

## FAUNAL ASSEMBLAGES AND SEDIMENT CHEMISTRY OF SOME LAGOONS ALONG THE RED SEA COAST, EGYPT

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### ABSTRACT

Sixty-three invertebrate species (19 foraminifers, 4 bryozoans, 20 gastropods and 20 bivalves) from four lagoons along the Red Sea Coast have been identified, illustrated and their habitat, bio-and-paleogeographic distribution (if present) were done. They belong to 48 genera and 34 families. The habitat of the recorded fauna indicated that they belong to Indo-Pacific affinity and few of them also have Mediterranean-Atlantic one. Um El-Howitat lagoon sediments are enriched in Fe, Mg, Pb, Co and Cu that attributed to the anthropogenic inputs, and recorded the highest total phosphorous content coming from the phosphate shipping in Abu Tartour harbor, in addition to the domestic and sewage materials from the coastal activities. Marsa El Shuni lagoon recorded the lowest content of total phosphorous and the highest content of Zn, Ni and Cd attributed to the natural inputs from Shuni Valley. Abu Sha`ar lagoon recorded the highest total organic matter content, indicating the influx of terrigenous materials. Abu Galawa lagoon recorded the highest carbonate content and the lowest heavy metals content due to the dominance of biogenic sediments from surrounding coral reefs and the absence of terrigenous influx.

**Key Words:** Faunal assemblages, sediment chemistry, Red Sea coast.

### INTRODUCTION

The present study deals with the identification of some invertebrate fauna, and the chemistry of the 46 samples of sediments, collected from Abu Galawa, Abu Sha`ar, Um El-Howitat, and Marsa El Shuni lagoons along the Red Sea Coast. Egypt (Fig. 1), from the beach to 13m depth.

#### Abu Galawa lagoon

It is a small lagoon, of rectangular shape, with 7m maximum depths during the high tide, and lies 7 km northeast Hurghada biological station. It covers about 1000 m<sup>2</sup>. Dense coral reef developed in irregular prongs in the eastern side, while the northern and southern sides are generally composed of biogenic sand. The bottom is covered by seagrass and contains a lot of biogenic materials.

#### Abu Sha`ar lagoon

It is a narrow and shallow lagoon, with 6-10m maximum depths, and lies 5 km north Hurghada biological station. It has two entrances: the first is narrow and situated southward, while the second is situated to the north. The bottom is rocky and covered by thin layer of terrigenous materials and biogenic fragments. It has relatively high bio-diversity, especially flora, while the coral reefs are poor.

#### Um El-Howitat lagoon

It lies 10 km to the south of Safaga, bounded by fringing reefs to the east and with 12m maximum depths. The beach sediments are composed of coarse sand followed by fine sand, while the bottom is covered by seagrass, algae, muddy and biogenic sand. Sediments are derived to the lagoon from Wadi Qena and its tributaries.

#### Marsa El Shuni lagoon

It lies 50 km to the north of Marsa Alam, parallel to the shore, with 3m maximum

depths. It has not any water inlets and is isolated from the open sea during low tide. The beach sediments are composed of fine sand, while the bottom is covered by seagrass, algae and corals.

### Materials and methods

Forty-six sediment samples were collected by grab sampler (5 from Abu Galawa, 15 from Abu Sha'ar, 17 from Um El-Howitat and 9 from Marsa El Shuni see (Fig. 1) Samples were washed several times by distilled water to remove soluble salts and dried at room temperature. Ten grams of each bulk sample were grinded in an electric agate mortar and then passed through a sieve for chemical analyses as: total phosphorous content, total carbonate content, total organic matter content and 8 heavy metals have been measured by AAS at the National Institute of Oceanography and Fisheries, Hurghada, Egypt (Basaham & El-Sayed 1998; Dean 1974; Flannery *et al.* 1982; Oregioni & Aston 1984).

### FAUNAL ASSEMBLAGES

Order Foraminiferida Eichwald, 1830  
 Family Textulariidae Ehrenberg, 1838  
 Genus *Textularia* DeFrance, 1824  
*Textularia agglutinans* d'Orbigny, 1839  
 (Pl. 1, Fig. 1)

1839 *Textularia agglutinans* d'Orbigny: 144, pl. 1, figs. 17, 18, 32, 34.

2000 *Textularia agglutinans* d'Orbigny; Aref & Madkour: 258, pl. 1, fig. 2.

**Occurrence:** Um El-Howitat 1, 7, 11, Abu Sha'ar 3, 6, 7, 8, 10, 11, 13, and Abu

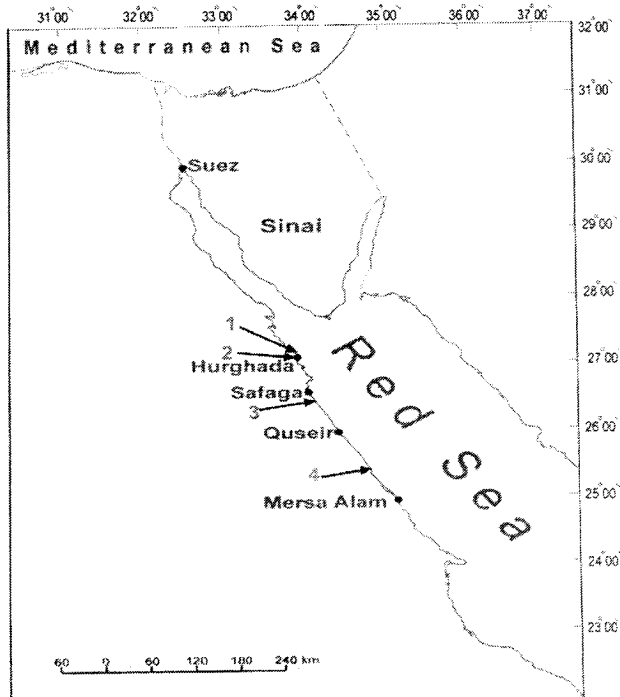


Fig. 1: Location Map.

1. Abu Galawa

2. Abu Sha'ar

3. Um El-Howitat

4. Marsa El Shuni

Galawa 1, 3.

**Habitat:** tropical Pacific and Red Sea, in shallow water, from the shoreline to 10 m depth.

**Distribution:** Miocene of Florida, Pliocene of Italy (Aref & Madkour, 2000).

**Range:** Miocene-Recent.

*Textularia gramen* d'Orbigny, 1846

(Pl. 1, Fig. 2)

1846 *Textularia gramen* d'Orbigny: 248, pl. 15. Figs. 4-6.

1991 *Textularia gramen* d'Orbigny; El-Nahass: 40, pl. 11, fig. 4.

**Occurrence:** Um El-Howitat 1, 6, 13, Abu Sha`ar 1, 3, 4, 6,7, 8, 11, and Abu Galawa 1, 5.

**Distribution:** Miocene of central Europe and Florida (d'Orbigny, 1846).

**Habitat:** Atlantic Ocean, Mediterranean Sea, Red Sea and Sinai beaches, in shallow, warm water of photic zone (El-Nahass, 1991).

**Range:** Miocene-Recent.

Family Valvulinidae Berthelin, 1880

Genus *Clavulina* d'Orbigny, 1826

*Clavulina angularis* d'Orbigny, 1826

(Pl. 1, Fig.3)

1826 *Clavulina angularis* d'Orbigny: 268, pl. 12, fig. 7.

1992 *Clavulina angularis* d'Orbigny; El Deeb: 185, pl. 1, figs. 6, 7.

2000 *Clavulina angularis* d'Orbigny; Aref & Madkour: 260, pl. 1, fig. 12.

**Occurrence:** Um El-Howitat 1, 2, 4, 7. Abu Sha`ar 3, 10, 11, Shuni 3, 5, and Abu Galawa 3, 4.

**Habitat:** Mediterranean Sea, West Indies, Pacific Ocean, and Red Sea. It is restricted to the shallow water and coral reef areas at depths 2-23 m (Aref & Madkour, 2000).

Family Spiroloculinidae Wiesner, 1920

Genus *Adelosina* Rasheed, 1971

*Adelosina sidebottomi* Rasheed, 1971

(Pl.1, Fig. 4)

1997 *Adelosina sidebottomi* Rasheed; Cherif, Al-Ghadban & Al-Rifaiy: 218, pl. 2, figs. 9, 10.

**Occurrence:** Um El-Howitat 6, 8, 9, 12 Abu Sha`ar 5, 12, 13, 14, 15, Shuni 2, 7 and Abu Galawa 3.

**Habitat:** Recent of the Arabian Gulf, in shallow shelf above 45 m depths (Cherif *et al.* 1997).

Genus *Spiroloculina* d'Orbigny, 1826

*Spiroloculina indica* Cushman & Todd, 1944

(Pl. 1, Fig. 5)

2000 *Spiroloculina indica* Cushman & Todd; Aref & Madkour: 260, pl. 1, fig.17.

**Occurrence:** Um El-Howitat 4, 5, 8, 14, 16, Abu Sha`ar 7, 8, 10, 14, Abu Galawa 1, 5 and Shuni 3, 8.

**Habitat:** Red Sea, in the shallow water at depths 1-50 m (Aref & Madkour, 2000).

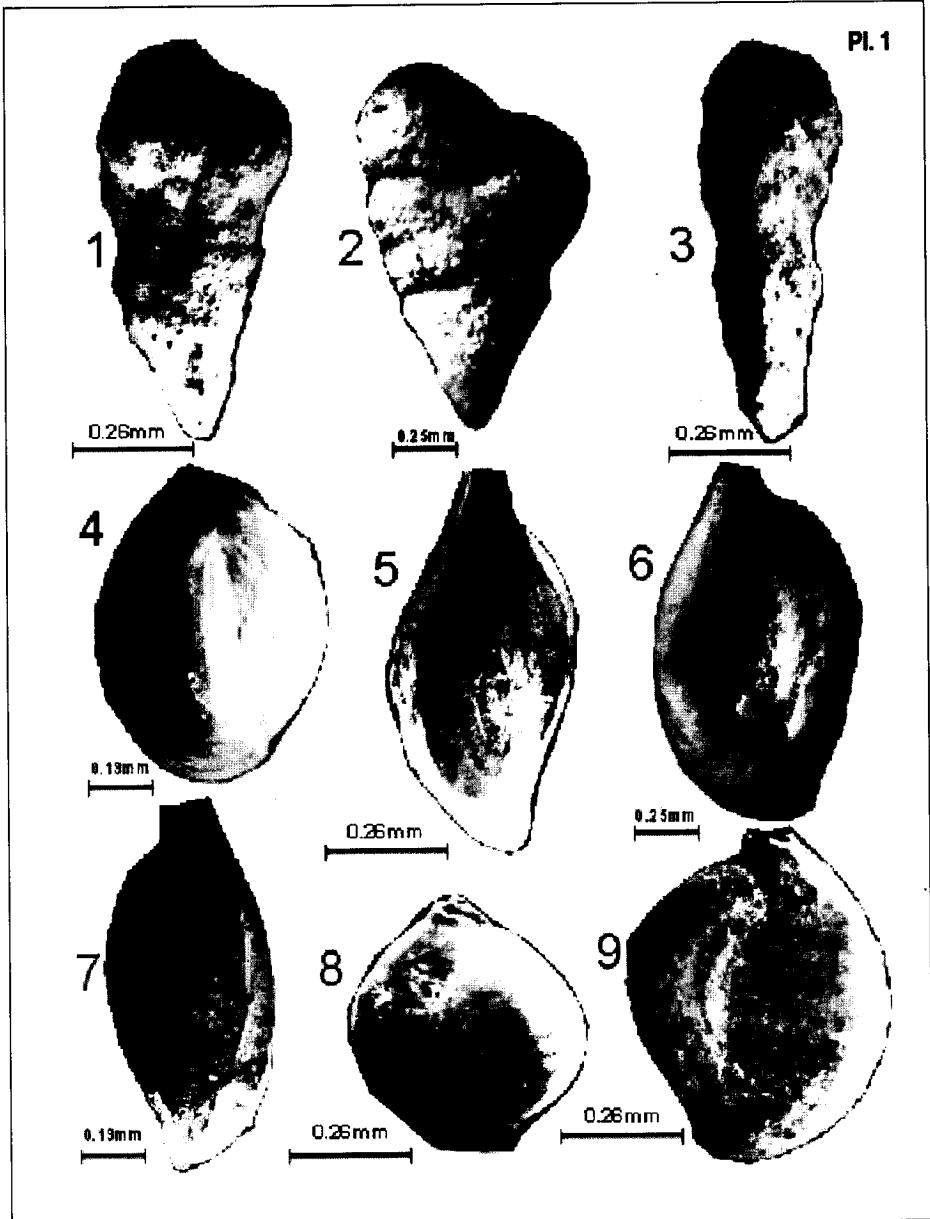


Fig.

1: *Textularia agglutinans* d'Orbigny, 1839, 2: *Textularia gramen* d'Orbigny, 1846

3: *Clavulina angularis* d'Orbigny, 1826, 4: *Adelosina sidebottomi* Rasheed, 1971

5: *Spiroloculina indica* Cushman & Todd, 1944, 6: *Spiroloculina rotundata* (Williamson, 1858)

7: *Quinqueloculina angularis* d'Orbigny, 1826, 8: *Quinqueloculina buchiana* d'Orbigny, 1846

9: *Quinqueloculina lamarckiana* d'Orbigny, 1839

*Spiroloculina rotundata* (Williamson, 1858)

(Pl. 1, Fig. 6)

1997 *Spiroloculina rotundata* (Williamson); Cherif, Al-Ghadban & Al-Rifaiy: 262, pl. 2, figs. 21, 22.

**Occurrence:** Um El-Howitat 3, 4, 5, 9, 12 Abu Sha`ar 11, 15, Shuni 1, 6 and Abu Galawa 1, 3.

**Habitat:** Arabian Gulf, in shallow water (Cherif *et al.* 1997)

## Family Hauerinidae Schwager, 1876

Genus *Quinqueloculina* d'Orbigny, 1826*Quinqueloculina angularis* d'Orbigny, 1826

(Pl. 1, Fig. 7)

1826 *Quinqueloculina angularis* d'Orbigny: 66, pl. 3, figs. 12a, b.

1996 *Quinqueloculina angularis* d'Orbigny; Abdel Wahab: 118, pl. II, fig. 1.

**Occurrence:** Um El-Howitat 1, 2, 4, 7, Abu Sha`ar 1, 2, 5, 6, 8, 10, 13, 14 and Shuni 2, 5, 8.

**Habitat:** St. Helene Island (d'Orbigny, 1826), Red Sea, Jedda Bay (Bahafzallah, 1979), and Egyptian Red Sea Coast (Abdel Wahab, 1996). In the intertidal zone, at depths 0.7-15 m.

*Quinqueloculina buchiana* d'Orbigny, 1846

(Pl. 1, Fig. 8)

1997 *Quinqueloculina buchiana* d'Orbigny; Cherif, Al-Ghadban & Al-Rifaiy: 258, pl. 4, Figs. 7, 8, 9, 10.

**Occurrence:** Um El-Howitat 1, 6, 8, 9, 16, Abu Sha`ar 1, 2, 3, 10, 12 and Shuni 3, 4, 7.

**Habitat:** Shallow shelf (30-40m depths) of the Arabian Gulf (Cherif *et al.* 1997).

*Quinqueloculina lamarckiana* d'Orbigny, 1839

(Pl. 1, Fig.9)

1949 *Quinqueloculina lamarckiana* d'Orbigny; Said: 10, pl.1, fig. 28.

1998 *Quinqueloculina lamarckiana* d'Orbigny; Selima: 424, pl. 4, fig. 1.

**Occurrence:** Um El-Howitat 2, 5, 10, 12, 14, Abu Sha`ar 6, 9, 11, 15 and Shuni 1, 6, 9.

**Habitat:** West Indies (d'Orbigny, 1839), Red Sea, Jedda Bay (Bahafzallah, 1979) and Egyptian Red Sea (Said, 1949 & Ebaid-Alla, 1988). In the shallow water areas, at depths 0.5-29 m (Aref & Madkour, 2000).

## Family Peneroplidae Schultze. 1854

Genus *Peneroplis* de Montfort, 1808*Peneroplis pertusus* (Forskal, 1775)

(Pl. 2, Figs. 1, 2)

2001 *Peneroplis pertusus* (Forskal); Samir & El-Din: 213, pl. II, figs. 3, 4.

2003 *Peneroplis pertusus* (Forskal); Kholeif & Ibrahim: 166, pl. 3, fig. 1.

**Occurrence:** Um El-Howitat 1, 2, 4, 6, 10, Abu Sha`ar 3, 4, 5, 6, 7, 9, 11, 12, 14, Shuni 3, 5, 7, 8, and Abu Galawa 1, 3, 5.

**Habitat:** Mediterranean and Red Sea of Egypt (Said & Kamel, 1954, Ebaid-Alla, 1988; Abdel Wahab, 1996), and from the tropical zones of the Pacific Ocean (Robert, 1980). It has been recorded in abundant numbers at depths 0.5- 31 m.

*Peneroplis planatus* (Fichtel & Moll, 1803)  
(Pl. 2, Figs. 3, 4)

1803 *Nautilus planatus* Fichtel & Moll: 91, pl. 16, fig. 1.

2001 *Peneroplis planatus* (Fichtel & Moll); Samir & El-Din: 213, pl. II, figs. 5-9.

**Occurrence:** Um El-Howitat 1, 2, 4, 10, Abu Sha`ar 3, 7, 9, 10, Abu Galawa 1, 3, Shuni 2, 5, 7.

**Habitat:** Recent Coast of Italy (Mediterranean Sea) and Red Sea from Jedda Bay, and Egypt, at depths 0.5-35 m.

*Peneroplis proteus* d`Orbigny, 1839  
(Pl. 2, Figs. 5, 6)

1930 *Peneroplis proteus* d`Orbigny; Cushman: 37, pl. 13, figs. 1-17.

2000 *Peneroplis proteus* d`Orbigny; Aref & Madkour: 264, pl. 4, fig. 20.

**Occurrence:** Um El-Howitat 1, 2, 4, 10, Abu Sha`ar 2, 7, 9, 11, 12 Shuni 3, 5, 9 and Abu Galawa 5.

**Habitat:** Caribbean Sea, Atlantic and Pacific oceans, Red Sea Coast of Egypt (Abdel Wahab, 1996). It was recorded in shallow water at depths 0.5-30m.

Genus *Spirolina* Lamarck, 1804  
*Spirolina arietina* (Batsch, 1884)  
(Pl. 2, Figs. 7, 8, 9)

1930 *Spirolina arietina* (Batsch); Cushman: 143. Pl. 15, figs. 4, 5.

1998 *Spirolina arietina* (Batsch); Selima: 430, pl. 2, fig. 1.

2000 *Spirolina arietina* (Batsch); Aref & Madkour: 265, pl. 4, fig. 23.

**Occurrence:** Um El-Howitat 1, 2, 4, 10, Abu Sha`ar 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13,14, Abu Galawa 1, 3, 4, and Shuni 1, 3, 4, 6, 7, 8, 9.

**Habitat:** Italy (Batsch 1791), Red Sea (Said, 1949; Anan, 1984, Ebaid-Alla, 1988 and Bahafzallah, 1979). It was recorded in warm shallow water, at depths 0.5-30 m.

Family Soritidae Eherenberg, 1839  
Genus *Sorites* Ehrenberg, 1839  
*Sorites marginalis* (Lamarck, 1816)  
(Pl. 3, Fig. 1)

1816 *Orbulites marginalis* Lamarck: 196.

1949 *Sorites marginalis* (Lamarck); Said: 25, pl. 3, fig. 1.

2000 *Sorites marginalis* (Lamarck); Aref & Madkour: 261, pl. 3, fig. 22.

**Occurrence:** Um El-Howitat 1, 2, 6, 8, 10, 11, 13, Abu Sha`ar 2, 3, 5, 7, 10, Abu Galawa 1, 2, 3, 5 and Shuni 3, 4, 5, 6, 7, 8, 9.

**Habitat:** Red Sea Coast of Egypt and Saudi Arabia (Abdel Wahab, 1996). In shallow water and seagrass environments, at depths 0-45 m.

*Sorites orbiculus* (Forsk., 1775)

(Pl. 3, Figs. 2, 3)

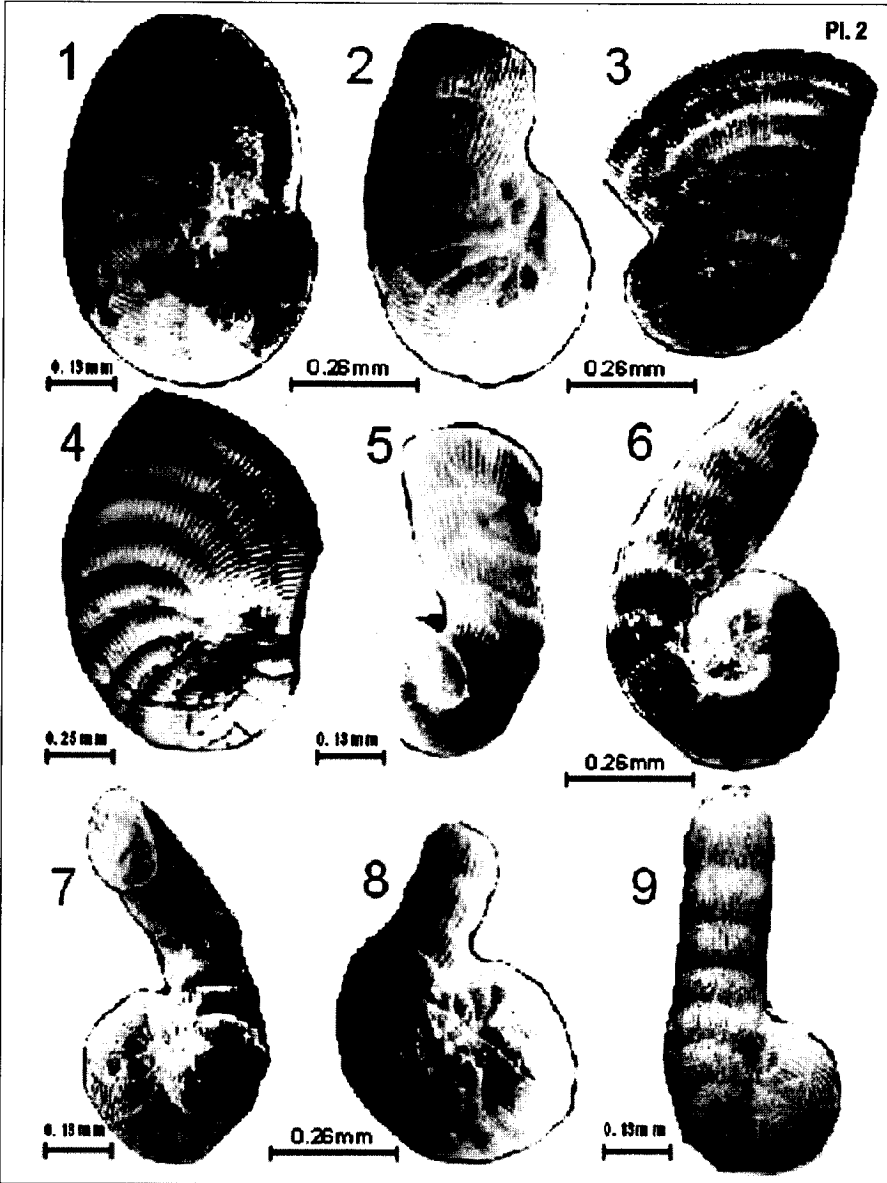
1991 *Sorites orbiculus* (Forsk.); El-Nahass: 49, pl. VI, figs 1, 2.2000 *Sorites orbiculus* (Forsk.); Hohenegger: 135, fig. 7.**Occurrence:** Um El-Howitat 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14, Abu Sha'ar 1, 3, 4, 5, 7,

Fig.

- 1, 2: *Peneroplis pertusus* (Forsk., 1775),  
 3, 4: *Peneroplis planatus* (Fichtel & Mool, 1803)  
 5, 6: *Peneroplis proteus* d'Orbigny, 1839,  
 7, 8, 9: *Spirolina arietina* (Batsch, 1884)

11, 14, Abu Galawa 1, 3, 4, and Shuni 2, 3, 5, 7, 8.

**Habitat:** Red Sea Coast of Egypt and Sinai (El-Nahass, 1991). On rigid and flexible substrates without pronounced seagrass preference.

Genus *Amphisours* Ehrenberg, 1839  
*Amphisours hemprichii* Ehrenberg, 1838  
 (Pl.3, Figs. 4, 5)

1984 *Amphisours hemprichii* Ehrenberg; Anan: 237.

2000 *Amphisours hemprichii* Ehrenberg; Hohenegger: 135, text - fig. 7.

**Occurrence:** Um El-Howitat 2, 12 and Abu Sha`ar 2, 6.

**Habitat:** Red Sea Coast of Egypt and Sinai beaches. It is found in moderate number at depths 0.5-35 m.

Family Rotaliidae Ehrenberg, 1839  
 Genus *Pararotalia* Le Calvez, 1949  
*Pararotalia ozawai* (Asano, 1936)  
 (Pl. 3, Fig. 6)

1981 *Pararotalia ozawai* (Asano); Chasens: 195, pl. 2, figs. 13, 14.

**Occurrence:** Um El-Howitat 1, 2, 5, 7, Shuni 2, 6, Abu Galawa 1, 4 and Shuni 2, 6.

**Habitat:** Kenya Coastline (Chasens, 1981). On the fore-reef at approximately 2 m depth.

Family Calcarinidae Schwager, 1876  
 Genus *Calcarina* d'Orbigny, 1826  
*Calcarina calcar* d'Orbigny, 1826  
 (Pl. 3, Fig. 7)

1826 *Calcarina calcar* d'Orbigny: 709, pl. 6, fig. 7.

1991 *Calcarina calcar* d'Orbigny; El-Nahass: 49, pl. VII, figs. 5a, b.

**Occurrence:** Um El-Howitat 1, 2, 4, 6, 11, Abu Sha`ar 6, 7, 9, 13 and Shuni 2, 7.

**Habitat:** Red Sea Coast of Egypt and Saudi Arabia (Aref & Madkour, 2000). It is found in common numbers at depths 0.5-26 m.

Family Elphidiidae Galloway, 1933  
 Genus *Elphidium* de Montfort, 1848  
*Elphidium striato-punctatus* Fichtel & Moll, 1798  
 (Pl. 3, Fig. 8)

1979 *Elphidium striato-punctatus* Fichtel & Moll; Bahafzallah: 202, pl. 18, Figs. 9, 10.

2000 *Elphidium striato-punctatus* Fichtel & Moll; Aref & Madkour: 267, pl. 6, figs. 11, 12.

**Occurrence:** Abu Sha`ar 4, 8, 9, 13, Shuni 2, 6, 7, 8, Abu Galawa 1, 3 and Um El-Howitat 3, 8, 15.

**Habitat:** Atlantic and Pacific oceans. It is recorded in abundance at depths 0-31 m (Aref & Madkour, 2000).



Phylum Bryozoa Ehrenberg, 1831  
 Order Cheilostomata Busk, 1852  
 Family Cabereidae Busk, 1852  
 Genus *Tricellaria* Fleming, 1828  
*Tricellaria occidentalis* (Trask, 1857)  
 (Pl. 4, Figs. 1, 2)

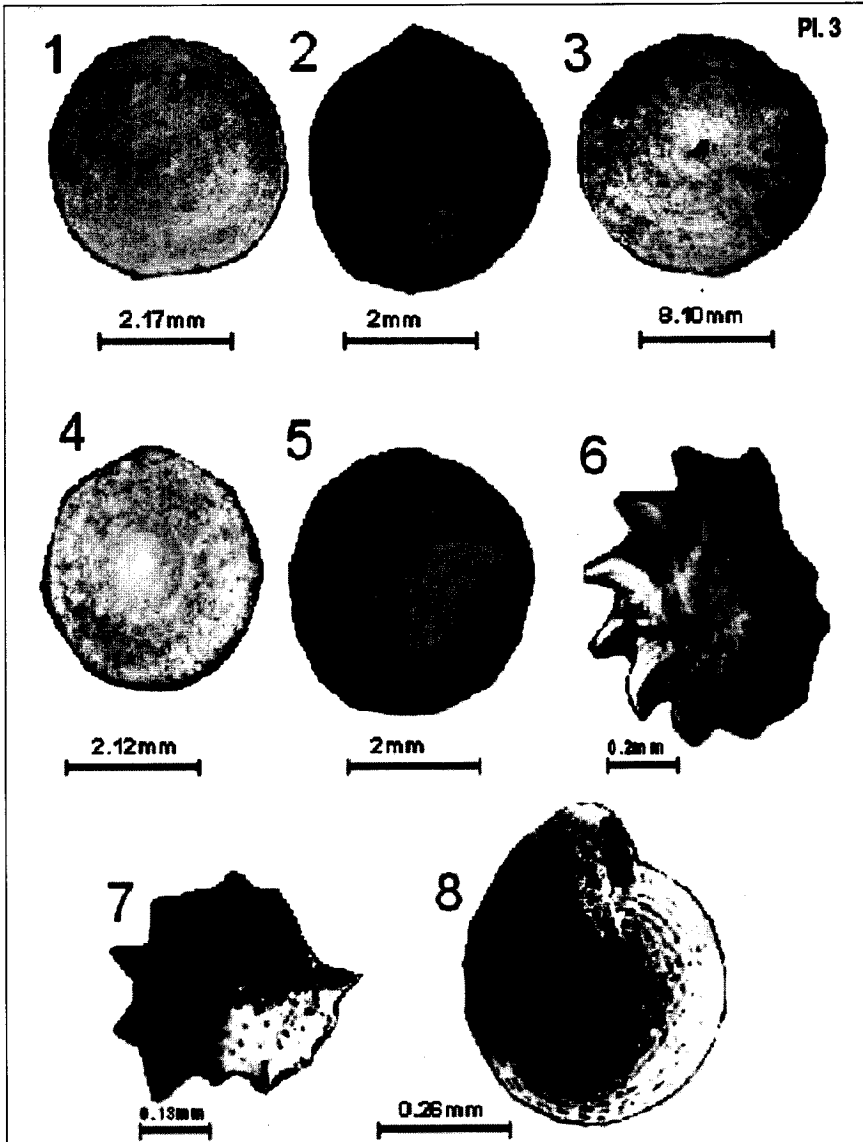


Fig.

- 1: *Sorites marginalis* (Lamarck, 1816), 2, 3: *Sorites orbiculus* (Forsk., 1775)  
 4: *Amphisours hemprichii* Ehrenberg, 1838, 5: Irregular growth of *Amphisours hemprichii*  
 Ehrenberg, 1838  
 6: *Pararotalia ozawai* (Asano, 1936), 7: *Calcarina calcar* d'Orbigny, 1826  
 8: *Elphidium striato-punctatus* Fichtel & Moll, 1798

1857 *Menipora occidentalis* Trask: 113.

2004 *Tricellaria occidentalis* (Trask); El-Sorogy, Abdelwahab, Ziko, El-Dera, Saber & Abu Elkhair: 206, pl. 2, figs. 3, 4.

**Occurrence:** Abu Galawa 5.

**Habitat:** Red Sea, Pacific Ocean, New Zealand, British Colombia, USA, Japan, China, South Australia, Victoria and New South Wales (El-Sorogy *et al.* 2004).

Family Margarettidae Harmer, 1956

Genus *Margaretta* Gray. 1848

*Margaretta cereoides* (Ellis & Solander, 1786)

(Pl. 4, Figs. 3, 4)

1786 *Cellaria cereoides* Ellis & Solander: 26, pl. 5, figs B-E.

2002 *Margaretta cereoides* (Ellis & Solander); El Safori: 450, pl. 7, fig.6.

**Occurrence:** Um El-Howitat 1.

**Distribution:** In Egypt, it is recorded from the Miocene, Post-Pliocene and Pleistocene; Eocene of France, Italy, and Spain; Oligocene of Germany, Italy, Poland, Rumania, and CSSR; Miocene of France, Poland, Rumania and CSSR; Pliocene of Italy, North and Central America, and Austria, (El-Dera, 1991 and El-Sorogy *et al.* 2004).

**Habitat:** Indian and Pacific oceans, Mediterranean, Adriatic, and Red Sea. In Atlantic, it is only recorded from the tropical and subtropical regions. It is mostly distributed in the shallow sublittoral zones, from depths 10-45 m (El-Dera, 1991 and El-Sorogy *et al.* 2001)

**Range:** Eocene-Recent.

Family Wateriporidae Vigneaux, 1949

Genus *Wateripora* Neviani, 1895

*Watersipora subtorquata* (d'Orbigny, 1852)

(Pl. 4, Fig. 5)

1842 *Escharina troquata* d'Orbigny: pl. 4, fig. 3.

2001 *Watersipora subtorquata* (d'Orbigny); El-Sorogy, Abdel Wahab, Ziko & El-Dera: 71, pl. 5, fig. 4.

2004 *Watersipora subtorquata* (d'Orbigny); El-Sorogy, Abdel wahab, Ziko, El-Dera, Saber & Abu Elkhair: 217, pl. 6, figs 5, 6.

**Occurrence:** Abu Sha`ar 3.

**Habitat:** Red Sea, New Zealand, Gulf of Aqaba, Brazil, Bermuda, West Indies, Japan, Great Barrier Reef in Australia, Cap Verde Island, Torres strait (Gordon, 1989 and El-Sorogy *et al.* 2004).

Family Pasytheidae Davis, 1934

Genus *Gemellipora* Smitt, 1873

*Gemellipora eburnea* Smitt, 1873

(Pl. 4, Fig. 6)

1873 *Gemellipora eburnea* Smitt: 35, 75.

1957 *Gemellipora eburnea* Smitt; Harmer: 944.

1984 *Gemellipora eburnea* Smitt; Gordon: 112. Pl. 44, figs. A, B.

**Occurrence:** Um El-Howitat 2.

**Habitat:** Amphi-Atlantic from temperate to tropical latitudes in Hawaii and Indonesia (Gorden, 1984).



**Fig.**

- 1, 2: *Tricellaria occidentalis* (Trask, 1857); 1: Segment of zoarium 2: the same enlargement shows hyperstomial ovicells
- 3, 4: *Margareta cereoides* (Ellis & Solander, 1786); Branch of zoarium shows the zoecial arrangement and shape
- 5: *Watersipora subtorquata* (d'Orbigny, 1852); A part of zoarium shows shape and arrangement of zoecia.
- 6: *Gemellipora eburnea* Smitt, 1873; A part of zoarium shows zoecium shape.

Phylum Mollusca Cuvier, 1795  
 Class Gastropoda Cuvier, 1797  
 Order Archaeogastropoda Thiele, 1925  
 Family Fissurellidae Fleming, 1822  
 Genus *Diodora* Gray, 1821

*Diodora (Capiluna) borroni* (Newton, 1900)  
 (Pl. 5, Figs. 1, 2)

1900 *Capiluna ruppelli* var. *borroni* Newton: 502, pl. 22, figs. 1-4.

2001 *Diodora (Capiluna) borroni* (Newton); Nour: 49, pl. 4, figs. 5, 6.

**Occurrence:** Um El-Howitat 4, 6, 9, 14, Abu Shaar 5 and Shuni 3.

**Distribution:** Pleistocene of Red Sea Coast (Nour, 2001).

**Habitat:** In Red Sea and Gulf of Aqaba as rocky shore dwellers.

**Range:** Pleistocene-Recent.

Family Trochidae Rafinesque, 1815

Genus *Ethalia* Pilsbry, 1905

*Ethalia carneolata* Melvill, 1897

(Pl. 5, Figs. 3, 4)

1995 *Ethalia carneolata* Melvill; Bosch, Dance, Moolenbeek and Oliver: 35, Fig. 42.

**Occurrence:** Um El-Howitat 2, 12, Abu Galawa 4, Abu Shàar 11, 13, and Shuni 6.

**Habitat:** Offshore of the Arabian Gulf and Gulf of Oman (Bosch *et al.* 1995).

Family Rissoidae Gray, 1847

Genus *Rissoina* de Orbigny, 1840

*Rissoina phormis* Melvill, 1904

(Pl. 5, Fig. 5)

1995 *Rissoina phormis* Melvill; Bosch, Dance, Moolenbeek and Oliver: 48, Fig. 133.

**Occurrence:** Um El-Howitat 1, 4, 16, Abu Shàar 5, 14, Shuni 3 and Abu Galawa 3.

**Habitat:** Intertidal zone of the Gulf of Oman (Bosch *et al.* 1995).

*Rissoina cf. pulchella* (Brazier, 1877)

(Pl. 5, Fig. 6)

1995 *Rissoina cf. pulchella* (Brazier); Bosch, Dance, Moolenbeek and Oliver: 48, Fig. 134.

**Occurrence:** Um El-Howitat 1, 3, 10, Abu Shàar 3, 14, Shuni 8 and Abu Galawa 1.

**Habitat:** Intertidal zone of the Gulf of Oman (Bosch *et al.* 1995).

Genus *Voorwindia* Ponder, 1985

*Voorwindia tiberiana* (Issel, 1869)

(Pl. 5, Fig. 7)

1995 *Voorwindia tiberiana* (Issel); Bosch, Dance, Moolenbeek and Oliver: 48, fig. 137.

**Occurrence:** Um El-Howitat 1, 2, 9, 16, Abu Shàar 4, 15 and Shuni 5.

**Habitat:** Intertidal and offshore of the Arabian Gulf and the Gulf of Oman (Bosch *et al.* 1995).

Family Cerithiidae Fleming, 1828  
 Genus *Cerithium* Bruguiere, 1789  
*Cerithium caeruleum* Sowerby, 1855  
 (Pl. 5, Figs. 8, 9)

1982 *Cerithium caeruleum* Sowerby; Donald and Bosch: 49.

1995 *Cerithium caeruleum* Sowerby; Bosch, Dance, Moolenbeek and Oliver: 51,

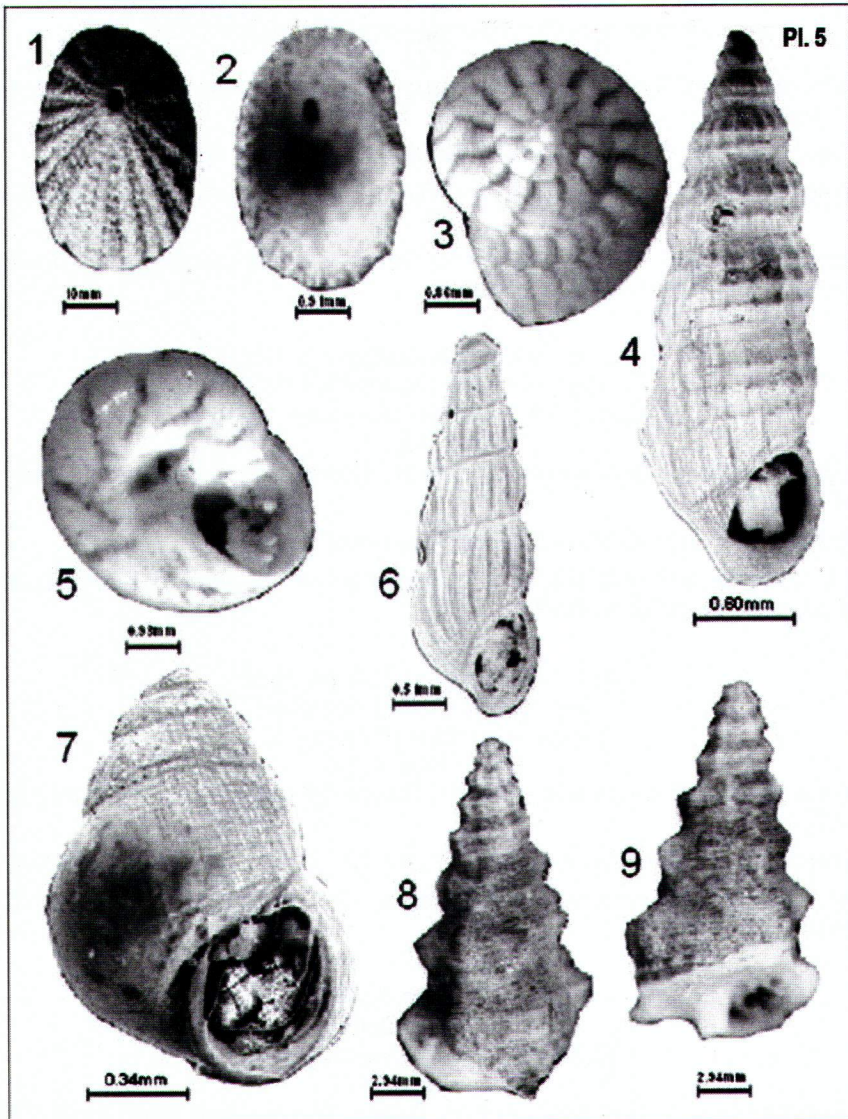


Fig.

1,2: *Diodora (Capiluna) borroni* (Newton, 1900); 1: Apical view. 2: Ventral view.

3, 4: *Ethalia carneolata* Melvill, 1897; 3: Apical view. 4: Apertural and umbilical view.

Fig. 5: *Rissoina phormis* Melvill, 1904; Apertural view.

Fig. 6: *Rissoina cf. pulchella* (Brazier, 1877); Apertural view.

Fig. 7: *Voorwindia tiberiana* (Issel, 1869); Apertural view.

Figs. 8, 9: *Cerithium caeruleum* Sowerby, 1855; 8: Spiral view. 9: Apertural view.

fig. 158.

2004 *Cerithium caeruleum* Sowerby; Nour: 60, figs. 27, 28.

**Occurrence:** Um El-Howitat 5, 13, Abu Shàar 6, 9, Shuni 4, 8 and Abu Galawa 1.

**Habitat:** Shells found under rocks, in intertidal zone of the Red Sea, the Arabian Gulf, and the Gulf of Oman (Bosch *et al.* 1995).

*Cerithium nodulosum adansonii* Bruguière, 1792

(Pl. 6, Figs. 1, 2)

1995 *Cerithium nodulosum adansonii* Bruguière; Bosch, Dance, Moolenbeek and Oliver: 52, fig. 160.

2005 *Cerithium nodulosum* Bruguière; Nour: 61, pl. 1, figs. 29, 30.

**Occurrence:** Um El-Howitat 3, 11, Abu Shàar 12, 13, Shuni 1, 3 and Abu Galawa 3.

**Habitat:** Shells found on muddy and silty flats in intertidal zone of the Arabian Gulf and the Gulf of Oman (Bosch *et al.* 1995).

Family Epitoniidae Berry, 1910

Genus *Epitonium* Rding, 1798

*Epitonium irregulare* (Sowerby, 1844)

(Pl. 6, Fig. 3)

1995 *Epitonium irregulare* (Sowerby); Bosch, Dance, Moolenbeek and Oliver: 108, Fig. 421.

**Occurrence:** Um El-Howitat 2, 3, 6 and Abu Shàar 2, 5.

**Habitat:** Intertidal and offshore among muddy stones of the Arabian Gulf, and the Gulf of Oman (Bosch *et al.* 1995).

Family Buccinidae Pollock, 1998

Genus *Pisania* Bivona, 1832

*Pisania tritonoides* (Reeve, 1846)

(Pl. 6, Figs. 4, 5)

1995 *Pisania tritonoides* (Reeve); Bosch, Dance, Moolenbeek and Oliver: 128, Fig. 527.

**Occurrence:** Um El-Howitat 3, 10, Abu Shàar 10, Shuni 6, 8 and Abu Galawa 2.

**Habitat:** Offshore and beaches of the Arabian Gulf and the Gulf of Oman (Bosch *et al.* 1995).

Family Columbelloidea Swainson, 1840

Genus *Euplica* Dall, 1889

*Euplica varians* (Sowerby, 1832)

(Pl. 6, Figs. 6, 7)

1995 *Euplica varians* (Sowerby); Bosch, Dance, Moolenbeek and Oliver: 129, fig. 532.

**Occurrence:** Um El-Howitat 3, 16, Shuni 2, 8 and Abu Galawa 5.

**Habitat:** Intertidal rocks and beaches of the Arabian Gulf, and the Gulf of Oman (Bosch *et al.* 1995).

Genus *Mitrella* Risso, 1826  
*Mitrella allizonae* (Melvill and Standen, 1901)

(Pl.6, Figs. 8, 9)  
 1995 *Mitrella allizonae* (Melvill and Standen); Bosch, Dance, Moolenbeek and  
 Oliver: 130, fig. 535.

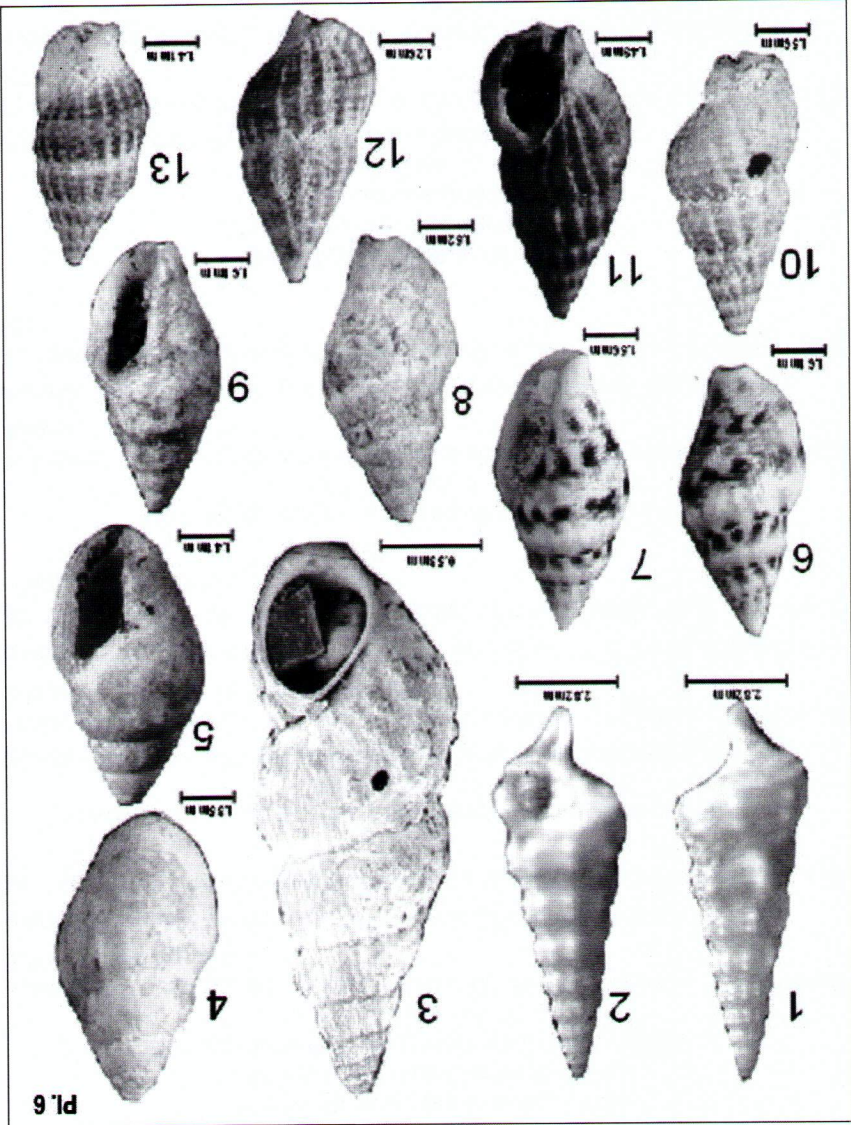


Fig. 1, 2: *Cerithium nodulosum adansonii* Bruguière, 1792; 1: Spiral view, 2: Apertural view.  
 3: *Epitonium irregulare* (Sowerby, 1844); Apertural view.  
 4: *Pisania tritonoides* (Reeve, 1846); 4: Spiral view, 5: Apertural view.  
 6: *Euplaca varians* (Sowerby, 1832); 6: Spiral view, 7: Apertural view.  
 8: *Mitrella allizonae* (Melvill & Standen, 1901); 8: Spiral view, 9: Apertural view.  
 10, 11: *Nassarius (Aciculina) ischnus* (Melvill, 1899); 10: Spiral view, 11: Apertural view.  
 12, 13: *Nassarius (Niotha) albescens gemmiferus* (Adams, 1852); 12: Spiral view, 13: Apertural view.

**Occurrence:** Um El-Howitat 7, 14 , Abu Shaar 3, 13 , Shuni 2, 9 and Abu Galawa 3.

**Habitat:** Offshore and beaches of the Arabian Gulf, and the Gulf of Oman (Bosch *et al.* 1995).

Family Nassariidae Iredale, 1916

Genus *Nassarius* Dumeril, 1806

*Nassarius (Aciculina) ischnus* (Melvill, 1899)

(Pl. 6, Figs. 10, 11)

1995 *Nassarius (Aciculina) ischnus* (Melvill); Bosch, Dance, Moolenbeek and Oliver: 132, fig. 545.

**Occurrence:** Um El-Howitat 1, 3, 10, 11, Abu Shaar 5 and Shuni 7.

**Habitat:** Offshore of the Arabian Gulf, and the Gulf of Oman (Bosch *et al.* 1995).

*Nassarius (Niotha) albescens gemmuliferus* (Adams, 1852)

(Pl. 6 , Figs. 12, 13)

1982 *Nassarius albescens gemmuliferus* (Adams); Donald and Bosch: 105.

1995 *Nassarius (Niotha) albescens gemmuliferus* (Adams); Bosch, Dance, Moolenbeek and Oliver: 132, fig. 551.

**Occurrence:** Um El-Howitat 1, 3, 5, 10, 11, Abu Shaar 7, 13 and Shuni 5, 7.

**Habitat:** Under intertidal and offshore rocks of the Arabian Gulf and the Gulf of Oman (Bosch *et al.* 1995).

*Nassarius (Zeuxis) mammilliferus* (Melvill, 1897)

(Pl. 7, Figs. 1, 2)

1995 *Nassarius (Zeuxis) mammilliferus* (Melvill); Bosch, Dance, Moolenbeek and Oliver: 134, fig. 565.

**Occurrence:** Um El-Howitat 1, 3, 7, 10, Abu Shaar 2, 9 and Shuni 2, 6, 7.

**Habitat:** Muddy sand offshore of the Arabian Gulf, and the Gulf of Oman (Bosch *et al.* 1995).

Family Fasciolariidae Gray, 1853

Genus *Fusinus* Rafinesque, 1815

*Fusinus arabicus* (Melvill, 1898)

(Pl. 7, Figs. 3, 4)

1982 *Fusinus arabicus* (Melvill ); Donald and Bosch: 109.

1995 *Fusinus arabicus* (Melvill ); Bosch, Dance, Moolenbeek and Oliver: 136, fig. 578.

**Occurrence:** Um El-Howitat 6, 14, Abu Shaar 6, 8, 14 and Abu Galawa 3.

**Habitat:** It lives in sand at low tide levels along the Batinah Coast beaches, the Arabian Gulf, and the Gulf of Oman (Bosch *et al.* 1995).

Family Olividae Latreille, 1825

Genus *Ancilla* Lamarck, 1799

*Ancilla (Chilotygma) exigua exigua* (Sowerby, 1830)

(Pl. 7, Figs. 5, 6)



1995 *Ancilla (Chilotygma) exigua exigua* (Sowerby); Bosch, Dance, Moolenbeek and Oliver: 144, fig. 599.

**Occurrence:** Um El-Howitat 2, 9, 15, Abu Shaar 7, 9, 14 and Shuni 3, 6.

**Habitat:** Intertidal in sand of the Arabian Gulf, and the Gulf of Oman (Bosch *et al.* 1995).

*Ancilla (Sparella) farsiana* Kilburn, 1981

(Pl. 7, Figs. 7, 8)

1995 *Ancilla (Sparella) farsiana* Kilburn; Bosch, Dance, Moolenbeek and Oliver: 145, fig. 604.

**Occurrence:** Um El-Howitat 5, 10, Abu Shaar 4, 12 and Shuni 1, 4, 8.

**Habitat:** Intertidal and offshore in sand of the Arabian Gulf and the Gulf of Oman (Bosch *et al.* 1995).

Family Marginellidae Gill, 1867

Genus *Granulina* Jousseaume, 1888

*Granulina oodes* (Melvill, 1898)

(Pl. 7, Fig. 9)

1995 *Granulina oodes* (Melvill); Bosch, Dance, Moolenbeek and Oliver: 146, fig. 608.

**Occurrence:** Um El-Howitat 2, 7, 10, Abu Shaar 1, 6, Shuni 5, 8 and Abu Galawa 1.

**Habitat:** Intertidal and below in sand of the Red Sea Coast, the Arabian Gulf and the Gulf of Oman (Bosch *et al.* 1995).

Family Conidae Fleming, 1822

Genus *Conus* Linnaeus, 1758

*Conus arenatus* Hwass, 1792

(Pl. 7, Figs. 10, 11)

1982 *Conus (Punctincolis) arenatus* (Bruguere); El-Shazly: 150, pl. 10, figs. 5, 6, 9.

1995 *Conus arenatus* Hwass; Bosch, Dance, Moolenbeek and Oliver: 158, fig. 690.

2004 *Conus arenatus* Hwass; Nour: 83, pl. 4, figs. 5, 6.

**Occurrence:** Um El-Howitat 4, 8, Abu Shaar 9 and Abu Galawa 1, 3, 5.

**Habitat:** Shells found among coral and rocky shore of the Arabian Gulf, and the Gulf of Oman (Bosch *et al.* 1995).

Family Amphibolidae Gray, 1840

Genus *Salinator* Hedley, 1900

*Salinator fragilis* (Lamarck, 1822)

(Pl. 7, Fig. 12)

1995 *Salinator fragilis* (Lamarck); Bosch, Dance, Moolenbeek and Oliver: 186, fig. 864.

**Occurrence:** Um El-Howitat 2, 12, Abu Shaar 3, 10, Shuni 3 and Abu Galawa 2.

**Habitat:** Black mud often near mangroves and beaches of the Arabian Gulf and the Gulf of Oman (Bosch *et al.* 1995).

Class Bivalvia Linnaeus, 1758  
 Order Acroidea Stoliczka, 1871  
 Family Arcidae Lamarck, 1809  
 Genus *Acar* Gray, 1857  
*Acar plicata* (Dillwyn, 1817).  
 (Pl. 8, Figs. 1, 2)

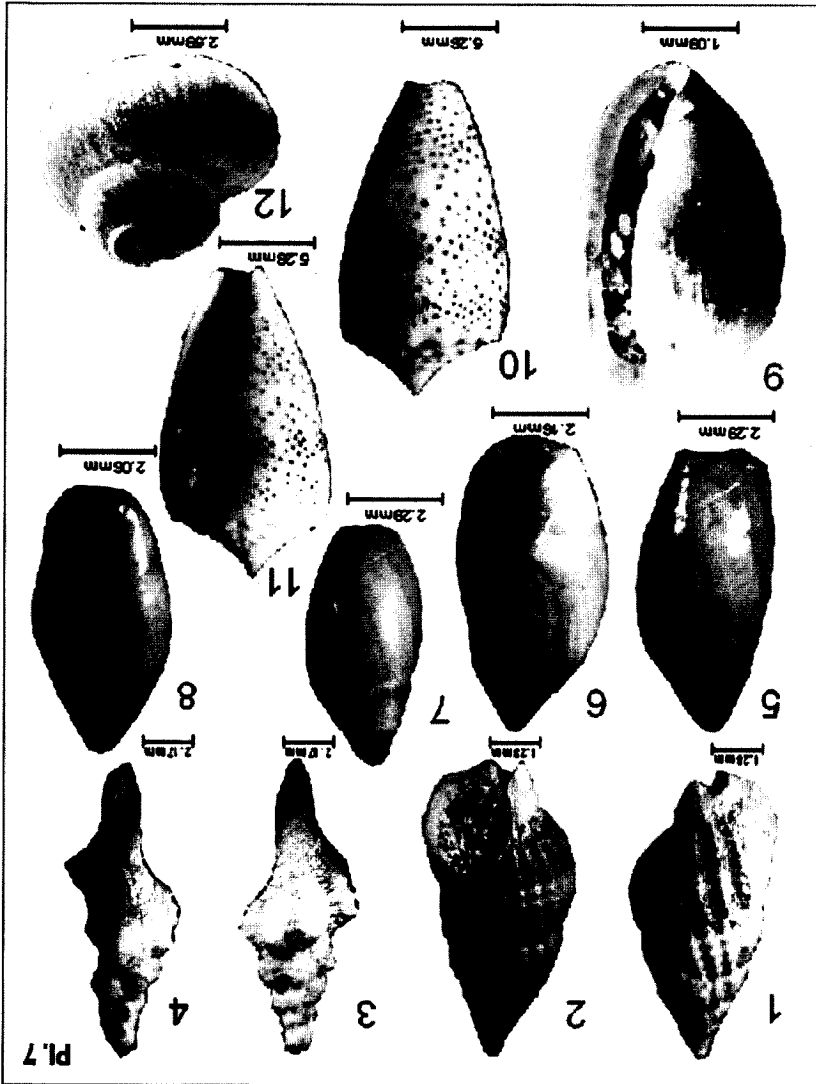


Fig. 1, 2: *Nassarius (Zeuxis) mammilliferus* (Melvill, 1897); 1: Spiral view, 2: Apertural view.  
 3, 4: *Fusinus arabicus* (Melvill, 1898); 3: Spiral view, 4: Apertural view.  
 5, 6: *Ancilla (Chilotygmata) exigua* (Sowerby, 1830); 5: Spiral view, 6: Apertural view.  
 7, 8: *Ancilla (Sparella) farsiana* Kilburn, 1981; 7: Spiral view, 8: Apertural view.  
 9: *Granulina oodes* (Melvill, 1898); Apertural view.  
 10, 11: *Conus arenatus* Hwass, 1792; 10: Spiral view, 11: Apertural view.  
 12: *Salinator fragilis* Lamarck, 1822; Spiral view.

1982 *Acar plicata* (Dillwyn); Donald and Bosch: 150.

1992 *Acar plicata* (Dillwyn); Oliver: 34, pl. 1, figs. 5a, b.

**Occurrence:** Um El-Howitat 5, 11, 14, Abu Shaar 7 and Shuni 5.

**Habitat:** Shells found attached to corals and rocks of the Red Sea, Indo-Pacific in the Arabian Gulf and the Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

Order Mytiloidea Ferussac, 1822

Family Mytilidae Rafinesque, 1815

Genus *Brachidontes* Swainson, 1840

*Brachidontes variabilis* (Krauss, 1848)

(Pl. 8, Figs. 3, 4)

1992 *Brachidontes variabilis* (Krauss); Oliver: 48, pl. 5, figs. 2a-c.

1995 *Brachidontes variabilis* (Krauss); Bosch, Dance, Moolenbeek and Oliver: 214, fig. 943.

2001 *Brachidontes variabilis* (Krauss); Nour: 88, pl. 8, figs. 13, 14.

**Occurrence:** Um El-Howitat 2, 7, 12 Abu Shaar 3, 13, Shuni 7 and Abu Galawa 3.

**Habitat:** Attached to rocks of the Suez Canal, the Red Sea, Indian Ocean, the Arabian Gulf and the Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

Order Petrioida Newell, 1965

Family Spondylidae Gray, 1826

Genus *Spondylus* Linnaeus, 1758

*Spondylus gloriandus* Melvill and Standen, 1907

(Pl. 8, Figs. 5, 6)

1992 *Spondylus gloriandus* Melvill and Standen; Oliver: 80.

1995 *Spondylus gloriandus* Melvill and Standen; Bosch, Dance, Moolenbeek and Oliver: 234, fig. 1016.

**Occurrence:** Um El-Howitat 5, 11, 15 Abu Shaar 4, Shuni 3, and Abu Galawa 2.

**Distribution:** Pliocene and Pleistocene of the Red Sea Coast, Gulf of Aqaba, Indo-Pacific, Mediterranean, Kuwait and Arabian Gulf (Oliver, 1992 and Bosch *et al.* 1995).

**Habitat:** Cemented to rocks and cobbles offshore of the Red Sea Coast, the Gulf of Aqaba, Indo-Pacific, Mediterranean, Kuwait and Arabian Gulf (Oliver, 1992 and Bosch *et al.* 1995).

**Range:** Pliocene- Recent

Order Veneroidea H. and Adams, 1856

Family Lucinidae Fleming, 1828

Genus *Divaricella* Von Martens, 1880

*Divaricella ornatissima* (d'Orbigny, 1846)

(Pl. 8, Figs. 7, 8)

1995 *Divaricella ornatissima* (d'Orbigny); Bosch, Dance, Moolenbeek and Oliver: 237, fig. 1033.

2001 *Divaricella ornatissima* (d'Orbigny); Nour: 97, pl. 10, figs. 7, 8.

**Occurrence:** Um El-Howitat 9, Abu Shaar 1, 3, 6, Shuni 8 and Abu Galawa 3.

**Habitat:** Off shore of the Red Sea and the Gulf of Oman (Nour, 2001 and Bosch *et al.* 1995).

Genus *Pillucina* Pilsbry, 1921  
*Pillucina angela* (Melvill, 1899)  
 (Pl. 8, Figs. 9, 10)

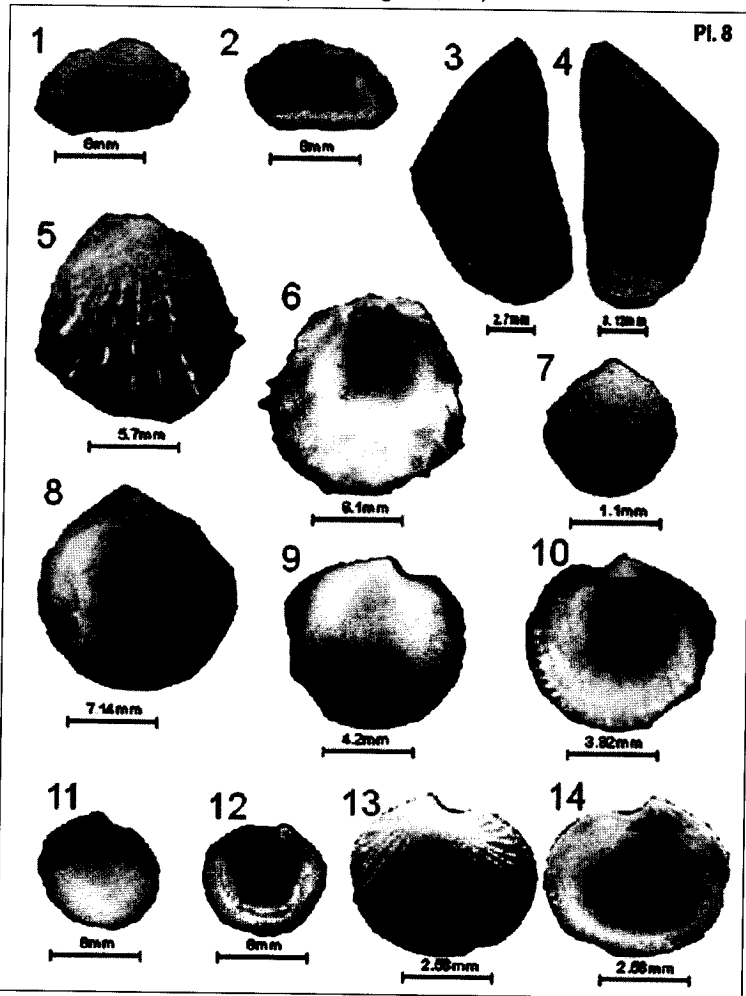


Fig.

- 1, 2: *Acar plicata* (Dillwyn, 1817); 1: External view of R. v. 2: Internal view of the same.  
 3, 4: *Brachidontes variabilis* (Krauss, 1848); 3: External view of R. v. 4: Internal view of the same.  
 5, 6: *Spondylus gloriandus* (Melvill & Standen, 1907); 5: External view of L. v. 6: Internal view of the same.  
 7, 8: *Divaricella ornatissima* (d'Orbigny, 1846); 7: External view of L. v. 8: Internal view of the same.  
 9, 10: *Pillucina angela* (Melvill, 1899); 9: External view of L. v. 10: Internal view of the same.  
 11, 12: *Pillucina fischeriana* (Issel, 1869); 11: External view of R. v. 12: Internal view of the same.  
 13, 14: *Ctena divergens* (Philippi, 1850); 13: External view of L. v. 14: Internal view of the same.

1995 *Pillucina angela* (Melvill); Bosch, Dance, Moolenbeek and Oliver: 236, fig. 1025.

2001 *Pillucina angela* (Melvill); Nour: 96, pl.10, figs. 3, 4.

**Occurrence:** Um El-Howitat 2, 6, 13, Abu Shàar 2, 5, Shuni 7 and Abu Galawa 5.

**Habitat:** Off shore of the Red Sea and the Gulf of Oman (Nour, 2001 and Bosch *et al.* 1995).

*Pillucina fischeriana* (Issel, 1869)

(Pl. 8, Figs. 11, 12)

1992 *Pillucina fischeriana* (Issel); Oliver: 98, pl. 20, figs. 4a, b.

1995 *Pillucina fischeriana* (Issel); Bosch, Dance, Moolenbeek and Oliver: 236, fig. 1026.

**Occurrence:** Abu Galawa 1, 3.

**Habitat:** Muddy sand of intertidal zone specially in lagoons and mud flats of the Red Sea, Indian Ocean, the Gulf of Oman. (Oliver, 1992 and Bosch *et al.* 1995).

Genus *Ctena* Morche, 1861

*Ctena divergens* (Philippi, 1850)

(Pl. 8, Figs. 13, 14)

1992 *Ctena divergens* (Philippi); Oliver: 99, pl. 19, figs. 4a, b.

1995 *Ctena divergens* (Philippi); Bosch, Dance, Moolenbeek and Oliver: 235, fig. 1022.

**Occurrence:** Um El-Howitat 4, 6, Abu Shàar 5 and Abu Galawa 5.

**Habitat:** In coarse sands and gravels in shallow water of the Red Sea Coast, Indo-Pacific (Oliver, 1992 and Bosch *et al.* 1995).

Genus *Anodontia* Link, 1807

*Anodontia edentula* (Linnaeus, 1758)

(Pl. 9, Figs. 1, 2)

1758 *Venus edentula* Linnaeus; 10:689

1992 *Anodontia edentula* (Linnaeus); Oliver: 100, pl. 20, figs. 8a, b.

1995 *Anodontia edentula* (Linnaeus); Bosch, Dance, Moolenbeek and Oliver: 236, fig. 1028.

**Occurrence:** Um El-Howitat 4, 7, Abu Shaar 11, Shuni 5 and Abu Galawa 3.

**Habitat:** In muds and muddy sands in shallow water of the Red Sea Coast, Indo-Pacific, the Arabian Gulf and the Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

Family Ungulinidae H. & Adams, 1857

Genus *Diplodonta* Bronn, 1831

*Diplodonta (Diplodonta) rotundata* (Montagu, 1883)

(Pl. 9, Figs. 3, 4)

1969 *Diplodonta (Diplodonta) rotundata* (Montagu); Moore: 515, figs. E20, 10.

2005 *Diplodonta (Diplodonta) rotundata* (Montagu); Nour: 100, pl. 6, figs. 4, 5.

**Occurrence:** Um El-Howitat 6, 12, Abu Shaar 2, 9, Shuni 1, 5, and Abu Galawa 2.

**Distribution:** Miocene, Pliocene, and Pleistocene of Red Sea Coast and Mediterranean (Oliver 1992 and Nour 2004).

**Habitat:** Found in muddy sand of the Red Sea Coast and Mediterranean (Oliver, 1992).

**Range:** Miocene-Recent

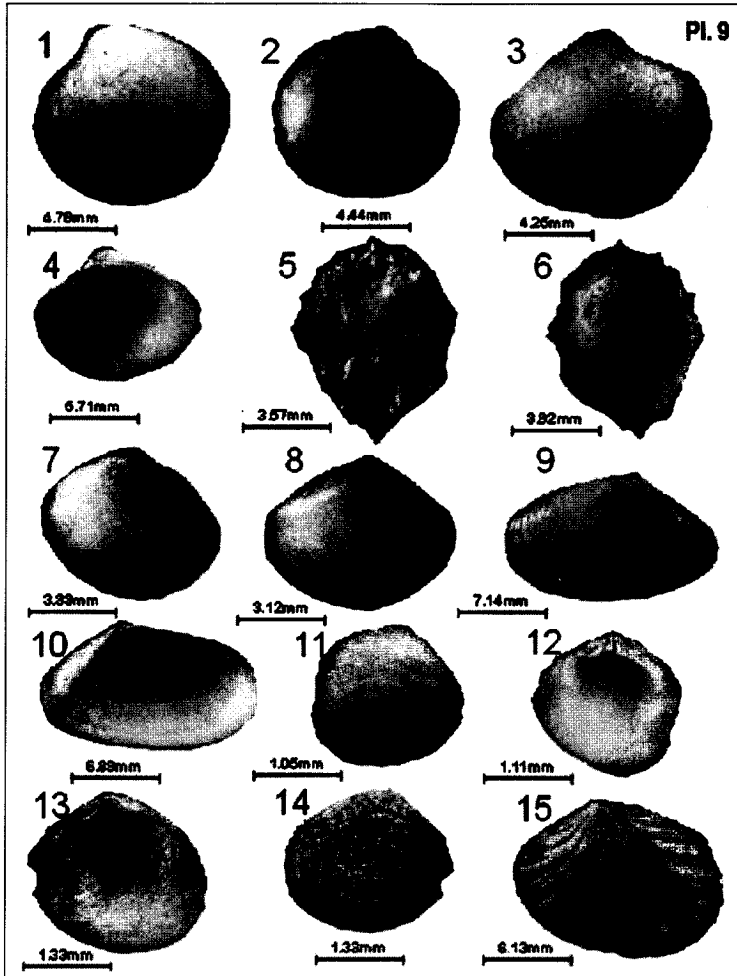


Fig.

- 1, 2: *Anodontia edentula* (Linnaeus, 1758); 1: External view of L. v. 2: Internal view of the same
- 3, 4: *Diplodontia (Diplodontia) rotundata* (Montagu, 1883); 3: External view of R. v. 4: Internal view of the same.
- 5, 6: *Chama reflexa* (Reeve, 1846); 5: External view of L. v. 6: Internal view of the same.
- 7, 8: *Psammotreta (Pseudometis) praerupta* (Salisbury, 1934); 7: External view of R. v. 8: Internal view of the same.
- 9, 10: *Gari weinkauffi* (Crosse, 1864); 9: External view of R. v. 10: Internal view of the same.
- 11, 12: *Circe (Circe) scripta* (Linnaeus, 1758); 11: External view of R. v. 12: Internal view of the same.
- 13, 14: *Circe (Parmulophora) corrugata* (Dillwyn, 1817); 13: External view of R. v. 14: Internal view of the same.
- 15: *Gafrarium pectinatum* (Linnaeus, 1758); 15: External view of L. v.

Family Chamidae Lamarck, 1809  
 Genus *Chama* Linnaeus, 1758  
*Chama reflexa* (Reeve, 1846)  
 (Pl. 9, Figs. 5, 6)

1992 *Chama reflexa* (Reeve); Oliver: 106

1995 *Chama reflexa* (Reeve); Bosch, Dance, Moolenbeek and Oliver: 242, fig.1066.

**Occurrence:** Um El-Howitat 4, 9, 14, Abu Shaar 8, and Shuni 4.

**Habitat:** On sides and under rocks, lower shore and below of the Red Sea, Indo-Pacific, the Arabian Gulf and the Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

Family Tellinidae de Blainville, 1814  
 Genus *Psammotreta* Dall, 1900  
 Subgenus *Pseudometis* Lamy, 1918  
*Psammotreta (Pseudometis) praeupta* (Salisbury, 1934)  
 (Pl. 9, Figs. 7, 8)

1992 *Psammotreta (Pseudometis) praeupta* (Salisbury); Oliver: 157, pl. 37, figs. 4a, b.

1995 *Psammotreta praeupta* (Salisbury); Bosch, Dance, Moolenbeek and Oliver: 257, fig. 1147.

**Occurrence:** Abu Shàar 4, 14, Shuni 2, 8 and Abu Galawa 1, 5.

**Habitat:** In muddy sand in shallow water of Lake Timsah, Great and Little lakes, Suez, Aden, Indo-Pacific, Red Sea, Arabian Gulf and Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

Family Psammobiidae Fleming, 1828  
 Genus *Gari* Schumacher, 1817  
*Gari weinkauffi* (Crosse, 1864)  
 (Pl. 9, Figs. 9, 10)

1992 *Gari weinkauffi* (Crosse); Oliver: 162. pl. 36, figs. 7a, b.

1995 *Gari weinkauffi* (Crosse); Bosch, Dance, Moolenbeek and Oliver: 260, fig.1164.

**Occurrence:** Um El-Howitat 4, 10, 16, Abu Shaar 12, Shuni 2, 5 and Abu Galawa 4.

**Habitat:** Muddy gravels and off shore of Suez, Sudan, Massouah, Aden, Djibouti, Indian Ocean, Red Sea, Arabian Gulf and Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

Family Veneridae Rafinesque, 1815  
 Genus: *Circe* Schumacher, 1817  
*Circe (Circe) scripta* (Linnaeus, 1758)  
 (Pl. 9, Figs. 11, 12)

1758 *Venus scripta* Linnaeus, syst. Nat; ed. 10: 689

1992 *Circe (Circe) scripta* (Linnaeus); Oliver: 181, pl. 39, figs. 1a, b, c.

2005 *Circe scripta* (Linnaeus); Nour: 108, pl. 6, figs. 16, 17.

**Occurrence:** Um El-Howitat 4, 9, 14, Abu Shaar 7, 13, and Shuni 4, 8.

**Habitat:** In sand and gravelly sand, intertidal and in shallow water of Red Sea Coast, Indo-pacific and Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

Subgenus *Parmulophora* Dall, 1915

*Circe (Parmulophora) corrugata* (Dillwyn, 1817)

(Pl. 9, Figs. 13, 14)

1817 *Venus corrugata* Dillwyn, 1: 201.

1969 *Circe (Parmulophora) corrugata* (Dillwyn); Moore: 672

1992 *Circe (Parmulophora) corrugata* (Dillwyn); Oliver: 181, pl. 39, figs. 2a, b.

2005 *Circe (Parmulophora) corrugata* (Dillwyn); Nour: 109, pl. 6, figs. 18, 19.

**Occurrence:** Um El-Howitat 7, 12, Abu Shàar 4,11 and Shuni 2,7.

**Distribution:** Pliocene and Pleistocene of Red Sea Coast, Farsan Island, Gulf of Suez, Aden, Gulf of Oman, Indian and Pacific oceans, Madagascar and Australia (Oliver, 1992 and Bosch *et al.* 1995).

**Habitat:** In mud flats, sand and gravelly sand in intertidal zone of the Red Sea coast Farsan Island, Gulf of Suez, Aden, Gulf of Oman. Indian and Pacific oceans, Madagascar, Pacific Ocean and Australia (Oliver, 1992 and Bosch *et al.* 1995).

**Range:** Pliocene- Recent

Genus *Gafrarium* Röding, 1798

*Gafrarium pectinatum* (Linnaeus, 1758)

(Pl. 9, Fig. 15, Pl. 10, Fig 1.)

1982 *Gafrarium pectinatum* (Linnaeus); Donald and Bosch: 185

1992 *Gafrarium pectinatum* (Linnaeus); Oliver: 182, pl. 39, figs. 6a, b.

1995 *Gafrarium pectinatum* (Linnaeus); Bosch, Dance, Moolenbeek and Oliver: 268. fig. 1200.

**Occurrence:** Um El-Howitat 4, 11, Shuni 5 and Abu Galawa 2, 4.

**Habitat:** In muddy gravels and sands of intertidal zone and in shallow water of the Red Sea, Indo-Pacific, Arabian Gulf and Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

Genus *Circentia* Jousseaume, 1888

*Circentia callipyga* (Born, 1778)

(Pl. 10, Figs. 2, 3)

1982 *Circentia callipyga* (Born); Donald and Bosch: 184

1992 *Circentia callipyga* (Born); Oliver: 183, pl. 41, figs. 1-16.

**Occurrence:** Um El-Howitat 9, Abu Shàar 6, 8, Shuni 6 and Abu Galawa 1.

**Habitat:** In sands in shallow water of Red Sea, Indian–Ocean, Gulf of Oman and Indo-Pacific (Oliver, 1992 and Bosch *et al.* 1995).

Genus *Callista* Poli, 1791

*Callista florida* (Lamarck, 1818)

(Pl. 10, Figs. 4, 5)

1992 *Callista florida* (Lamarck); Oliver: 187, pl. 40, figs. 7a, b.



1995 *Callista florida* (Lamarck); Bosch, Dance, Moolenbeek and Oliver: 269, fig. 1207.

**Occurrence:** Um El-Howitat 5, 9, 15 Abu Shaar 3, 10, Shuni 3, and Abu Galawa 1, 3.

**Distribution:** Pleistocene of Red Sea Coast, Indian Ocean, Arabian Gulf and Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

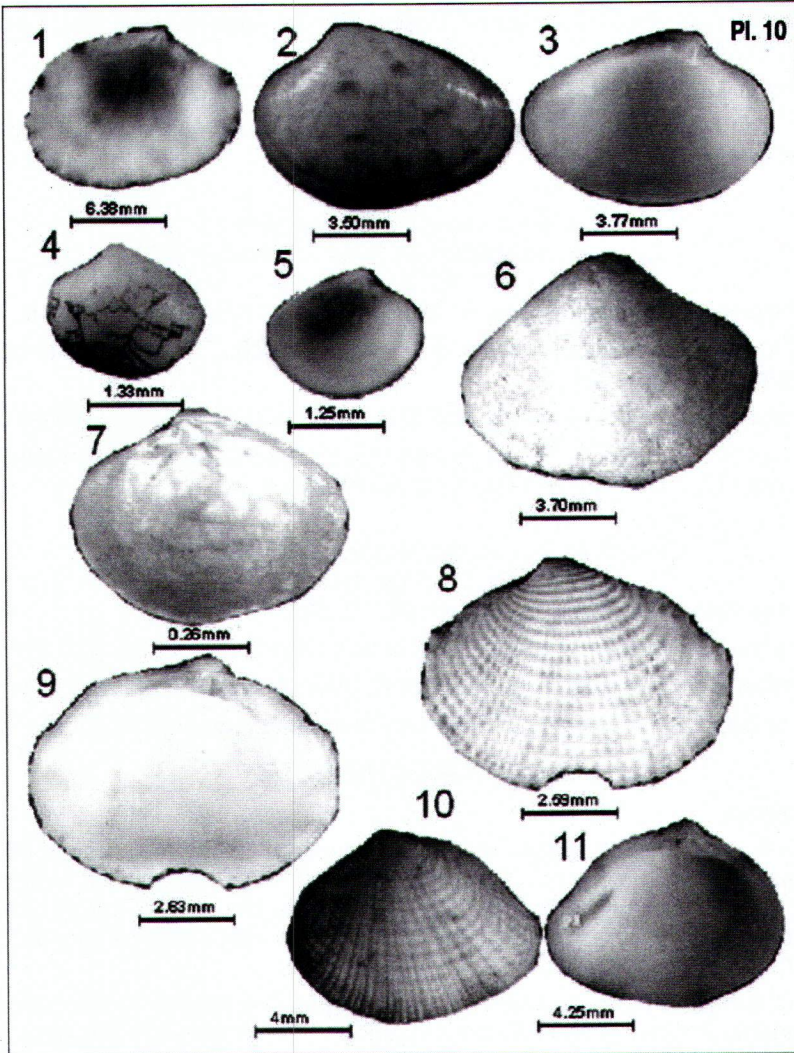


Fig.

- 1: *Gafrarium pectinatum* (Linnaeus, 1758); 1: Internal view of L. v.  
 2, 3: *Circentia callipyga* (Born, 1778); 2: External view of L. v. 3: Internal view of the same.  
 4, 5: *Callista florida* (Lamarck, 1818); 4: External view of L. v. 5: Internal view of the same.  
 6, 7: *Marcia marmorata* (Lamarck, 1818); 6: External view of R. v. 7: Internal view of the same.  
 8, 9: *Timoclea costellifera* (Adams & Reeve, 1848); 8: External view of L. v. 9: Internal view of the same.  
 10, 11: *Timoclea (Glycodonta) marica* (Linnaeus, 1758); 10: External view of L. v. 11: Internal view of the same.

**Habitat:** In muddy sand and gravel, off shore of Red Sea Coast, Indian Ocean, Arabian Gulf and Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

**Range:** Pleistocene-Recent.

Genus *Marcia* Adams, 1857  
*Marcia marmorata* (Lamarck, 1818)  
 (Pl. 10, Figs. 6, 7)

1995 *Marcia marmorata* (Lamarck); Bosch, Dance, Moolenbeek and Oliver: 272, fig. 1224.

**Occurrence:** Um El-Howitat 3, 12, Abu Shàar 8, 14, and Abu Galawa 2.

**Habitat:** Sand flats and intertidal zone of the Arabian Gulf and Gulf of Oman (Bosch *et al.* 1995).

Genus *Timoclea* Brown, 1827  
*Timoclea costellifera* (Adams & Reeve, 1848)  
 (Pl. 10, Figs. 8, 9)

1992 *Timoclea costellifera* (Adams & Reeve); Oliver: 192, pl 38, figs. 8a, b.

1995 *Timoclea costellifera* (Adams & Reeve); Bosch, Dance, Moolenbeek and Oliver: 266, fig. 1194.

**Occurrence:** Um El-Howitat 9, 11, Abu Shàar 4, Shuni 3, and Abu Galawa 3, 5.

**Habitat:** Off shore of Suez, Aqaba, Indian-Ocean, Red Sea coast, Arabian Gulf and Gulf of Oman (Oliver, 1992 and Bosch *et al.* 1995).

*Timoclea (Glycodonta) marica* (Linnaeus, 1758)  
 (Pl. 10, Figs. 10, 11)

1758 *Venus marica* Linnaeus; syst. Nat, ed. 10: 685

1992 *Timoclea (Glycodonta) marica* (Linnaeus); Oliver: 193, pl. 38, figs. 9a, b.

**Occurrence:** Um El-Howitat 9, Abu Shàar 8, Shuni 6 and Abu Galawa 1, 4.

**Habitat:** In sand, shallow water of Red Sea coast and Indo-Pacific (Oliver, 1992).

## SEDIMENT CHEMISTRY

### Heavy metals

Um El-Howitat lagoon shows the highest average contents of iron (1051 µg/g), manganese (232 µg/g), lead (6.06 µg/g), cobalt (1.21 µg/g), and copper (0.76 µg/g). El Shuni lagoon contains the highest contents of zinc (9.2 µg/g), nickel (3.14 µg/g) and 1.08 µg/g for cadmium. The comparisons with the other studied lagoons seen in Table (1) and (Fig. 2).

The enrichment of trace metals in Um El-Howitat lagoon is attributed to the anthropogenic inputs, while in El Shuni lagoon, it is attributed to the natural inputs from El-Shuni Valley, in addition to other oceanographic factors acting in both areas.

As expected, the heavy metals contents in Abu Galawa lagoon are the lowest values among all lagoons due to the continuous mixing with the open sea and oxidizing nature of the sediments see (Tab. 1, and Fig. 2).

### 2. Total phosphorous (TP)

Among the different studied lagoons, Um El-Howitat includes the highest

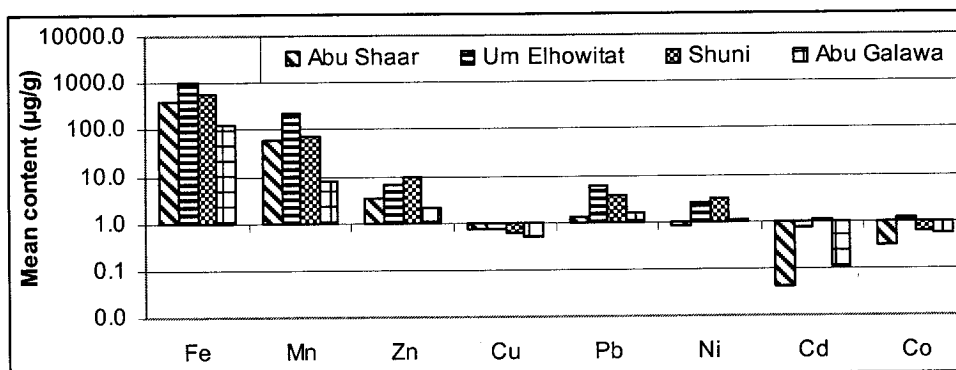


Fig. (2): Distribution of heavy metals content in the studied lagoons.

average (5714 µg/g) of the total phosphorous content (Table 1). This is significantly attributed to the fine suspended matters and the huge amounts of smothers emanating from the phosphate shipping in Abu Tartour harbor, in addition to the domestic and sewage materials from the coastal activities. El-Shuni lagoon includes the lowest average contents (3029 µg/g) of the total phosphorous (Tab. 1). The average content in Abu Galawa lagoon (4795 µg/g) is slightly higher than those of Abu Sha'ar lagoon (3699 µg/g) (Tab.1). El-Askary *et al.* (1988) attributed the highest phosphorous content in the northern Red Sea Coast sediments to uncertain inputs from terrestrial sources and/or phosphatization of the calcareous skeletons.

Total phosphorous is transported throughout the three finest fractions from the source areas and retains in sediments. This transported phase is probably the apatite mineral, which is insoluble in seawater and consequently inactive for the plant growth. The other phases of phosphorous in the sediments are the organic and sorbed over carbonate particles. These phases resulted directly from the human sewage from the coastal activities. Also, they are mobile and easily consumed by the overlying fauna and flora. These phases are indicated by the over-flushing of macro algal flora as *Halimeda* sp. and *Digenya simplex* in the tidal flat zones (Dar and Soliman, 2003).

### 3. Carbonate content

Carbonate sediments are made up for the most part of the skeletal parts of marine organisms. Abu Galawa lagoon has the highest carbonate content. It ranges from 69.1 % to 98.2 % with an average of 91.76 % (Tab. 1). That is due to the dominance of biogenic sediments from surrounding coral reefs and the absent of terrigenous influx. Carbonate content in Abu Sha'ar lagoon ranges from 58.8 % to 95.6 % with an average of 81.12 % that agree with El-Mamoney (1995) who found that the carbonate contents of the marine sediments in Abu Sha'ar varies from 21.75 % to 98.29 % (Tab.1). Um El-Howitat lagoon has the lowest carbonates content and it ranges from 15.4 % to 96.2 % and averaging 61.12%, in spite of the presence of coral reefs. The sediments of El-Shuni lagoon ranges from 70 % to 88 % and averaging 78% (Tab.1).

Generally, carbonate contents in the studied lagoons are significantly high and uniform in distribution although dominance influx of terrigenous materials except Abu Galawa lagoon due to the presence of coral reefs.

Maxwell (1968) classified sediments according to carbonate contents to high carbonate (>80 %), impure carbonate (80 % - 60 %), transitional (60 % - 40 %),

terrigenous (40 % - 20 %) and high terrigenous (<20 %). According to this classification, sediments of Abu Galawa and Abu Sha'ar lagoons are described as of high carbonate content but the sediments of the other two lagoons are described as impure carbonate content .

#### 4. Total Organic Matter (TOM)

The term total organic matter was applied in chemical sense for decomposable matter composed mainly of hydrogen, nitrogen and carbon. The presence of organic matter is related to fine sediments (Trask, 1939 and El-Askary *et al.* 1988).

Total organic matter content in the sediment of the studied lagoons are significantly high indicating the influx of terrigenous materials, which tends to appear in uniform distribution along most samples of each lagoon.

The sediments of El-Shuni lagoon have the highest TOM content. It ranges from 2.4 % to 5.1 % with an average of 3.6 % (Table 1), while Um El-Howitat lagoon recorded the lowest average of 2.2 % compared with other lagoons (Table 1).

Generally, the increasing of total organic matter in the studied lagoons can be attributed to the two following reasons: 1) The high rate of sedimentation and increasing of the fine particles in samples due to the main reason for their high content in Abu Sha'ar, Um El-Howitat and El-Shuni lagoons. 2) High organic productivity in some areas due to the seagrass bottom facies.

**Table 1: Heavy metals, total phosphorous, carbonate content and total organic matter in the studied lagoons.**

Studied lagoons	Heavy metals								TP	Carb. %	TOM	
	Fe	Mn	Zn	Cu	Pb	Ni	Cd	Co				
Abu Shaar	Average	378	57	3.46	0.75	1.28	0.78	0.04	0.32	3699	81.12	2.72
	Minimum	94	10	1.7	0.12	0	0	0	0	233	58.8	2
	Maximum	919	178	9.51	3.29	5.78	2.48	0.13	1.08	5828	95.6	3.2
Um Elhowita	Average	1051	232	6.47	0.76	6.06	2.54	0.76	1.21	5714	61.12	2.21
	Minimum	100	90	2.27	0.19	3.77	1.49	0.38	0.77	818	15.5	0.05
	Maximum	1265	435	11.14	1.48	9.21	3.88	2.8	1.97	9696	96.2	3.9
El-Shuni	Average	557	70	9.22	0.6	3.63	3.14	1.08	0.6	3029	78.08	3.62
	Minimum	131	14	4.96	0.34	0	1.53	0	0	37	70	2.4
	Maximum	1620	119	16.94	0.92	6.62	5.58	8.25	1.02	4362	88	5.1
Abu Galawa	Average	125	7.7	2.13	0.48	1.54	1.05	0.11	0.55	4795	91.76	2.87
	Minimum	84	4.2	1.46	0.19	0.39	0.34	0	0.3	3328	69.1	2.6
	Maximum	157	11.4	2.84	1.1	2.98	2.75	0.26	0.87	5790	98.2	3.1

#### Faunal diversity versus geochemistry of sediments

There is a relation between the diversity and the geochemistry of the studied lagoons. In Um El-Howitat lagoon, where the highest heavy metals content, and the total phosphorous content are recorded, it shows the relatively low diversity and also low total organic matter. On the other hand, in Abu Galawa lagoon - and to some extent Marsa El-Shuni Lagoon-, the lowest heavy metals content is recorded, and the highest relative diversity and carbonate content is also observed. This result may be referred to the partially pristine conditions prevailing in Abu Galawa and Marsa El-Shuni lagoons, the Abu Galawa lagoon has relatively an open

connection to the sea, and the Marsa El-Shuni Lagoon is clear from the anthropogenic effect.

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