entrances of large wadies. They are formed of friable sandy and locally gravelly sediments. Shells and fragments of molluscs, algae, corals, and foraminifera are drifted by storms and high tide above these beaches (Pl. 2/1). The foraminiferal tests *Sorites* may form up to 25% of the beach component in some localities. In some localities the sandy and pebbly sediments are consolidated to form hard rocky shore. The fissures and cracks in such rocky shore contain water during low tide and so some gastropods tolerate survival in such fissures.

4- Mangrove beaches

Mangrove stands are found in many stations on the Red Sea Coast. They become more frequent and extensive towards the south. The roots are nurseries and provide nests for several species of fish, shrimps, algae, bivalves and other crustaceans (Pl. 1/4). The trees form breeding habitats and nesting sites for birds.

The sediments between mangrove stands are very fine due to trapping away from strong waves. In the study area mangroves are represented by one species *Avicennia marina* as in south Um-El Howaitat and 98km south Mersa Alam.

MODES OF LIFE

The studied invertebrate rocky shore dwellers are classified here into four major groups, namely: Incrusters, clingers, crawlers, and byssate.

1) Incrusters:

Incrusters are those sessile epibenthos which are permanently attached to the substrate by cementation, and cement themselves by calcification. This group includes the following taxa: Barnacles, incrusting bryozoans, vermitids, serpulids, and chamas. All of them - except bryozoans- are among the most tolerant benthos to the extreme conditions and desiccation that exist in the Red Sea intertidal and supratidal zones. They are capable of storing water to enable them to survive long periods of emersion.

Barnacles

Cirripeds or barnacles are highly unusual crustaceans that loose many of their typical arthropod features. All adults of the principle order are sessile, and all have

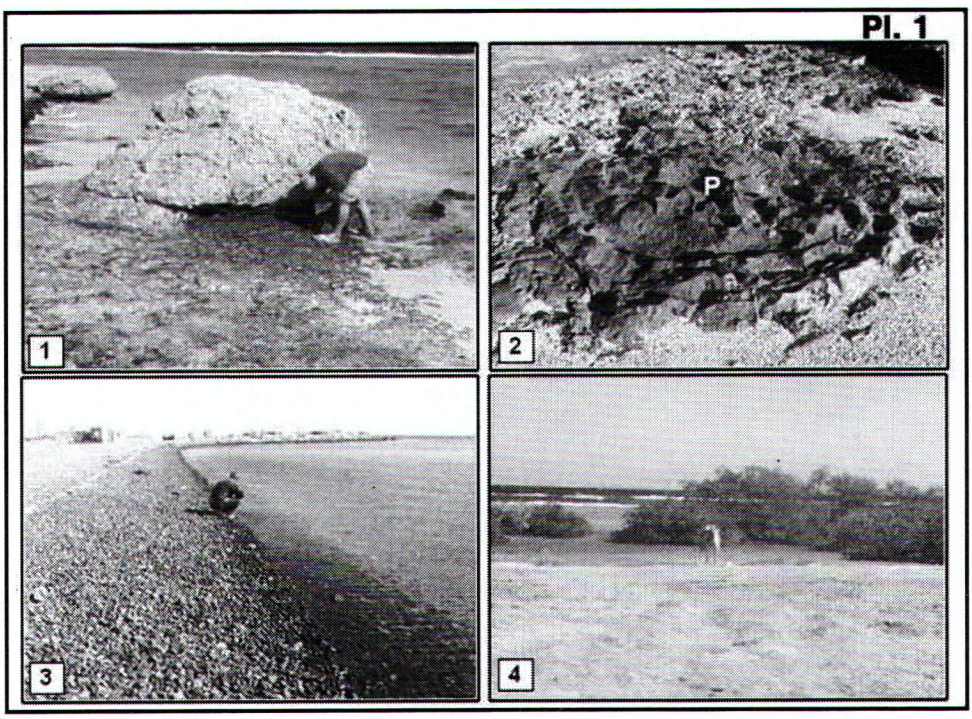

Fig. 1: Reefal beach facing the sea, composed of hard, massive algal coralline limestone walls, of the youngest Pleistocene raised coral reef, 112km N. Mersa Alam.

Fig. 2: Reefal beach composed of flat, large coral masses of *Porites* (P). It becomes covered by sea water during the high tide, 40km N. Mersa Alam.

Fig. 3: Gravelly beach composed of pebbles to cobbles of igneous origin, transported to the shore from the hinterland, Northern Safaga Bay.

Fig. 4: Mangrove beach formed of frequent and extensive mangrove trees, south Um El-Howaitat area.

a bivalve larval stage that bears a close superficial resemblance to a smooth-shelled ostracod. The carapace of the larva is discarded during metamorphosis and replaced by a fleshy mantle and a series of calcified plates that form a protective compartment for the body and appendages.

Barnacles are common worldwide in all modern shallow marine environments, occupying shorelines of all continents. They are also commonly attached to such swimming and floating objects as whales and ships. The shell is bilaterally symmetrical and consists of four to eight calcified compartmental plates that are usually rigidly articulated to form a circular wall. The wall is anchored to the substrate by either a membranous basis or a calcareous basal plate (Boardman *et al.* 1987). Barnacles are not as common in the Red Sea as they are in many other marine locations. This is partially due to the restricted diurnal tidal range which occurs for the greater part of the Red Sea.

In those areas where a significant daily tidal fluctuation dose occurs, the barnacles *Balanus perforatus* Brugiere, 1792 and giant barnacle *Tetracelita squamosa* may form quite distinct zones. Both species are occurring close to the top of the shore and extending over the major area of the barnacle zone. The above-mentioned barnacles are found on any available rocky hard substrates, either natural or artificial (solid wastes, pipes, ships). Barnacles are collected from many stations (Table 1).

The community density attains a maximum value from 400-500 individuals/m^2 in *Balanus perforatus* Brugiere,1792 which often observed without any associated encrusters (Pl. 2/2), while *Tetracelita squamosa* from 30-40 individuals/m^2 (Pl. 2/3), and is often associated with *Patella* (*P.*) *vulgata* Fleming, 1822 and *Monodonta nebulosa* (Forskal, 1775).

BRYOZOANS, VERMETIDS AND SERPULIDS

Bryozoans are colonial, sessile animals. Most bryozoans form flat encrusting colonies, some are plant-like and others form erect plates. They are among the first organisms to colonize newly exposed surfaces on coral-reefs. They play a significant role in cementing together coral fragments and thus consolidating the structure of the reef (Vine, 1986).

Along the Red Sea Coast, one can see colonies of encrusting bryozoans, with diameters up to 0.8 to 3 cm on the underside of dead coral branches and heads and shells of other groups. Also they encrusted cobbles and boulders of rhyolite, basalt and porphyritic dacite. All represent the suitable hard and smooth substrate needed for such bryozoan growth. In the studied localities (Table 1), the encrusting bryozoans are represented by many species of membraniporiform and celleporiform (both are encrusting growth-forms), such as *Holoporella polythele* (Reuss, 1848) *Watersipora subtorquata* (d'Orbigny, 1852). They are associated with *Balanus perforatus* Brugiere, 1792 and serpulid-tube worms, namely *Spirorbis* sp. and *Serpula* sp. (Pl. 2/4, Pl. 3/1).

Family Vermetidae is a worm gastropod, having irregularly coiled, tubular shells cemented to hard substrates, which is often a living coral or the hydro-coral *Millepora*. The animals capture floating organic matter by mucus threads or by cling action (Bosch *et al.* 1995). In the studied localities (Table 1), *Dendropoma maximum*, attains densities of more than 22 specimens/m^2, and prefers the hard substrate of man made concrete pipes and skeletons of corals and other shells in

the intertidal zone (Pl. 2/4).

Family Serpulidae (calcareous tube-worms) is divided into two main groups: Spirorbidae, with generally coiled tubes and Serpulidae, with generally uncoiled tubes (Vine, 1986). Their white calcareous tubes are frequently patterned with longitudinal ridges, spines or by transverse thickening (Pl. 3/1). In the studied localities (Table 1), the habitat and occurrences of the serpulids are closely similar to the above mentioned encrusting bryozoans and vermetids.

Chama

Shells of the Family Chamidae are inequilateral and strongly inequivalved, with spiral umbos. The attached or lower valve is cup-shaped, thick and is cemented to the substrate, while the upper or free one is more flattened, thinner and acts as a lid. Scaly or spiny projections are often present. They live attached to coral boulders or in crevices on the reef-platform, and often present below low tide level (Pl. 3/2). They are suspension feeders and mostly found as single valves, cast up on the beaches after a storm (Donald and Bosch, 1982).

Only one species of the family Chamidae is recorded from the studied localities

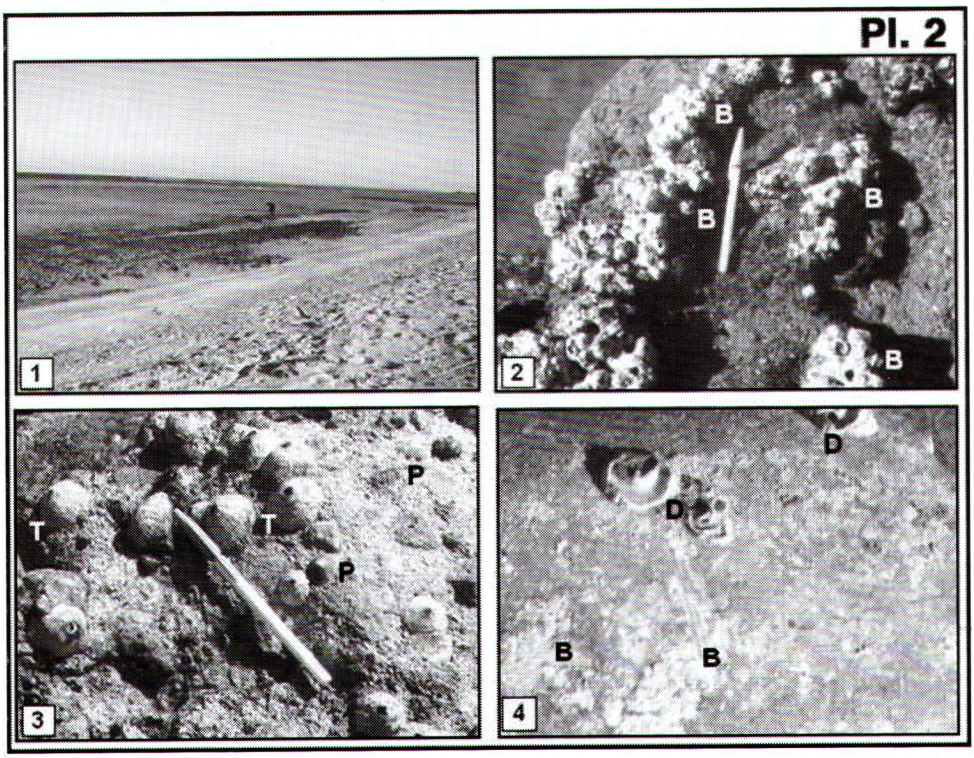

Fig.1: Sandy beach, mostly composed of friable and consolidated sandy and pebbly sediments, 37km north Quseir area.

Fig. 2: *Balanus perforatus* (B) fixed on the upper part of the youngest Pleistocene raised coral reef, 55km south Mersa Alam.

Fig. 3: *Tetracelita squamosa* (T) fixed on the upper parts of the youngest Pleistocene raised coral reefs and associated with *Patella* (*P.*) *vulgata* (P), Hurghada beach.

Fig. 4: *Dendropoma maximum* (D) prefers the hard substrate of man made concrete pipes, associated with encrusting bryozoans (B), intertidal zone, 12km north Safaga.

(Table 1), namely *Chama pacifica* (Broderip, 1835). It is recorded in living position in station 35, where a thin muddy sand layer covered the flat hard substrate (the youngest Pleistocene raised coral reef). The community density there attains about 30-40 individuals/m^2.

2) Clingers:

Clingers are very slow vagile epibenthos, and clinging tightly to rocks in shallow water or in littoral (or exposed to splash) zone. They are represented by limpets and chitons. They adhere themselves firmly by a strong and large muscular foot and use well developed radula for grazing on algae. They tolerate the same environmental stresses mentioned in the incrusters. Representatives of this group confined their foraging activities to the hours of darkness, generally at low tide. Patellas and chitons are strongly attached to the substrate in comparison to neritas which are attached but not as strong as the later taxa. This is attributed to their smaller feet (Bosch *et al* 1995).

Chiton

Chiton is a genus of the Class Amphinura, usually found from high-tide level to moderately shallow water, on or under rocks, stones or similar hard substrates. Chitons are vegetarian, feeding mainly on algae (Donald and Bosch 1982).

Chitons or coat-of-mail shells are common in some localities along the Red Sea Coast (Table 1). They have flattened bodies with eight overlapping transverse plates, which are partially embedded in and surrounded by a relatively thick and fleshy girdle, which may have spines or scales. A large muscular foot dominates the underside. The head lacks eyes or tentacles. Most species become active at night when they use a well-developed radula to scrape their algal food from rock surfaces (Vine 1986). The species is represented in the studied locations by *Chiton peregrinus* Thiele 1910.

In the study areas it is obvious that the abundance of the Chitons decreases radically or even becomes absent where thick algae cover the shore, especially in phosphate-polluted areas, such as in El-Hamrawein area. The thick algal cover prevents the firm fixation of Chitons on such substrates.

In the studied area *Chiton peregrinus* Thiele, 1910 lives on and under raised reefs, using foot exercises a powerful suction force to cling firmly to rocks. The beach is often a wall of Pleistocene reefs, reaching the high tide level (Pl. 3/3). These walls are often nearly vertical or of inclinations ranging from 60-90º. In some sites, the communities range from 7-10 individuals/m^2. *Chiton peregrinus* Thiele 1910 is commonly associated with *Nerita* (*Theliostyla*) *albicilla* (Linnaeus, 1758), and *Monodonta nebulosa* (Forskal, 1775).

Patella

Patellids are saucer-shaped shells, often irregular in outline, elevated or depressed. Radiating ribs may be prominent and extend beyond margin. The internal muscle scar is horse-shaped and often distinctively colored. The animals lack an operculum and true gills. They are shore dwellers, and adhere to smooth rocks, often tenaciously. They tend to return to the same location after grazing algae and may make shallow impressions in rocky surfaces.

They are vegetarians, usually moving about at night to browse on algae on the rocks. Their shells are perfectly shaped for withstanding the violent action of the

waves and they can cling tightly to the rocks, storing water within the shells and thus having the ability to tolerate long periods out the water, as many live at or near the high tide mark (Donald and Bosch 1982).

Table 1: The distribution of the living studied species along the Red Sea Coast.

Station numbers	Locations / Species	*Balanus perforatus*	*Tetracelita squamosa*	*Holoporella polythele*	*Watersipora subtorquata*	*Spirorbis* sp.	*Serpula* sp.	*Dendropoma maximum*	*Chama pacifica*	*Chiton peregrinus*	*Patella (P.) vulgata*	*Nerita (Theliostyla) albicilla,*	*N. longii,*	*N. textilies,*	*Planaxis sulcatus*	*Cerithium caeruleum*	*C. nodulosum*	*Rhinoclavis (Proclava) kochi*	*Modiolus (M.) auriculatus*	*Tridacna squamosa*
1	Abu Darag								*			*		*		*	*	*		
2	Zafarana										*	*		*	*		*		*	
3	60km south Zafarana										*	*		*			*		*	
4	75km south Zafarana	*	*									*	*	*		*	*	*	*	*
5	Hurghada city		*	*	*	*	*	*	*		*	*		*	*		*			*
6	10km S. Hurghada	*	*						*	*	*	*	*	*	*	*	*	*		
7	20km S. Hurghada			*	*	*	*	*			*	*		*	*				*	*
8	31km N. Safaga			*	*	*	*	*	*			*		*					*	*
9	17km N. Safaga	*		*	*	*	*	*				*							*	*
10	12km N. Safaga			*	*	*	*	*				*			*				*	
11	Northern Safaga bay			*	*	*	*	*	*			*	*	*	*	*	*	*	*	
12	Southern Safaga bay			*	*	*	*	*	*		*	*		*	*	*	*	*	*	*
13	68km N. Quseir											*				*	*	*	*	*
14	62km N. Quseir									*	*	*	*	*	*		*		*	
15	50km N. Quseir	*	*						*	*	*	*	*	*	*	*	*	*	*	*
16	37km N. Quseir											*			*	*	*	*	*	*
17	El-Hamrawein port								*	*		*							*	*
18	Quseir City								*	*		*		*	*		*		*	*
19	5km S. Quseir	*		*	*	*	*	*			*	*				*		*	*	
20	12km S. Quseir			*	*	*	*	*				*	*		*				*	*
21	112km N. Mersa Alam										*	*	*						*	
22	97km N. Mersa Alam	*							*		*	*		*					*	*
23	85km N. Mersa Alam								*			*		*					*	*
24	71km N. Mersa Alam	*									*	*		*	*	*	*	*	*	
25	55km N. Mersa Alam	*							*		*	*		*	*				*	
26	40km N. Mersa Alam	*							*			*	*	*	*	*	*	*	*	*
27	30km N. Mersa Alam											*		*	*	*		*	*	
28	19km N. Mersa Alam											*			*	*	*	*	*	*
29	Mersa Alam city	*	*						*			*		*	*				*	*
30	8km S. Mersa Alam	*										*	*			*	*	*	*	
31	20km S. Mersa Alam											*		*	*		*			
32	32km S. Mersa Alam	*									*	*			*		*		*	
33	43km S. Mersa Alam											*		*	*	*	*	*		*
34	55km S. Mersa Alam	*									*	*		*			*			*
35	60km S. Mersa Alam										*	*		*		*		*		
36	75km S. Mersa Alam											*	*	*	*	*	*	*		
37	87km S. Mersa Alam								*			*		*	*	*	*	*		
38	90km S. Mersa Alam	*	*									*		*	*	*	*	*		
39	95km S. Mersa Alam									*		*		*	*	*	*	*		
40	43km N. Berenice		*						*		*	*	*	*	*	*	*	*	*	

Family Patellidae is represented in the studied locations by only one species, namely *Patella* (*P.*) *vulgata* SD. Fleming 1822 (Pl. 3/4). This species is recorded from many stations (Table 1), where hard substrates are available in the high tide zones, clinging firmly to either gently sloped or nearly vertical shorelines. The community density attains a maximum of 12-20 individuals/m^2. *Patella* (*P.*) *vulgata* SD. Fleming, 1822 is commonly associated with *Balanus perforatus* Brugiere, 1792 and *monodonta nebulosa* (Forskal, 1775).

Nerita

All species of family Neritidae have solid globular shells with a low or depressed spire, a large body whorl and a callused columellar pad which may be smooth, granulated or ridged. There is no umbilicus. The shell surface may be smooth or spirally ribbed and the aperture may be denticulate at its outer edge. The calcareous operculum is thick and with half-moon shaped (Bosch *et al.* 1995).

Nerites are vegetarians and many of them live under intertidal rocks but some are conspicuous on rocky surfaces above high-tide level. They have the ability, to store water within their shells and hence can stand long periods of desiccation. This

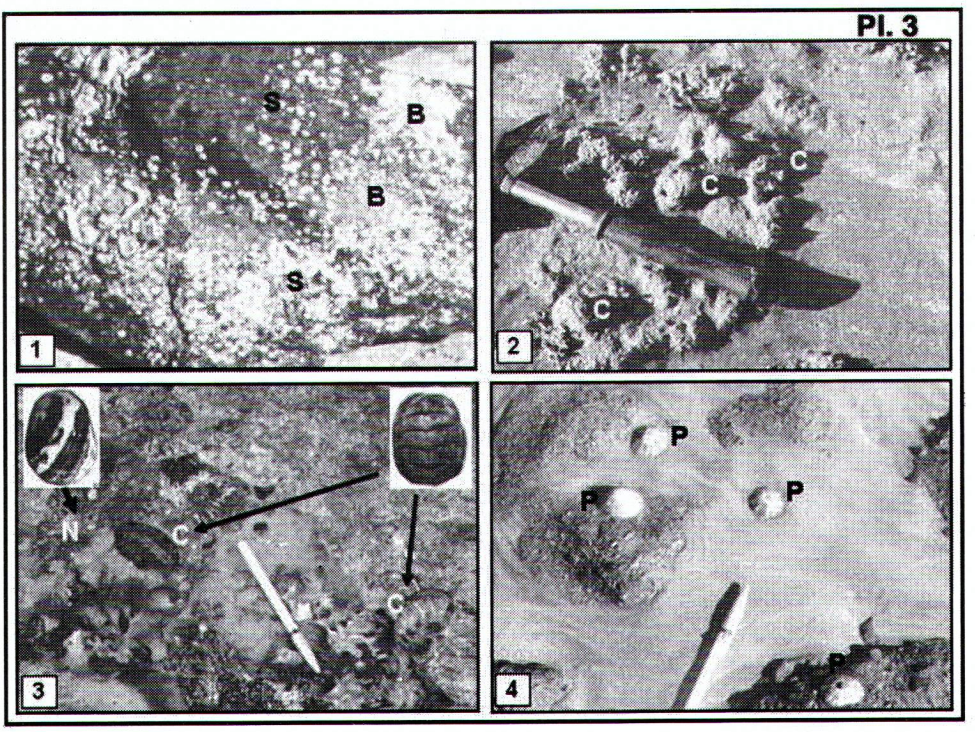

Fig. 1: Bryozoan (B) and serpulid (S) incrustations on rhyolitic cobble, high tide zone, Southern Safaga Bay.

Fig. 2: Many living *Chama pacifica* (C) cemented by their lower valves on flattened surface of the youngest Pleistocene raised coral reef, thin muddy sands cover the whole community, 55 km north Mersa Alam.

Fig. 3: *Chiton peregrinus* (C) and *Nerita* (*T.*) *albicilla* (N) cling firmly on the walls of the youngest Pleistocene raised reef in the high tide zone, Wadi Gasus.

Fig. 4 : *Patella* (*P.*) *vulgata* fixed firmly on hard beach rocks present within sandy pools of the high tide zone, 55km north Mersa Alam.

can be demonstrated if the animal is forcibly pulled away from the rock at which time it will squirt out water as it retracts into the shell (Donald and Bosch 1982).

Nerites are among the most tolerant gastropods to the extreme conditions of heat and desiccation, which exist in the Red Sea intertidal and supralittoral zones. The collected samples are still alive in the laboratory after more than one month. They are usually associated with living *Nodilittorina* (*N.*) *natalensis* (Philippi, 1847), *Cerithium caeruleum* Sowerby, 1855, *C. nodulosum* (Bruguière, 1792), *Rhinoclavis* (*Proclava*) *kochi* (Philippi, 1848), *Chiton peregrinus* Thiele 1910 and *Planaxis sulcatus* (Born 1780).

Family Neritidae is represented in the studied locations by three species, namely *Nerita* (*Theliostyla*) *albicilla* (Linnaeus, 1758), *Nerita longii* (Récluz), and *N. textilies* Gmelin, 1791 (Pl. 3/3 & Pl. 4/1). These species are recorded from many stations (Table 1). Wherever hard substrates are available in the high tide zones, Neritas are there, clinging firmly to either gently sloped or nearly vertical shorelines. The community density attains a maximum value of 10-20 individuals/m^2 in stations 14 and 39.

3) Crawlers

Crawlers are those epibenthos that and have long-spired turreted shells move slowly with their bodies close to the ground. They are here represented by four gastropod species: *Planaxis sulcatus* (Born 1780), *Cerithium caeruleum* Sowerby, 1855, *C. nodulosum* and *Rhinoclavis* (*Proclava*) *kochi* (Philippi, 1848). Moreover, their apertures and feet are small, so they can not adhere their shells firmly as the clingers do. For these reasons, the studied crawlers tend to inhabit the shallower parts of the intertidal zone. They can tolerate staying above sea water temporary for short time intervals, but not so long as the above mentioned clingers. Substrates needed for these crawlers should be of smooth surfaces clean of any sediment.

Planaxis

Planaxids are characterized by thick, conical-globose shells, and no umbilicus. There is a slight anterior canal and a thin, horny operculum. Often the tip of the spire is worn off (Donald and Bosch 1982). They are browse algae between tide marks (Bosch *et al.* 1995).

Family Planaxidae is represented in the studied localities by only one species namely *Planaxis sulcatus* (Born 1780). This species inhabits rocky shores and at the edge of pools in the intertidal zone, where it is frequently found in large numbers, clustering together.

Planaxis sulcatus (Born 1780) is recorded from many localities (Table 1) gently sloped or nearly flat, as a characteristic member of the "splash zone" community, where the beach often consists of cherty stones and rock fragments (Pl. 4/2).

The communities range from 60-80individals/m^2 and are usually associated with living *Monodonta nebulosa* (Forskal, 1775), *Nerita* (*Theliostyla*) *albicilla* (Linnaeus, 1758), *N. longii* (Récluz), *N. textilis* Gmelin, 1791, *Nodilittorina* (*N.*) *natalensis* (Philippi, 1847), *Cerithium caeruleum* Sowerby, 1855, *Rhinoclavis* (*Proclava*) *kochi* (Philippi, 1848) and *Chiton peregrinus* Thiele 1910.

Cerithium

Family Cerithiidae is characterized by elongate shells with an anterior, recurved siphonal canal and a posterior notch. The operculum is horny. Many species are

sculptured with tuberules, nodules, spiral cords or ribs. Some live often on silty or muddy places, others prefer the vicinity of coral reefs where there are frequent patches of sand or rubble. Family Cerithiidae are a shallow water family, herbivorous, which feed on plant detritus and algae and some may congregate in large numbers (Donald and Bosch 1982 and Bosch et al 1995).

In the studied localities (Table 1), Family Cerithiidae is represented by three species, namely *Cerithium caeruleum* Sowerby 1855, *C. nodulosum* (Bruguière 1792) and *Rhinoclavis* (*Proclava*) *kochi* (Philippi, 1848). They live on hard, nearly flat substrates of rock fragments, between corals (Pl. 4/1) and some species live on firm substrate.

The communities range around 80-100 individuals/m^2 and are usually associated with living *Nerita* (*Theliostyla*) *albicilla* (Linnaeus, 1758), *N. longii* (Récluz) and *Planaxis sulcatus* (Born 1780).

4) Byssate

Many bivalves secrete threads of the protein collagen, with which they attach themselves to the sea floor. This group is represented in this study by two bivalve species: *Modiolus* (*M.*) *auriculatus* (Krauss) and *Tridacna squamosa* Lamarck, 1819. Both species live entirely covered by sea water, and can not be found alive if exposed above.

Modiolus

Shells of Family Mytilidae are equivalved, inequilateral, with or without hinge teeth. The umbo is usually at or near the anterior end. They frequently live in large colonies in groups or banks. To avoid being traumatized by waves and currents, they attach themselves to fixed objects by means of a threadlike byssus which is very strong and difficult to pull apart (Donald and Bosch 1982).

Modiolus (*M.*) *auriculatus* (Krauss) lives attached to hard substrates offered by the youngest Pleistocene raised coral reef in the shallow waters below the low tide level and found in irregular lines (Pl. 4/3). The studied samples are found alive in areas covered all time by water. Thin layers of soft sediments cover parts of these substrates, as well as the attached parts of the mussels. The community density attains *ca.* 200-250 individuals/m^2. The observed living specimens are not longer than 1.5 cm; while the dead shells of the same species which are collected from beach attain lengths of about 5 cm. Larger shells of the species seem to be drifted from deeper niches (Table 1).

Tridacna

Family Tridacnidae is characterized by equivalved, inequilateral very heavy thick shells, with an opening anterior to the umbos for the byssus. Each valve has an undulating external form resulting from a number of radiating ribs. Edges are serrated and interlocking. The animal of *Tridacna* is a suspension feeder and cultivating algae on the inner side of its mantle. In order to grow algae, sunlight is necessary and hence *Tridacna* will always be found in water shallow enough to allow penetration of sunlight (Donald and Bosch 1982).

In the studied localities Family Tridacnidae is represented by one species, namely *Tridacna squamosa* Lamarck, 1819. Its ribs are more widely spaced and they bear open, tubular fluted scales which have a more separate appearance (between adjacent ribs).

T. squamosa Lamarck, 1819 lives among living corals in the back reef and on the sea-grass zone (Pl. 4/4). The substrate is nearly flat, consolidated coral heads in the intertidal zone.

This species is recorded from many stations (Table 1), associated with star fish and dead coral branches. The community density attains a maximum of 2 individuals/m^2.

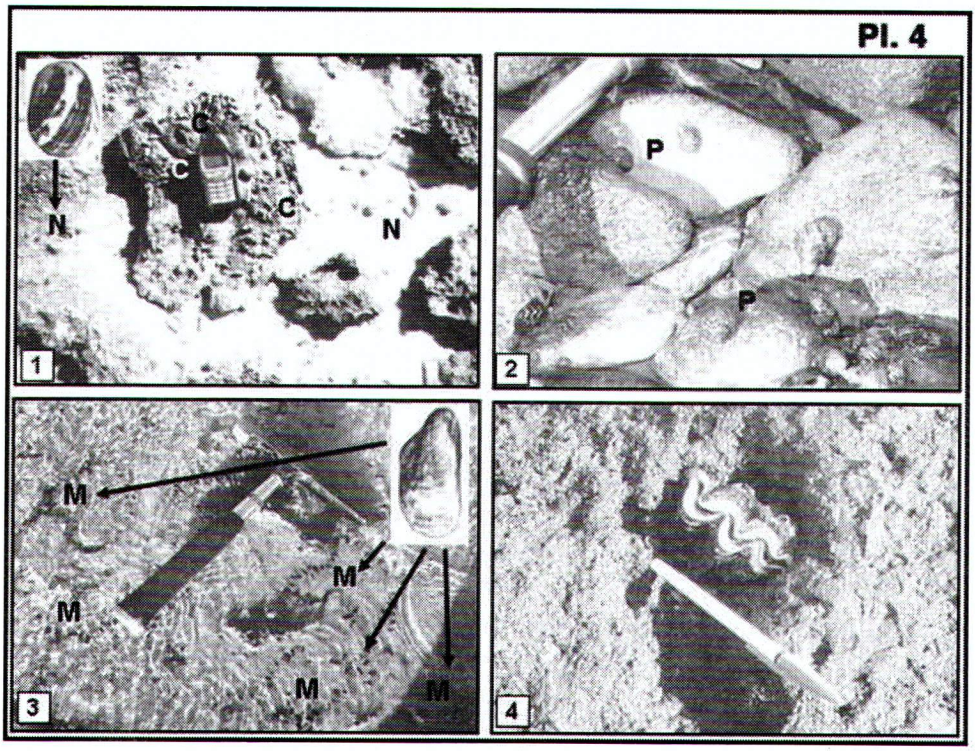

Fig. 1: Cerithiidae (C) and Neritidae (N) species are congregate in large numbers above coral fragments and in the pool around, the intertidal zone, 98 km south Mersa Alam.

Fig. 2: *Planaxis sulcatus* (P) found in large numbers on non-consolidated gravels, Abu Darag area.

Fig. 3: Linear chains of *Modulis*

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