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MOLLUSCAN FAUNA OF HARD SUBSTRATE ALONG THE COASTAL ZONE OF WESTERN LIBYA

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Abstract: A total of 36 molluscs species were encountered along the western coast of Libya between Gout alruman and Tellil. Samples were collected during September and October 2004 using a 25 × 25 cm quadrate on a sectorial belt. Gastropoda was the most dominant class with 25 species followed by Bivalvia (10 species) and one species of Polyplacophora. No significant differences in number of molluscan species were recorded between locations. The results showed a clear variations in the quantity of benthic animals in all studied station which ranged between 136 – 7276 individuals.

Kew Words: Abundance, Benthic, Diversity, Intertidal, Libya, Mollusca, Rock substrate

INTRODUCTION

Marine molluscs occupy different habitat, especially the intertidal zone and the continental shelf, they live either freely or coexisting with other organisms (Howaege, 1998). In the Mediterranean, there are more than 2100 described species (Coll *et al.*, 2010), the most common molluscs belong to genera: *Mactra, Tellina, Donax, Acanthocardia, Abra, Cerastoderma, Ruditapes, Scrabicularia, Loripes, Gaslrana* (Bivalvia); *Akera, Crabula* (Gastropoda) (Guelorget and Perthisot, 1994).

Mollusks have general importance in ecosystems. As well, many species have either commercial or medical importance to humans. Sessile molluscs are used as quantitative biological indicators for chemical contaminants in aquatic environments around the world (Nakhlé *et al.*, 2006). Despite the Mediterranean molluscan fauna are considered as the best known in the world (Oliverio, 2003), the Libyan molluscs are poor known due to lack of comprehensive studies. Little studies have been conducted regarding Libyan molluscs, althogh Libya has long coast. 139 species were recorded in the continental shelf (Contransimex, 1977), Huni and Aravindan (1984) recoded 16 species of intertidal molluscs on a rocky platform of Tajura coast, and in 1989, Naas recorded 20 species of littoral prosobranhias from the western Libyan coast. In a study to figure out the animals coexisting with algae on rocks in intertidal zone of Tripoli and Tajura, 11 species of molluscs were identified (Aynen, 2001). Few researchers reported alien molluscs from Libyan waters (Röckel, 1986; Giannuzzi-Savelli *et al.*, 2001; Zgozi *et al.*, 2002; Ben Souissi *et al.*, 2007; Zaouali *et al.*, 2007). Recently, (Bazairi *et al.*, 2013) assessed the presence of marine alien species in El-Kouf National Park including moulluscs.

This paper discusses the molluscan diversity and abundance in rocky shores of intertidal zones along the western Libyan coast between Ghott-Eroman and Tellil, and aimed to identify benthic molluscan fauna of this area.

MATERIALS AND METHODS

Study area

Present study was conducted in the intertidal zone of six locations characterized by rocky bottom (Fig. 1) during September-October 2004.

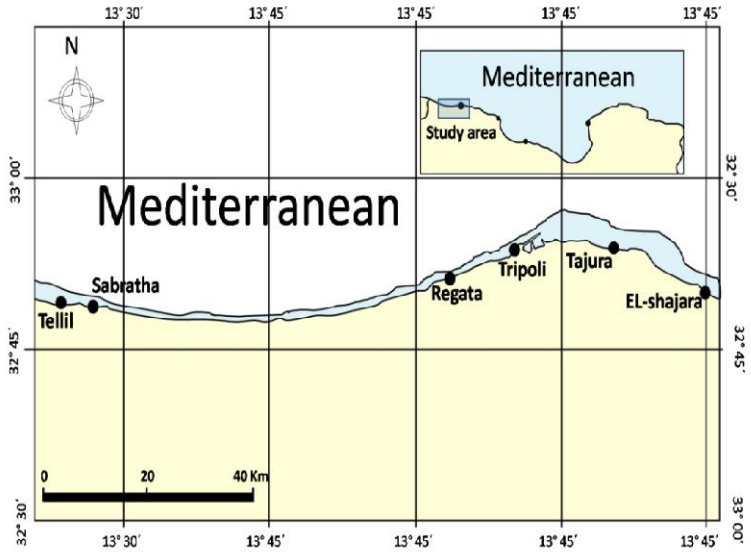

Figure 1: The sampling locations along the Libyan coast

EL-Shajara harbor (Ghott-Eroman)

It is a harbor for fishing boats located at 13° 30′ 00″ E, 32° 50′ 06″ N, characterized by flat rocky beach, bared during the low tide. It includes some little pools.

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Tajura

It is a flat rocky beach located at 13° 22′ 00″ E, 32° 54′ 00″ N, characterized by shallow waters. The area is semi-protected, exposed at low tide, but some areas still semi-immersed. It does not include big pools.

Ain Azargha

It is a flat rocky area including sandy rocks and others like rubble of construction materials. It is located off the administrative assembly Zat EL-emad, Tripoli at 13° 09′ 43″ E, 32° 53′ 22″ N. It is exposed at low tide.

Siahia Regata

It is a rocky beach of calcareous rocks located at 13° 03′ 44″ E, 32° 51′ 38″ N. It is characterized by exposed rocks at low tide. It includes few little pools.

Sabratha (off Tumors Center)

It is a harbor for fishing boats called Zuagha, located at (13° 26′ 43″ E, 32° 48′ 55″ N), as steep rocky shore characterized by some big pools. It is exposed completely at low tide. There are some signs of pollution by tar.

Tellil beach

It is a rocky-sandy beach, exposed completely at low tide. It is located at 13° 24′ 53″ E, 32° 47′ 50″ N, characterized by poor cover of algae and by small and big pools.

Sampling

Samples were collected during September - October 2004 from the intertidal zone of all locations using a 25 × 25 cm quadrate (0.0625 m^3) with a sectorial belt of 35-50 m long vertical to the coast and divided to meters, each square meter representing one sample (Boudouresque and Belsher 1997). The specimens were collected manually using a spatula, the collected specimens of each sample (square) were put in plastic bags, stored at -20° C until sorting. The specimens were later identified according to De Hass and Knorr (1979), Fischer *et al*., (1987), Tornaritis (1987), Riedl (1991).

Statistical analysis

The Chi-square was used to compare the locations regarding the number of individuals and number of species, as well, Kruskal-Wallis test was used to compare data among locations (Daniel, 1995).

Diversity indices

The diversity, richness, evenness and similarity indices of location communities were calculated:

Margalef's species richness index (R): It is an index for the total number of species in a sample (Howaege 1998). It depends on the relationship between the number of species and the total number (observed) of individuals, which increases by sample volume. (Ludwing and Reynolds, 1988; Howaege, 1998):

$$R = \frac{m-1}{Ln\,(N)}$$

where *m* is the number of species in the sample and *N* is the total number of individuals.

Simpson's dominance index (λ): It is considered as the first index in regard to the ecological studies. Its values are restricted between 0 and 1. Value increase indicates that most of the individuals of the sample belong to one species, which means the sample has low diversity (Howaege, 1998):

$$\lambda = \sum_{i=1}^{m} \frac{n_i(n_i-1)}{N(N-1)}$$

where *m* is the total number of species, n_i is the number of the individuals in the i^{th} species and *N* is the total number of individuals.

Shannon's diversity index (H'): It is used to measure diversity in categorical data. The advantage of this index is that it takes into account the number of species and the evenness of the species. The index value is zero when there is one species in the sample but increases either by having additional unique species, or by having a greater species evenness (Ludwing and Reynolds, 1988):

$$H' = \sum_{i=1}^{m} \frac{n_i}{N} \left| Ln \frac{n_i}{N} \right|$$

where *m* is the total number of species, n_i is the number of the individuals in the i^{th} species and *N* is the total number of individuals.

Heip's evenness index (E): It is an index which reveals the distribution of abundance among species in the sample, subsequently the value of evenness decreases when the distribution of individuals among species is wide, and vice versa (Ludwing and Reynolds, 1988):

$$E = \frac{e^{H'}-1}{m-1}$$

where *H'* is Shannon's diversity index and *m* is the total number of species.

Sorensen's coefficient of similarity (Ss): It is a binomial test used for comparing the similarity of two samples. Its values restricted between 0 and 1. Value 0 means the two samples are completely different, while value 1 means that the two samples are the same (Howaege, 1998):

$$Ss = \frac{2a}{2a+b+c}$$

where a is the shared species between sample 1 and 2, b is the unique species in sample 2 and c is the unique species in sample 1.

Table 1: Number of species and individuals of recorded classes in the study locations

Location	No. of species				No. of individuals			
	Gastropoda	Bivalvia	Polyplacophora	Total	Gastropoda	Bivalvia	Polyplacophora	Total
EL-Shajara	12	5	1	**18**	58	74	3	**135**
Tajura	9	5	0	**15**	160	28	0	**188**
Tripoli	12	6	1	**19**	5152	121	2	**5275**
Regata	6	5	1	**12**	89	7273	14	**7376**
Sabratha	10	3	1	**14**	114	79	9	**202**
Tellil	8	4	1	**13**	21	520	12	**553**
Total	25	10	1	**36**	5594	8095	40	**13729**

RESULTS AND DISCUSSION

Diversity

The results showed that 36 species of molluscs were recorded in the western part of Libyan coast over a period of two months of October and November 2004. They belong to three classes: Gastropoda (25 species), Bivalvia (10 species) and one species of Polyplacophora (Table 1). There are significant differences among classes in regard to number of species (χ^2, P=4.8 X10^{-6}).

Gastropoda was the most diverse taxa (25 species), while Bivalvia was the abundant one (8095 specimens), both classes were represented in all sampling locations. Polyplacophora was represented by one species (*Chiton olivaceus*), it was not collected from Tajura. Gastropods has an importance among mollusks in general; they constitutes the largest proportion of the number of species in rocky areas, not necessarily number of individuals (Antoniadou and Chintiroglou, 2005, Larbaa and Soltani, 2013); they have an impact on the environment and marine algae, especially in terms of grazing (Beck, 2000; Chapman, 2000). Belgacem *et al.* (2013) reported that Gastrpoda was the most diverse class among their specimens of mollusks.

The most diverse location was Tripoli followed by EL-Shajara; Regata was the least diverse location, although 54% of specimens were sampled there. There is no significant differences between locations in regard to number of species (χ^2, P=0.77). The western coast of Libya has been studied more intensively than the other parts of the coast, especially Tajura area, which has been investigated in many studies. In a previous study, Naas (1989) recorded 20 species of littoral gastropods from the western Libyan, less than what we found in our study; in another study on a rocky platform of Tajura coast, 16 species of intertidal molluscs were recorded (Huni and Aravindan, 1984). Aynen (2001) identified 11 species of molluscs associated with algae on rocks in intertidal zone of Tripoli and Tajura. Many studies dealt with mediterranean molluscs (Safriel *et al.* 1980; Barasha *et al.*, 1982; Dauvin *et al.*, 2013; Demür *et al.*, 2003; Larbaa and Soltani, 2013).

Each location had unique sampled species: *Mitra* sp and *Odostomia* sp were collected only from EL-Shajara; three species (*Cantharus dorbignyi*, *Ostrea* sp and *Pisania* sp) were collected only from Tajura; four species (*Alvania discors*, *Barleeia unifasciata*, *Gibbula ardens* and *Venerupis decussata*) were collected only from Tripoli; two species (*Arca tetragona* and *Ostrea edulis*) were collected only from Regata sampling sites; three species (*Alvania lineata*, *Tricolia tenuis* and *Turboella lia*) were collected only from Sabratha; and only one species from Tellil *Dendropoma petraeum*. Three species were represented in all locations: *Cerithium vulgtum* (96% specimens from Tripoli), *Brachidontes variabilis* (91% specimens from Regata) and *Musculus costulatus* (75% specimens from Regata). The rest were presented either in 2, 3, 4 or 5 locations (Table 2). The recorded species, in this study, have been reported from Mediterranean (Bartoli and Gibson, 1998; Rossi and Costantini 2000; Antoniadou *et al.*, 2005; Beqiraj *et al.*, 2008; Dhora, 2009; Ali and Bream, 2010; Coll *et al.*, 2010; Bassler-Veit *et al.*, 2013; Duğan *et al.* 2013).

Some molluscs correlated positively with algae; the bivalve *Brachidontes variabilis* associated in aggregations with *Ulva lactuca* (Linnaeus, 1753) and *Corallina mediterranea* (Areschoug, 1852) which offer good shelters for reproduction to protection against predators and waves (Chia, 1974). It coexisted with other algae, but to a lesser extent. On the other hand, some other mollusks such as *Cerithium vulgtum*, *Barleeia unifasciata* and *Gibbula ardens* were coexisted with certain species of algae (*Ulva lactuca*, *Ulva prolifera* (O.F.Müller, 1778) and *Caulerpa racemosa* (Forsskål) J.Agardh, 1873, but without any adhesion.

Table 2: A list of molluscan species which recorded in the study

Class	SN	EL-Shajara	Tajura	Tripoli	Regata	Sabratha	Tellil	Total
Gastropoda	*Alvania cimex* (Linnaeus, 1758)	11	15	9	0	0	0	35
	Alvania lineata (Risso, 1826)	0	0	0	0	1	0	1
	Alvania discors (Allan, 1818)	0	0	16	0	0	0	16
	Barleeia unifasciata (Montagu, 1803)	0	0	1058	0	0	0	1058
	Bittium reticulatum (da Costa, 1778)	5	1	13	2	38	0	59
	Cantharus dorbignyi (Payraudeau, 1826)	0	1	0	0	0	0	1
	Cerithium vulgtum (Bruguière, 1792)	19	108	3803	12	10	6	3958
	Conus mediterraneus (Bruguière, 1792)	4	3	5	0	1	1	14
	Cancellaria sp.	3	4	0	0	0	0	7
	Columbella rustica (Linnaeus, 1758)	1	0	0	0	6	0	7
	Dendropoma petraeum (Monterosato, 1884)	0	0	0	0	0	2	2
	Fissurella nubecula (Linnaeus, 1758)	0	0	1	49	0	1	51
	Gibbula ardens (Salis Marschlins, 1793)	0	0	234	0	0	0	234
	Haminoea hydatis (Linnaeus, 1758)	0	9	2	0	0	0	11
	Hexaplex trunculus (Linnaeus, 1758)	1	0	3	21	0	1	26
	Mitra sp.	1	0	0	0	0	0	1
	Odostomia (Fleming, 1813) sp	1	0	0	0	0	0	1
	Phorcus richardi (Payraudeau, 1826)	0	4	0	0	0	1	5
	Pisania striata (Gmelin, 1791)	7	9	7	0	31	2	56
	Pisania sp.	0	10	0	0	0	0	10
	Pusillina lineolata (Michaud, 1830)	1	0	0	0	23	0	24
	Rissoa lia (Monterosato, 1884)	0	0	0	0	2	0	2
	Tenagodus obtusus (Schumacher, 1817)	0	0	1	4	0	0	5
	Tricolia pullus (Linnaeus, 1758)	4	0	0	0	1	7	12
	Tricolia tenuis (Michaud, 1829)	0	0	0	0	1	0	1
Bivalvia	*Arca tetragona* (Poli, 1795)	0	0	0	1	0	0	1
	Brachidontes variabilis (Krauss, 1848)	65	15	89	7052	43	506	7770
	Gregariella sp.	1	0	0	16	0	7	24
	Irus irus (Linnaeus, 1758)	1	1	4	0	0	4	10
	Musculus costulatus (Risso, 1826)	5	9	1	165	35	3	218
	Ostrea edulis (Linnaeus, 1758)	0	0	0	11	0	0	11
	Ostrea sp.	0	1	0	0	0	0	1
	Parvicardium sp.	0	2	4	0	0	0	6
	Pinctada radiata (Leach, 1814)	2	0	21	29	1	0	53
	Venerupis decussata (Linnaeus, 1758)	0	0	2	0	0	0	2
Polyplacophora	*Chiton olivaceus* (Spengler, 1797)	3	0	2	14	9	12	40

Abundance

13729 molluscs were collected in the study. The number of sampled individuals varied among locations between 135 (EL-Shajara) and 7376 (Regata) (Table 1). The bivalves showed the highest abundance followed by gastropods wh, the latter were more abundant in three locations, probably because of their ability to resist dry condition at low tide, and the nature of seabed which is rich in algae (diversity and density) (Riedl, 1991). At the same time, the stones and boulders of the rocky shores offer shelters against the effect of waves (Crothers 1970; Bacchiocchi and Airoldi, 2003). Indeed, the distribution of the macrofauna is the relationships among environmental factors and species characteristics (de Arruda and Amaral, 2003). Polyplacophora showed the least abundance in all locations. Three species showed high abundance, more than 1000 individuals: *Brachidontes variabilis*, *Cerithium vulgtum* and *Barleeia unifasciata*, while many showed low abundance, one individual in eight species (Table 2). This might referred to the good distribution of the members of species, algae beds and the absence of a predator (Bertnes *et al*., 1999).

About 57% of species (21 species) were recorded in more than one location. Only three species were observed in all locations (Table 2).

There were significant differences among locations and classes (χ^2, P<1.0 X10^{-}12). No significant differences was observed between Tajura and Sabratha with respect to the number of individuals (χ^2, P=0.48).

Sorensen's coefficient of similarity (Ss):

The locations showed approximate values of Sorensen's coefficient of similarity, which varied between 0.25 and 0.37 (Table 3). This similarity was, probably, due to that all locations are characterized by rocky bottom.

Table 3: Sorensen's coefficient of similarity for molluscs species among locations

Station	EL-Shajara	Tajura	Tripoli	Regata	Sabratha
Tajura	0.35				
Tripoli	0.37	0.37			
Regata	0.34	0.27	0.36		
Sabratha	0.33	0.25	0.29	0.27	
Tellil	0.36	0.36	0.33	0.32	0.34

Diversity indices

The stations showed obvious differences in respect of the diversity indices (Table 4). The Margalef's species richness index showed that EL-Shajara was the richest station (7.97), which indicating that it is the most diverse location in respect of molluscan species. While the least diverse station was Regata (2.85). The Shannon's diversity index were between 0.21 (Tellil) and 0.89 (Sabratha). The highest value of Heip's evenness index was in Sabratha (0.52) while the lowest value was recorded in Tellil (0.05). According to Simpson's dominance index, there was obvious dominance of some species in Regata (0.91), but less obviousness recorded in Sabratha (0.15).

Table 4: Diversity indices of mollusks in the study area (R: Margalef's species richness index; H': Shannon's diversity index; He.: Heip's evenness index; λ: Simpson's dominance index).

Location	No. individuals	No. species	Indices			
			R	H'	He.	Λ
EL-Shajara	135	18	7.97	0.84	0.35	0.26
Tajura	192	14	6.11	0.74	0.32	0.33
Tripoli	5276	19	4.84	0.38	0.08	0.56
Regata	7376	12	2.85	0.11	0.26	0.91
Sabratha	202	14	5.64	0.89	0.52	0.15
Tellil	553	13	4.37	0.21	0.05	0.84

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