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Identification of the gastropod snails and shells collected from Ain El-Sokhna region, Red Sea, Egypt

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ABSTRACT

The Red Sea is known by its unique coral reef topography that harbors many marine species making the Red Sea a biodiversity hot spot. The molluscan fauna of the Red Sea has been extensively studied for its ecology, biology and economic importance. In the present study, numerous live specimens and gastropod shells were collected from Ain El-Sokhna area on the western shore of the Red Sea's Gulf of Suez. Samplings were done during June-October, 2020. The collected species were identified based on published keys for the identification of Red Sea molluscs. A total of 24 gastropod species belonging to 12 families were identified. Among these, the highest abundant species was *Thais savignyi* (Muricidae) followed by *Cellana rota* (Nacellidea). Some other species were rarely abundant such as *Conomurex fasciatus* (Strombidae), the reef eating snail, *Drupella cornus* (Muricidae), *Nassarius fenistratus*, *N. castus* (Nassariidae), and *Polinices pecelephanti* (Naticidae). The present findings demonstrate a high molluscan biodiversity at Ain El-Sokhna region of the Red Sea and set the platform for further studies and assessments of biological and biomedical importance of identified molluscs species either as intermediate hosts for parasites or sources for bioactive compounds.

INTRODUCTION

The Red Sea is characterized by its wealthy marine life and unique coral reefs, which considered the world's best example of coral reef topography providing an adequate shelter for a wide range of animal species making the Red Sea an important biodiversity hotspot that continue to attracts the attention of scientific community **(Rusmore-Villaume, 2008)**. The entire Red Sea, including the coast of Egypt and coasts associated with gulfs (Suez and Aqaba), had been the subject for several investigations focusing on their ecology, biology and economic importance **(Gab-Allah *et al.*, 2007; William *et al.*, 2013, Zakaria, 2015)**.

The region of Ain El-Sokhna lies on the northwestern side of the Gulf of Suez. This region is distinguished by the presence of highly vulnerable and fragile natural resources, ecosystems, an extensive coastal plain, a huge tidal flat and an important coral reef hosting its aquatic ecosystem. This region has undergone rapid and growing changes in land use patterns in recent decades, in particular with the growth of tourist activities, the construction of the Ain El-Sokhna port, resorts and the subsequent increase of population. Due to the rapid development projects, the area is presently suffering from environmental pollution and loss of some natural resources **(Ahmed, 2000)**.

Mollusca represents one of the most species-rich phyla in the animal kingdom, 50,000 described species of molluscs, about 30,000 of these are found in the marine environments **(Gosling, 2004)**, which in turn are the second largest animal phylum and the largest in the marine realm **(Rusmore-Villaume, 2008; FAO, 2016)**. Due to their ecological prevalence, promoting colonization of almost all marine environments and being assisted by the long tradition of extensive field studies and taxonomy, marine molluscs is considered a powerful tool for studying marine biodiversity **(Crocetta *et al.*, 2020)**. Molluscan species may also be utilized as bioindicators of environmental health. Many pollutants and pathogens may be detected by investigations of distribution and abundance of molluscs due to their large size and limited mobility. Molluscs accumulate organic and inorganic substances that remain in their biomass because of the higher absorption rate of these materials compared to their catabolism and excretion. These features make molluscs ideal candidates for biomonitoring studies **(FAO, 2016)**.

Certain species of marine gastropods have direct or indirect commercial significance and even medical importance to humans **(Rusmore-Villaume, 2008)**. Marine molluscs are considered a promising source for a wide range of therapeutic applications, with purified, semi-purified, synthesized bioactive compounds or even crude extracts. Molluscs may be used directly as a food source and can also contribute to the prevention of disease by providing essential nutrients, as well as immuno-modulatory compounds and other secondary metabolites with direct biological activity **(Benkendorff *et al.*, 2015)**.

Molluscs at the Red Sea's neighboring areas including Suez Canal Lakes have been monitored for decades **(Fouda and Abou-Zied, 1990; Mohammed, 1992, 1997 and Mahmoud *et al.*, 2018)**. However, all these studies covered certain species or dealt with classification, ecology or general abundance of certain families. The present study aimed to broaden our overall knowledge of the identity of molluscan species distributed in this region of the Red Sea. Moreover, this research is anticipated to set the background for further studies and assessments of identified molluscs species using the advantage of tremendous diversity of marine environment at the scientific, therapeutic and economic levels.

MATERIALS AND METHODS

STUDY AREA AND SAMPLES COLLECTION

Samplings were done at Ain El-Sokhna, Egypt (latitude: 29º28'18.2''N and longitude: 32º27'12.6''E) (Fig. 1) during the period from June to October, 2020. Ain El-Sokhna belongs to the Suez Governorate on the western shore of the Red Sea's Gulf of Suez. It is located in the southern area of Suez, approximately 120 kilometers east of Cairo. The climate of Ain El-Sokhna is a hot desert climate as the rest of Egypt.

Live captured snails and shells were collected manually from the intertidal and shallow subtidal zones at depth of 1-3 m. Shells were collected from the shore after navigating a distance of 1-2 km. Samples were washed thoroughly at the site of collection using seawater to remove any attached sand grains, pebbles and other impurities encountered during assemblages. Snails were transferred to the laboratory alive in plastic aquaria containing seawater.

Fig. 1. A map showing the site of samples collection in the Red Sea at Ain El-Sokhna.

For identification, live-collected gastropod samples were quickly washed by rinsing in sterile water to weed out any remaining impurities and epiphytes. After that the specimens were fixed in 2% buffered formaldehyde and transferred to absolute ethanol (100%) **(Crocetta *et al.*, 2020)**. Fixed samples and empty shells were dried and photographed using Nikon camera for professionals (scale bar was considered for each photo taken). The specimens were then stored in the Medical Malacology Laboratory, Theodor Bilharz Research Institute, Egypt. Samples were identified to species level based on published identification keys such as **Dekker and Orlin (2000)**, **Rumore-Villaume (2008)** and taxonomy and nomenclature in the World Register of Marine Species **(WoRMS Editorial Board, 2019)**.

The abundance of each snail species was reported as frequent (F) for species with more than 10 snails, common (C) for species with snail's number ranging from 4 to 9, and rare (R) for species with 1-3 snails.

RESULTS

In Ain El-Sokhna region many species and genera are endemic depending on the nature of environment. A total of 24 gastropod species from 12 families were recorded in Table (1). The highest number of species was observed in Muricidae family (*Thais savignyi*) followed by Nacellidea family (*Cellana rota*).

Table 1. List of gastropod snail species and shells collected from Ain El-Sokhna region, Egypt.

Family	Genus	Species	Occurrence	Habitat
Cerithiidae	*Cerithium*	*adansonii*	Common	Coral and rocky bottom
		columna	Frequent	On alga-covered rock
		caeruleum	Common	Rocky shores, Shallow and Sand
Strombidae	*Canarium*	*erythrinum*	Common	Shallow marine sediments
	Conomurex	*fasciatus*	Rare	Demersal, shallow water and over soft bottoms
	Dolomena	*plicata*		Deep water
Turbinidae	[a]*Turbo*	*radiatus*	Frequent	Shallow water
Muricidae	*Murex*	*forskoehlii*	Common	Demersal, buried in soft bottoms
	[a]*Thais*	*savignyi*	Frequent	Rocky beaches
	[a]*Drupella*	*cornus*	Rare	Rocky area
Fasciolariidae	[a]*Latirus*	*polygonus*	Frequent	Hard bottoms
	Fusinus	*verrucosus*	Rare	Shallow water, on sandy or mixed bottoms
Trochidae	[a]*Tectus*	*dentatus*	Frequent	Shallow subtidal zones and coral reef shore
	[a]*Trochus*	*virgatus*	Frequent	Rocky habitat and Coral rubble
	[a]*Trochus*	*erithreus*	Frequent	Shallow rocky bottoms
Neritidae	[a]*Nerita*	*sanguinolenta*	Frequent	Shallow tide pools
	[a]*Nerita*	*orbignyana*	Frequent	On open rocky surfaces or boulders at mid to high tide and shallow water
Nacellidae	[a]*Cellana*	*rota*	Frequent	On or under coral heads and boulders of rocky shores
Nassariidae	*Nassarius*	*fenistratus*	Rare	Soft bottoms and rocky shore
	Nassarius	*castus*	Rare	Shallow water
Planaxidae	*Planaxis*	*savignyi*	Common	Rocky shores
	[a]*Planaxis*	*sulcatus*	Frequent	On stones and boulders of rocky shores
Naticidae	*Polinices*	*pecelephanti*	Rare	Sandy to muddy bottoms
Potamididae	[a]*Potamides*	*conicus*	Common	Rocky shores

[a] indicates live-captured specimens

Family: Cerithiidae

Shells are minute to large, elongate, turreted, spire with often some labial varices, aperture ovate and paucispiral operculum.

***Cerithium adansonii* (Bruguière, 1792)**

Description: The shell sized range from 15 to 70mm. Its color is glossy, brown and white. Shell is whorled, turreted, large with regular knobs and has a well-developed notch at the lower part of the shell aperture. The base of the apertural lip extends across the anterior siphonal canal (Fig.2-1a).

Distribution: Common in the Gulf of Suez (**Rusmore-Villaume, 2008)**.

***Cerithium columna* (Sowerby, 1834)**

Description: The shell sized from 7 to 35mm. Shells are elongated, turreted and sometimes smooth, plain white or beige with gray whorls at the apex or with rough texture, sharp tubercles and numerous spiral threads (Fig.2-1b).

Distribution: Common in the Gulf of Aqaba **(Rusmore-Villaume, 2008)**.

***Cerithium caeruleum* (Sowerby, 1855)**

Description: The shell sized from 13 to 40mm. Shells show few rows of nodules and tiny beads on whorls and the apex is usually eroded. The surface of the shell is brown, greyish-white or greenish with a white aperture (Fig.2-1c).

Distribution: A wide range of distribution in the Red Sea **(Rusmore-Villaume, 2008)**.

Family: Strombidae (known as the true conchs)

***Canarium erythrinum* (Dillwyn, 1817)**

Description: Shell sized from 20 to 50mm. The body whorl is large with numerous strong axial ribs, tall spire, sloping shoulders. Both sides of the aperture are lirate, dark yellow ring around the inside of the aperture. The aperture is white or beige (Fig.2-2a).

Distribution: Common in the Red sea **(Rusmore-Villaume, 2008)**.

***Conomurex fasciatus* (Born, 1778)**

Description: The shell size is from 15 to 65mm. The shell is lineated with dark brown to black spiral line around colored-light shell. It has a deep notch on their shell aperture, has white base color and lines passing vertically on its body. The aperture usually is coral orange (Fig.2-2b).

Distribution: A wide range of distribution in the Red Sea **(Rusmore-Villaume, 2008)**.

***Dolomena plicata* (Röding, 1798)**

Description: Known as “Pigeon Conch”. The shell size ranges from 35 to 57mm. The body whorl is large with numerous fine ribs on the spire. The columella contains numerous folds on its entire length with or without brownish color. The aperture is white with light brown transverse striae as shown in Figure (2-2c).

Distribution: A wide range of distribution in Red Sea and Africa **(Rusmore-Villaume, 2008**).

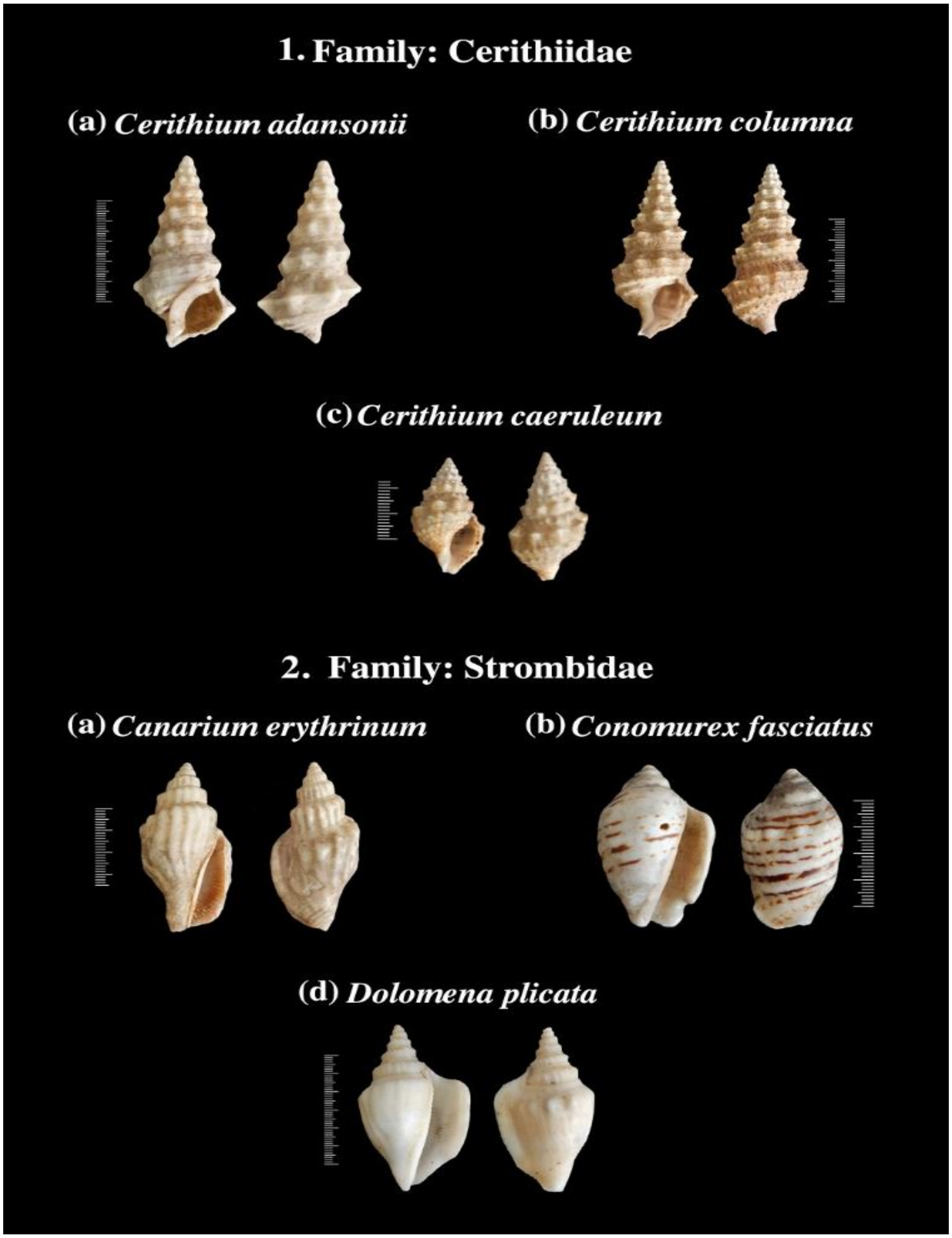

Fig. 2. Species of gastropod snails and shells collected from Ain El-Sokhna region: Families Cerithiidae and Strombidae.

Family: Turbinidae

The species of this family are known by Turban shells characterized by calcareous operculum.

Turbo radiatus **(Gmelin, 1791)**

Description: The size of the shell varies between 35 to 50mm. The shells have beige and brown colors, the darker color often predominating. The shells are spherical in shape with tubercles and divided to upper small spiral rows of small knobs and lower big spiral rows of big knobs. The operculum frequently found separated, called cat's eye. The snail in the water always develops rounded shape spines (Fig.3-3a).

Distribution: Common in all regions of the Red Sea **(Zuschinand and Stachowitsch, 2007)**.

Family: Muricidae

Muricidae, commonly known as murex or rock whelks, are carnivorous with variables shells.

***Murex forskoehlii* (Röding, 1798)**

Description: The shell size is from 15 to 115mm. The shell color is from white to beige with long spines and very long siphonal canal (Fig.3-4a).

Distribution: Common in Gulf of Suez and rare in the Gulf of Aqaba **(Rusmore-Villaume, 2008)**.

***Thais savignyi* (Deshayes, 1844)**

Description: The shell size is from 21 to 50mm. The shell has four spiral rows of distinct, well-separated, pointed, grey-brown tubercles. Pointed nodules are present on all whorls. The inner edge of the lip is with dark-brown patches. The aperture is white or with a small bend in the middle and a brown base (Fig.3-4b).

Distribution: Common in rocky beaches **(Rusmore-Villaume, 2008)**.

***Drupella cornus* (Röding, 1798)**

The common name is the horn drupe. These snails are mainly found on live corals and considered highly significant coral predators.

Description: The shell size is from 13 to 30mm. It is elongated with encrusted shell with spiral rows of pointed tubercles. Aperture is white and dentate as shown in Figure (3-4c).

Distribution: Live corals and rock in the Gulf of Aqaba, northern Red Sea **(Zuschin and and Stachowitsch, 2007)**.

Family: Fasciolariidae

All members in this family are carnivorous. Sometimes called spindle shells.

***Latirus polygonus* (Gmelin, 1791)**

Also known as the short-tailed *Latirus*.

Description: The shell size is from 50 to 99mm. The shells are spindle with elongated spire and the outline of whorls is not rounded. Aperture is with weak plicate on the columella. The siphonal canal is well developed. The color is creamy to pale with darker markings, or dark brown as shown in Figure (3-5a).

Distribution: A wide range of distribution in the Red Sea **(Rusmore-Villaume, 2008)**.

Fusinus verrucosus **(Gmelin, 1791)**

Description: Shell length is from 60-110mm. The shell is spindle shaped, beige, yellowish, or light brown shells with long siphonal canal and numerous spiral cords on the exterior columella. The shell is also characterized by sooth, purple-mouthed aperture (Fig.3-5b).

Distribution: A wide range of distribution in the Red Sea **(Rusmore-Villaume, 2008)**.

Fig. 3. Species of gastropod snails and shells collected from Ain El-Sokhna region: Families Turbinidae, Muricidae, and Fasciolariidae.

Family: Trochidae

The common name is the top- snails. The shell is corneous with multispiral operculum.

***Tectus dentatus* (Forskål, 1775)**

Description: Shell length is from 40 to 150mm, large solid and heavy shell with conical-turreted shape,. The surface shows strong rounded tubercles. Color of the shell is beige or pale brown with blue-green spiral band at the base (4-6a).

Distribution: Common in all regions of the Red Sea **(Zuschinand and Stachowitsch, 2007)**.

***Trochus virgatus* (Gmelin, 1791)**

Description: The shell size is from 30-60 mm with a conic-pyramidal shape containing sharp edges and apex which may be weakened by wear. The sutures are linear. The columella is smooth, oblique with one sharp tooth at the base. The aperture is mildly iridescent as shown in Figure (4-6b).

Distribution: A wide range of distribution in the Red Sea **(Rusmore-Villaume, 2008)**.

***Trochus erithreus* (Gmelin, 1791)**

Description: The shell size is range from 3 to 43mm. Solid shells have a broadly conical spire and a flat base. The shell shape is pyramidal with many small knobs (bumps) arranged in spiral rows. The base of the shell is flat or convex. The columella is smooth without teeth. The interior of the shell is pearly and usually mottled pink and white (Fig.4-6c).

Distribution: Abundant in all regions of the Red Sea **(Rusmore-Villaume, 2008)**.

Family: Neritidae

Nerita are herbivores gastropods that feed microalgae from rocky surfaces and inhabit cracks and hidden niches in the high rocky intertidal zone. Most neritidae species have a shelf beside the aperture. The calcareous operculum is characteristic to this family.

***Nerita sanguinolenta* (Menke, 1829)**

Description: The size of the shell ranges from 10 to 38mm. The shell is semi oval, with expanded-swollen body whorl containing a large columellar callus and few notches in middle. The shell color has different patterns; black-and-white (common type), bright orange or red and sometimes white or beige spots (Fig.5-7a).

Distribution: Abundant in all regions of the Red Sea **(Rusmore-Villaume, 2008)**.

***Nerita orbignyana* (Recluz, 1842)**

Description: The size of the shell is from 5 to 23mm. The shell is smooth and very colorful with shiny surface. The inner walls of the spire whorls are elevated (Fig.5-7b).

Distribution: Common in Gulf of Aqaba **(Dekker, 2000)**.

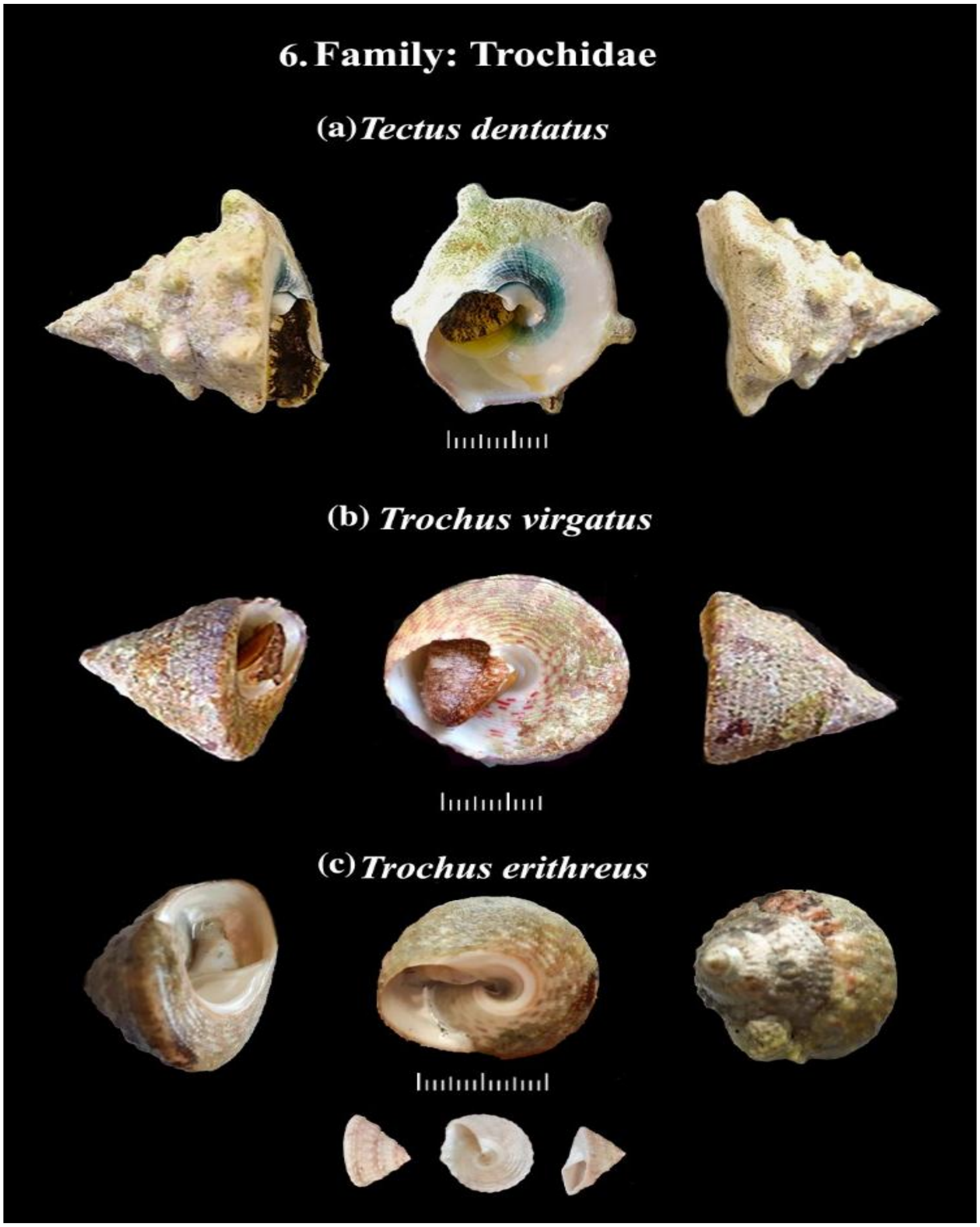

Fig. 4. Species of gastropod snails and shells collected from Ain El-Sokhna region: Family Trochidae.

Family: Nacellidae

***Cellana rota* (Gmelin 1791)**

Description: The shell size ranges from 20 to 50mm with regular ovate outline, conical with worm apex. The external sculpture consists of numerous fine, fat or radial rays and interior glossy silvery white, beige or yellow. The shell color is pale brown or yellowish with 8-10 sectors of dark brown mixed with blotches of the background color (Fig.5-8a).

Distribution: A wide range of distribution in the Red Sea **(Rusmore-Villaume, 2008)**.

Family: Nassariidae

Nassariidae are a group of scavenging gastropods.

***Nassarius fenistratus* (Marrat, 1877)**

Description: The shell size varies from 10 to 20mm. There are nodules over the shell, regular in the upper whorls and stronger. First row of nodules below the suture is slightly stronger. Body color is white with irregular brown markings. (Fig.5-9a).

Distribution: Profusely in Gulf of Aqaba and common in the south **(Rusmore-Villaume, 2008)**.

***Nassarius castus* (Gould, 1850)**

Description: The size of the shell is from 20 to 33mm with rounded axial ribs cut by deeply incised line below the suture, more incised spiral lines on the lower part of the body whorl. The color is brown, orange with a white line at the top of each rib (Fig.5-9b).

Distribution: Uncommon, but can be found in all regions **(Rusmore-Villaume, 2008)**.

Family: Planaxidae

The common name of family Planaxidae is planaxids or cluster winks. It is active crawling herbivorous, feeding primarily on microalgae covering rocky area.

***Planaxis savignyi* (Deshayes, 1844)**

Description: The size of the shell is from 8 up to 23mm. The shell is conic-ovate in shape, incised spiral lines. The color of the shell is usually brown with white spots or black, ovate aperture with inner lip. The operculum is thin, hornlike, and dark colored. The whorls sculptured with spiral cords (Fig.6-10a).

Distribution: Common in all regions **(Rusmore-Villaume, 2008)**.

***Planaxis sulcatus* (Born, 1778)**

Description: Shell size is from 8 up to 35mm in length. The shell is conic-ovate in shape, incised spiral lines which is black, ovate aperture with inner lip (Fig.6-10b).

Distribution: Distributed along the shore of the Red Sea **(Beltagi, 2018)**.

Family: Naticidae

Snails of this family are known as elephant's foot moon snail. Most of the naticides found in the northern Red Sea are spherical.

***Polinices peselephanti* (Link, 1807)**

Description: The shell size is from 35 to 70mm, and the color of shell is white with orange tings. The shell has large open umbilicus (Fig.6-11a).

Distribution: Limited in Ras Sudr in the Gulf of Suez **(Rusmore-Villaume, 2008)**.

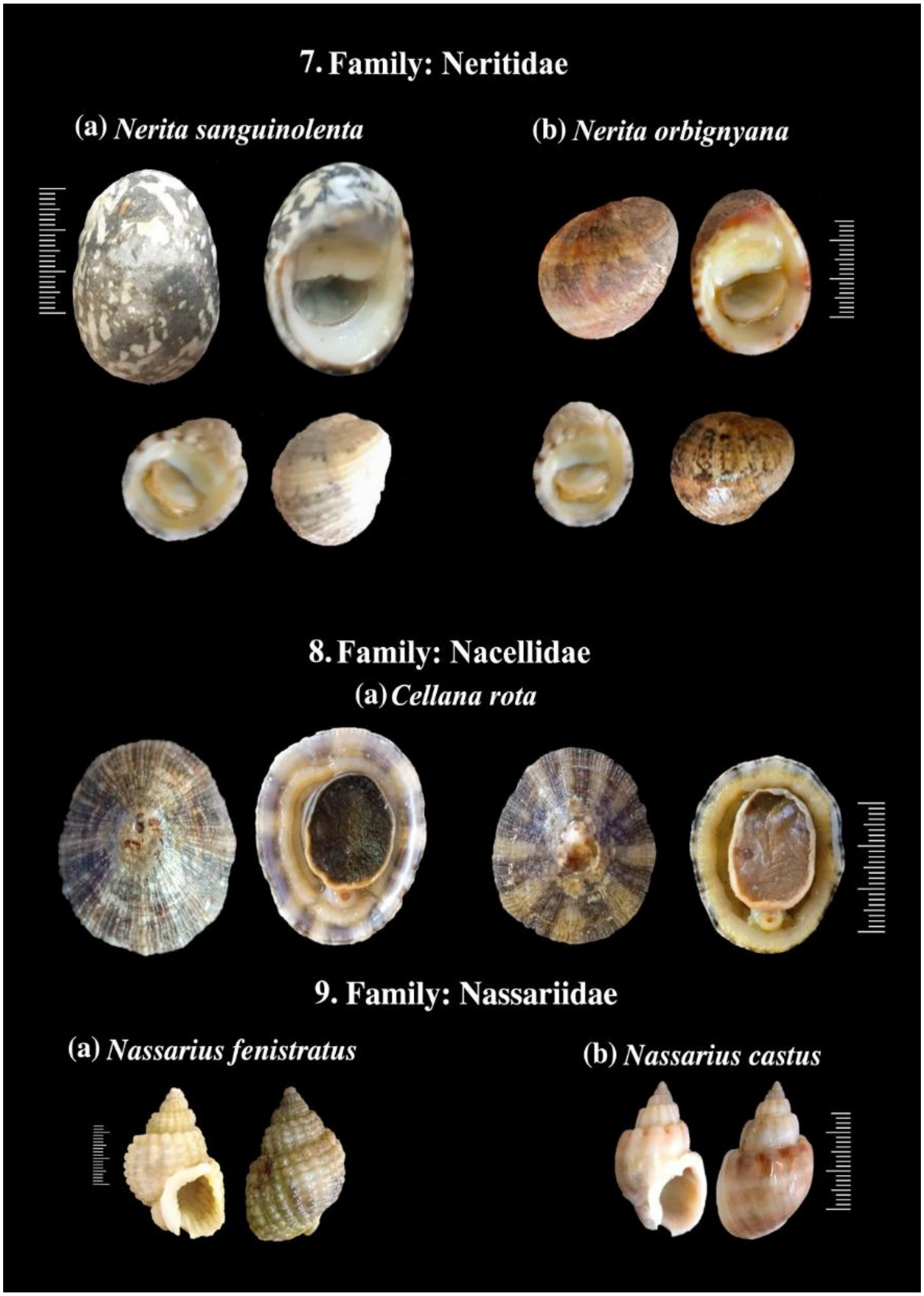

Fig. 5. Species of gastropod snails and shells collected from Ain El-Sokhna region: Families Neritidae, Nacellidae, and Nassariidae.

Family: Potamididae

***Potamides conicus* (Blainville, 1829)**

Description: The shell size is from 4 to 15mm, elongated, conical, strong and covered with small nodules. The color varies from beige to shade brown (Fig.6-12a).

Distribution: A wide range of distribution in the Red Sea **(Rusmore-Villaume, 2008)**.

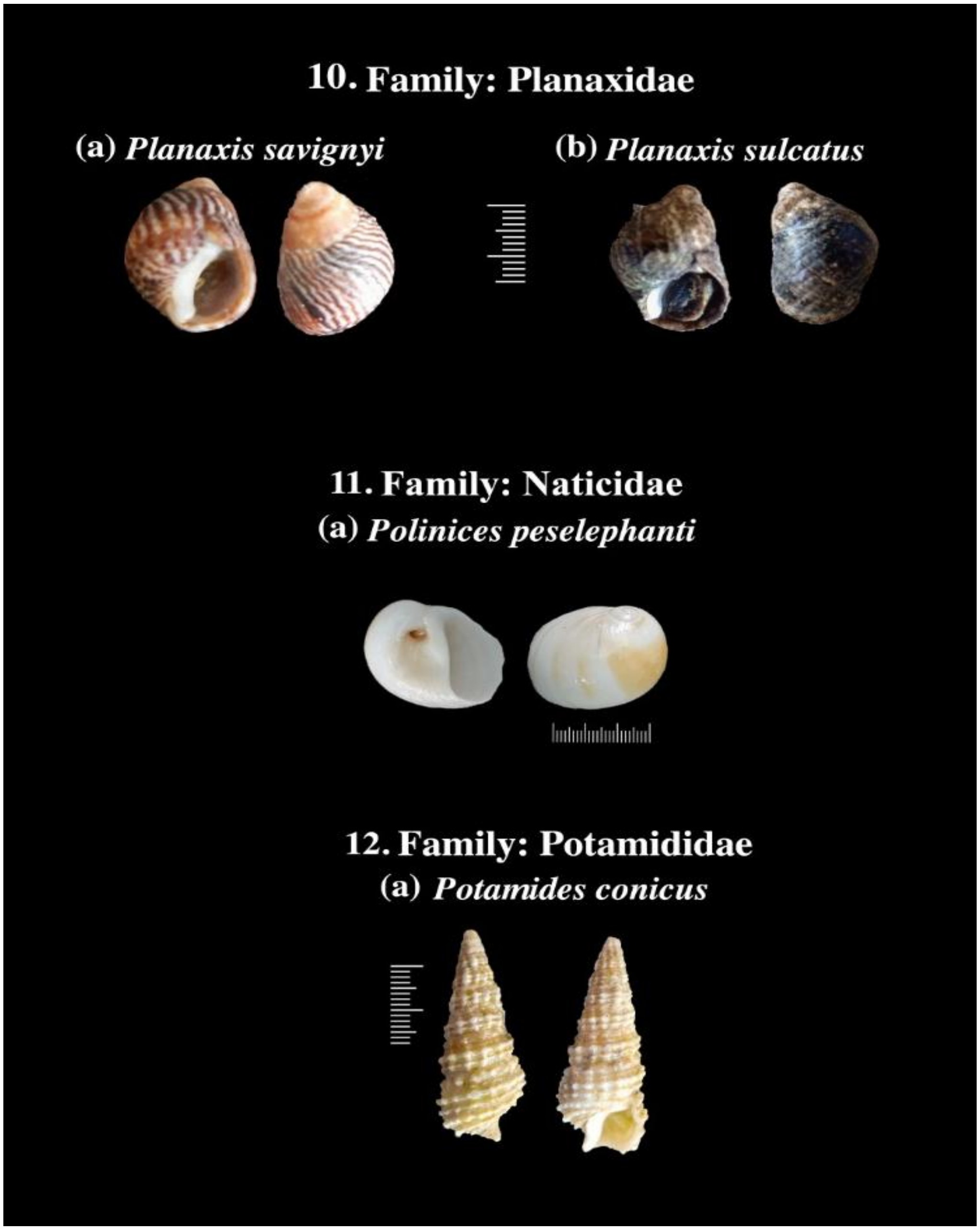

Fig. 6. Species of gastropod snails and shells collected from Ain El-Sokhna region: Families Planaxidae, Naticidae and Potamididae.

DISCUSSION

The present study documents and provides important baseline information mainly about species and distribution of molluscs inhabiting this promising region located at the northwestern part of the Gulf of Suez, Egyptian Red Sea. This type of studies is important because of enhanced local human activities and increasing sea surface temperature due to global warming which may be potential factors responsible for many changes in the ecological and biological composition **(Lasser *et al.*, 2007)**.

In the present study 24 gastropod snail species belonging to 12 different families were identified. All the species that were detected in the area under study have previously been proven to exist in the Red Sea **(Rusmore-Villaume, 2008; Hamdi, 2011)**, but the difference lies in the relative abundance of each type, which may be related to the movement of the surface water current in the Red Sea affecting the zooplanktons distributed at different locations. Also, lessepsian migration plays an important role in the presence of some species of gastropods **(Samir, 2018)**. The most abundant mollusk recorded in the tested site was *Thais savignyi*. The establishment status of *T. savignyi in* the Red sea was previously defined as casual **(Rusmore-Villaume, 2008)** or even rare as reported by **Hamdi (2011)**. The second common species recorded in the intertidal zone of Ain El-Sokhna was *Cellana rota* that was collected from the rocky substrata near the sea level at the region. This agrees with **Zuschin *et al.* (2009)** who reported that *C. rota* was frequently observed living in the rocky intertidal and supratidal of the northern Red Sea, for example at Tubya Al-Hamra and Tubya Al-Bayda, Egypt.

Planaxis sulcatus was also widely distributed in the area under investigation. It was previously noticed that *P. sulcatus* snails form distinct clusters along the Suez Canal rocky shores and often aggregate in clusters along the intertidal flats in the Suez Canal. Cluster numbers fluctuated widely either seasonally or with shore level **(Mohammed, 1999)**. Previous investigations showed that crude extracts or purified compounds from the snail species mentioned above have considerable antibacterial and anticancer activities (Table 2).

Table 2. Bioactive compounds extracted from some snail species identified in the present study and their activity.

Species	**Compounds**	**Activity**
Family: Muricidae *Thais savignyi*	Crude extracts	Antibacterial **(Ameri *et al.*, 2017)**
Family: Nacellidae *Cellana rota*	Crude extract	Antibacterial **(Ramasamy and Murugan, 2005)**
Family: Planaxidae *Planaxis sulcatus*	- Dihydrosinularin - 11-epi-sinulariolide - Planaxool - [7.7] paracyclophane	- Anticancer activity **(Sanduja *et al.*, 1986)** - Cytotoxic activity **(Alam *et al.*, 1988, 1993; Thanh *et al.* 2020)**

The family Trochidae in the investigated site was represented by three frequent species (*Tectus dentatus*, *Trochus virgatus* and *T. erithreus*). *T. dentatus* exhibits shallow waters of coral reefs and also along rocks and coral patches in the Red Sea, also known for its commercial importance, the shell can be used in the manufacture of dental fillings and wood furniture inoculations and the meat is used as a food source for the coastal population and tourism sector **(Hoffman *et al.*, 2006)**. Since this species has long been unfairly used due to its commercial impact and limited regulations concerning biology, ecology and fishery; there is an urgent need to assess the status of the population stock, which is critical for fishery management and sustainable utilization of the resource **(Abdel-Razek et al. 2013)**.

Different colors and patterns were noticed concerning *Nerita sanguinolenta*. The color of these snails is similar to the rocks on which they live, where red molluscs live on red granite rocks, black and white ones live on black and white rocks, and greenish ones live on greenish rocks **(Hamdi, 2011)**. According to **Rusmore-Villaume (2008)**, these variations may indicate a color-sensitive behavior of predators that pick off the ones that stand out against the rock.

Drupella cornus is typically described as a solid, whitish shell, up to 3cm, with four prominent rows of spiny nodules and numerous other smaller spines. Surface occasionally smooth, depending on the degree of overgrowth by coralline algae. At high population densities, the snails' scars, left from their feeding on living coral, can kill extensive coral areas leaving reefs to be colonized by filamentous algae **(Schoepf *et al.*, 2010)**. An interesting specimen of *D. cornus* **(MolluscaBase eds., 2020)** was collected in the present study (Fig. 3-4c). The sample showed a unique pattern of meanderings and overgrowth on its external surface which may be due to calcification of coralline algae stuck on the hard shell.

Although information on the ecology and biology of other species identified in the current study are scarce, yet it still important to study their occurrence, distribution and morphological characteristics to monitor the impact of climate changes and human activities on the biodiversity of marine environment in the Red Sea (**Bellard *et al*., 2012**).

CONCLUSION

Although the Red sea is considered a relatively stable system **(Por, 1973)**, the recent increase of human impact, shipping activities, drainage from tourist facilities and intensive tourist activities may affect this stability. Further quantitative sampling and statistical analysis are necessary to demonstrate the biological mapping for the spatial distribution patterns of different molluscan organisms inhibiting this important biological niche.

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