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ASSOCIATIONS BETWEEN SOME MACROALGAL SPECIES AND LIMPETS AT CERTAIN ROCKY INTERTIDAL ZONES OF AL-JABEL AL-AKHDAR COAST, LIBYA.

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Abstract

This study was set out to document the marine algal species associated with limpets living on the rocky shores of the north-eastern coast of Libya for the first time. Samples were collected from seven sites extend from Ras Hailal to Al-Hanyaa rocky shores during winter and spring 2012. Algal species associated with limpets in Al-Hanyaa polluted site were represented by two species belong to Chlorophyta and only one species for each Phaeophyta and Rhodophyta. On the other hand, a single species of Rhodophyta was recorded on *Patella turbinata* inhibiting the clean site of Susa. The present results showed that, the four algal species comprised *Ulva*, *Enteromorpha*, *Ectocarpus* and *Gelidium*, were found associated with *P. turbinata* and were the predominant species in polluted sites, while they disappeared completely at the clean sites. These results predicted that, *Boergeseniella fruticulosa*, growing either on *Patella turbinata* or the surrounding substrates, is a promising biomonitor for seawater cleanness. Also, the results confirmed the mutualism relationship between *Patella* and ephemeral algal species in the monitoring area, emphasizing their efficiency as biological monitors. Finally, in spite of physico-chemical parameters differences between siteswere significant, the diference between sites themselves were found to be non significant.

Keywords: Marine algae, *Patella turbinata*, association, pollution, biomonitors**.**

Introduction

Seaweeds are one of the most productive marine plant communities in the world. They can grow as individuals, but they more frequently live together in communities with animal species (Karleskint, *et al*., 2010). Seaweed communities affect and are affected by the environmental conditions. Together the intertidal and subtidal zones give rise to a narrow coastal area that accounts for less than one percent of the Earth's surface. However, the productivity of this region can equal or exceed that of most terrestrial communities (Dawes, 1998).Waves, tides and currents can be important factors determining the structure of a seaweed or sea grass community (Littler and Littler, 1985). However, tight interdependency between grazer *Patella turbinata* and marine algal species occur in gardening interactions in which algal assemblages within a fixed site are modified through the activities of grazer *Patella* that selectively enhances the food value of the grazed algae for *Patella* (Branch *et al*., 1992). Algae are regularly exposed to regenerated nitrogen by virtue of the intimate limpet-algae garden association. Algae have a potential uptake and exploit nitrogenous excretions of *Patella* before these are dissipated by water movement in the field. *Patella turbinata* and potentially other marine grading species can enhance the productivity of their algal gardens through the regeneration of limiting nutrients (Plagányi and Branch 2000). The relationships between plants and animals are well documented on land but it has received less attention in marine systems. Consequently, this study was carried out to shed light on the association between algal species and *P. turbinata*, inhibiting polluted and unpolluted Libyan coastline sites.

Materials and Methods

The study area:

As can be seen in Fig. (1), seven sites (S) were chosen to monitor marine algae associated with the limpet *P. turbinata* at the north-eastern coast of the Libyan Mediterranean Sea. These sites are characterized by the intertidal flat rocky shores, entitled S1 to S7, two of them were polluted with sewage, and their geographical positions can be describe as follow:-

S1:Ras Hailal, locates at latitude 32°53'2"N and longitude 22°11'8"E; **S2: Port Susa**, lies at latitude 32°54'11"N and longitude 21°57'50"E; **S3: Susa sewage discharge(polluted)**, locates at latitude 32°54'7"N and longitude 21°57'41"E, and lies adjacent to a sewage outlet; it considers as polluted site; **S4: Susa desalination plant**: locates at latitude 32°53'47"N and longitude 21°54'31"E; **S5: Al-Hamama**: lies at latitude 32°53'47"N and longitude 21°54'31"E; **S6: Al-Hanyaa (polluted):** locates at latitude 32°50'30"N and longitude 21°31'11"E, and lies adjacent to a sewage outlet, it considers also as polluted site; and finally, **S7: Al-Hanyaa (unpolluted):** locates at latitude 32°49'50"N and longitude 21°30'20"E.

The total distance between S1 and S7 is ≅ 64 Km. S2 is far from S1 with ≅ 20.7 Km, S3 is located on the other side of the port where, the sewage is discharged directly to the sea. S4 is remote from S3 ≅ 5Km. S5 is far from Susa ≅ 33 km. S6 is distant from S5 ≅ 12 km, finally S7 is faraway from S6 ≅ 2 Km.

Collection of samples

Water samples and different algal species associated with the same ages, size and healthy in appearance gastropod *P. turbinata*, were collected during low tide in winter and spring 2012.

The physico-chemical parameters including pH, temperature (Temp.), and electrical conductivity (E.C.) of water were determined in the field by pH meter, thermometer and electric conductivity meter, respectively. Other physico-chemical parameters of water were determined according to APHA (Anonymous, 1996). Algal fronds and assemblages growing mainly on adult individuals of *P. turbinata*, as epizoic, were found on the lower rocky shore at two sites of Al-Hanyaa (S6 and S7) and Susa desalination plant (S4). Samples were obtained by removing patches of epizoic algae, using sharp forcipes, for later microscopic analyses to identify the algal species using different taxonomical keys (Abbott and Hollenberg 1976; Womersley, 1984 and Abbott, 1999).

Fig. (1). Monitoring areas located on the north-eastern coast of the Libyan Mediterranean Sea.

Statistical analysis

Results were calculated as mean values with standard deviation ($\overline{X}$±SD). The physico-chemical values were analyzed by analysis of variance (ANOVA) and correlation testes.

Results

Physico-chemical parameters

The mean of the physico-chemical parameters of water at different sites were measured during the period of study. Data tabulated in table (1) revealed that the temperatures at different sites were found to be more or less similar, ranged from 16.15 ± 3.8 to 17.95 ± 3.3°C. The minimum value of pH was recorded at S2 (7.15); meanwhile the maximum was recorded at S6 (7.59). It is clear that the pH values were tend to alkaline side in all sites, where it was suitable for algal growth.

Table (1) : Means of some physico-chemical parameters determined during the study period at different sites*, Al-Jabel Al-Akhdar, Mediterranean coastline, Libya.

Sites	S2	S3	S4	S6	S7
Parameters	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Temp. ^{o}C	16.60 ±3.68	16.85±3.75	16.15±3.75	17.15±3.32	17.95±3.32
pH	7.15±0.54	7.44±0.37	7.50±0.28	7.59±0.44	7.55±0.35
Conductivity (µs/cm)	55350±3181	55550±3747	56450±2899	54550±919	55100±3252
TDS (mg/L)	34322±516	35029±163	35822±225	34021±151	34968±1057
DO (mg/L)	5.9±0.21	5.0±0.28	8.2±0.64	6.5±0.42	8.0±0.14
Total hardness (mg/L)	2300±141	2360±184	2600±156	2400±141	2500±307

* No evidence on association between algae and limpets was detected at sites S1& S5.

The variations in electrical conductivity values were found to be in a relatively narrow range at all sites, where, they varied between 54550 ± 919 at S6 and 56450 ± 2899 µs/cm at S4.The highest value of TDS was recorded for S4 (35822± 225mg/L) meanwhile, the lowest value (34021 ± 151mg/L) recorded at S6. It is noticeable that E.C and TDS took the same trend especially, those values recorded for S4 and S6. The dissolved oxygen value ranged between 5.0 ± 0.28 mg/L for S3 and 8.2 mg/L for S4. It is worthily to mention that the lowest values of DO were recorded for the polluted sites S3, S2 and S6.The maximum total hardness value recorded for S4 (2600 ± 56 mg/L) comparing with a minimum value of 2400± 141mg/L for S6.

Biological analysis:

1- Field biological observations

The results confirmed that algae associated with *P. turbinata* were observed only at three of the seven sites visited**.** *Patella* was found as living adults on the lower rocky shore at three sites, the first located on Susa desalination plant shore (S4), while other two sites located on Al-Hanyaa shore, S6, (polluted), and S7 (clean). It is conspicuous that, *Ulva* and *Enteromorpha* were grown only in polluted areas that suffered from sewage discharge effluents, meanwhile, *Boergeseniella* was found to grow in areas devoid of sewage pollution.

The adherent algal species can be classified according to their occurrence or nature of growth on *Patella* shells as follow:

1- Foliage group including: *Ulva* and *Enteromorpha* (Green algae, Chlorophyta).
2- Erect group including: *Boergeseniella* and *Gelidium* (Red algae, Rhodophyta).
3- Fleshy group including: *Ectocarpus* (Brown algae, Phaeophyta).

2- Taxonomical studies:

As shown in table (2), three divisions; Chlorophyta, Rhodophyta and Phaeophyta containing three classes were recorded (Ulvophyceae, Florideophyceae and Phaeophyceae). Of these, five taxa belong to four families and four orders were identified.

2. 1. Epizoic algal taxonomy:

The collected algal species were identified using different taxonomical keys as mentioned above and presented in table (2).

Table (2): Epizoic marine algae associated with *P. turbinata* shells and their taxonomy.

Taxonomy	**Algal groups**			
Division	**Chlorophyta**	**Rhodophyta**		**Phaeophyta** (Heterokontophyta**)**
Class	Ulvophyceae	Florideophyceae		Phaeophyceae
Order	Ulvales	Ceramiales	Gelidiales	Ectocarpales
Family	Ulvaceae	Rhodomelaceae	Gelidiaceae	Ectocarpaceae
Genus	*Ulva* *Enteromorpha*	*Boergeseniella*	*Gelidium*	*Ectocarpus*
Species	*Ulva lactuca* *Enteromorpha intestinalis*	*Boergeseniella fruticulosa*	*Gelidium puisillum*	*Ectocarpus siliculosus*
Locality	(S6)- (S2&S3)	(S4) – (S7)	(S6)	(S6)
Pollution status	polluted area	clean area	polluted area	polluted area

2.2. *Patella* taxonomy:

The invertebrate limpet was identified using different taxonomical keys (e.g. Borradaile *et al*., 1977) as follow:- Phylum: Mollusca; Class: Gastropoda; Order: Prosobranchiata (Streptoneura); Family: Patellidae; Genus: *Patella*; Species *Patella turbinata*.

3- Biological notes on the organisms studied:

-*Ulva lactuca* (sea lettuce) is bright green seaweed composed of lobed, membranous, ruffle-edged leaves that are coarse and sheet-like in appearance and resemble a leaf of lettuce. It ranges in length from 5 to 30cm. It inhabits high and low intertidal zones. Free-floating *Ulva* appears with large blooms in the spring at site S3. Almost, no stalk exists at the point of attachment, and no true roots are present.

As can be seen in Plate 1 (A-C) *Ulva* may be found attached to rocks and *Patella* shells by a holdfast, but it is also commonly found free floating. *Ulva* is among the most familiar shallow water seaweeds, often found in areas of exposed rocks and in stagnant tide pools at S3. Tolerant of nutrient loading that would suffocate many other aquatic plants, it can actually thrive in moderate levels of nutrient pollution. Large volumes of sea lettuce often indicate high levels of pollution as observed in

S3 which suffer from sewage pollution. It is often found in areas where sewage runoff is heavy. The density and location of this alga can often indicate the presence of high amounts of nutrients. As a result, sea lettuce is used as an indicator species to monitor pollution trends.

Enteromorpha intestinalis is un-branched tubular green intestine like; bright green in colour. Thallus forms hollow tubes or may become flattened with tubular and elongate fronds that may be flattened or inflated. They attach to *P. turbinata* shell by means of a minute disc-like holdfast (Plate 2 A and B). *Enteromorpha intestinalis* was found to grow on *P. turbinate* shell in winter and spring in polluted S6 at Al Hanyaa. This ephemeral seaweed is fast-growing species and reproduce quickly forming the gametophyte stage that produces gametes and form the sporophyte stage which produces mobile spores, which develop into the gametophyte stage and the cycle begins once more. The gametes and spores are produced in such massive quantities that causes the substrate or water turn into green as shown in Plate 2 (A and B). Their release is synchronized with the tidal cycles.

Boergeseniella fruticulosa is dark brown colored alga found in winter of 2012 on inconsistent substrates of the intertidal semi flat rocky shore of Al-Hanyaa, at a meadow of *Cystosiera comperssa*. As can be seen in Plate 3 (A - F), the long of *B. fruticulosa* varied from 1 to 12 cm, adheres to the substrate and *Patella* via a prostrate axis from which depart more erect axes. The branches of younger parts of the thallus are arranged in a regular and alternate on the main axis. Also, the lateral branches, grow with good regularly at intervals of 3-5 segments, some rare tricoblasti, which develop in the vicinity of the apex of young branches and that branch 3-4 times as shown in Plate 3 (A to C). In the present sample, it was observed that *B. fruticulosa* presents rhizoids anchor to *Patella*.

Ectocarpus siliculosus is filamentous brown alga. It forms soft beards on firm *P. turbinata*- shell and grows up to 4 cm long. As shown in plate 5 (A), *Ectocarpus* tufted, often only one to a few cm tall. Axes freely branched, main axis not distinguishable. Filaments algae reach up to 30µm in diameter, tapering toward the apices, sometimes forms terminal pseudo-hairs. Plate 5 B and C showed *Ectocarpus* plurilocular sporangia.

Gelidium puisillum is densely branched alga, uniaxial thallus is robust, dark purplish-red in color, attached by a well-developed tuft of branching axes (Plate 4 A and B). A cluster of erect primary axes arises from the attachment tuft. Erect axes are usually less than 1 cm tall. These erect thalli are branched to many of flattened marginal orders.

The gastropod *Patella* or the limpet represents a type of complete adaptation to life on an exposed coast between tide-marks. The mollusc cannot be detached from rocks without using great force, owing to the enormous power of the pallial muscles which press the shell against the rock. The enormously elongated radula is composed of very strong teeth and there are a small number of marginals. This type of radula is suited to the feeding habits of the limpet, which scrapes the crust of minute algae off the surface of rocks. Limpets have a remarkable “homing" sense, returning after excursions for food to the same spot, which may be marked by a depression in the rock (Plate 1).

4-Aspects of seaweeds and limpet associations.

When attempting to assess the various degrees of association status between algae and *Patella*, some aspects should be considered. Firstly, factors related to epizoic seaweeds including; abundance, distribution and host preference. Secondly, factors related to *Patella* including; surface of its shell on which algae grow, food preference. In addition, pollution condition was found to be a key factor in this relationship.

Epizoic algal species frequency

Reviewing Chlorophyta abundance, it was noticed that, *Enteromorpha intestinalis* and *Ulva lactuca* were the most frequent epi-*Patella* growth that appeared at S6 and represented by 42 % for each one. Meanwhile, the most frequent species of Rhodophyta which recorded within the different sites were *B. fruticulosa* (28 %), followed by *G. puisillum* (14%). Finally, Phaeophyta was represented by *Ectocarpus siliculosus* only, reaching 14 %at S6 (Table 3).

Table (3): Frequency of epizoic (epi-*Patella*) Algal taxa at the monitoring area.

Algal species	S1	S2	S3	S4	S5	S6	S7	Total	%
Chlorophyta									
Enteromorpha intestinalis	-	+	+	-	-	+	-	**3**	**42**
Ulva lactuca	-	+	+	-	-	+	-	**3**	**42**
Total percentage	**84%**								
Rhodophyta									
Boergeseniella fruticulosa	-	-	-	+	-	-	+	**2**	**28**
Gelidium puisillum	-	-	-	-	-	+	-	**1**	**14**
Total percentage	**42%**								
Phaeophyta									
Ectocarpus siliculosus	-	-	-	-	-	+	-	**1**	**14**
Total percentage	**14%**								
Total number of species	-	**2**	**2**	**1**	-	**4**	**1**	**10**	**100**

Spatial distribution of algal species (Species number)

As seen in table (3), S6 has got the first rank of algal species number determined, where it represented by 4 taxa; *E. intestinalis* and *U. lactuca*, *B. fruticulosa*, *G. puisillum*, *Ectocarpus. siliculosus*, followed by S2 and S3 which represented by two species; *E. intestinalis* and *U. lactuca*. While, S4 and S7 occupied the last rank of species number, representing by only one species *B. fruticulosa*.

Host preference

As shown in Plate (1C), *Ulva* and *Gelidium* prefer the association with *Patella* than other neighboring gastropods, where they grow successfully on *Patella*. Moreover, the observation appeared that the algal species prefer to grow on *Patella* than the surrounding substrate (Plate 1 to5). It is worth mentioning that the substrate was covered with green colour, resulting from massive quantities of algal spores transferred by *Patella* (Plate 2 A and B).

Generally, the feeding habit of algae, which obtain their nitrogenous compound requirements from the excretion of *Patella* under shell and calcium element from *Patella* shell, proved that *Patella* is one of the most gorgeous nitrogenous food source.

Limpet's shell surface

Plate 1(C), clears that the unique feature of *Patella* shell attract algal species to grow successfully. These features including, flat, rough surface of the striated shell and its high content of calcium, which enable algae to settle and thrive on it. While its neighbor "*Monodonta*" has smooth and spiral like shape shell, which obstruct the algal growth.

Food preference

Although *Patella* preferred more than one algal species in areas studied, it can select the kinds of algae on which they associate. Moreover, the field observations discovered that, *Patella* tend to associate with *Enteromorpha* and *Ulva* than other algal species. It is worthily to mention that S3 was predominated by *Enteromorpha intestinalis* during winter and substituted by *Ulva* during spring in a succession manner.

The predominant *Ulva* reached approx. 97% cover and *Enteromorpha intestinalis* reached approx. 3% cover in spring, coinciding with low density of *Patella* and rare association. In contrast, in S6, *Ulva* and *Enteromorpha* were absent on rocky substrate in spite of their presence on *Patella* shells which occurred in a relatively high density. This may prove the preference of *Patella* to *Enteromorpha* and *Ulva* as a valuable food, and account for the correlation relationship between *Patella* abundance and algal composition.

Pollution conditions

The results appeared that the sites; S2; S3 and S6 were discriminated by sewage pollution, where sewage pollutants discharged directly into these sites, affecting the kind, composition and abundance of seaweeds that grow on *Patella* and ambient substrate.

It is observable that, Chlorophyta was the most dominant group growing on *P. turbinata* in the polluted area. Also, it is discernable the coincidence of *E. intestinalis* with *U. lactuca* in their occurrence, but incomparable in their quantities at S2, S3 and S6. This companionship of *E. intestinalis* and *U. lactuca* in their appearance in polluted sites was synchronized in time and place of appearance.

S4 and S7 were the most clean sites, where *B. fruticulosa* was found to be abundant on *Patella* in S4. While, it grows on rocky shore only without such association in S7 located at Al-Hanyaa, proving the preference of *B. fruticulosa* to clean water regardless the attached substrate. It is worthy mentioned that the growth of *B. fruticulosa* is not affected by drained thermal water containing salts and other chemical wastes of the desalination plant in S4 at Susa.

Statistical analysis

Employing two-way ANOVA emphasized the highly statistical significance between the tested chemical parameters (F=22254, df = 5, $p < 0.01$). The calculated variance percentage showed that TDS and Conductivity (49 % for each factor) were responsible for the peculiar elevation in this significance. It worthily mentioned that the variance between sites was non-significant, proving the efficiency of the biological monitoring rather than the investigated chemical analysis.

As shown in table (4), the temperature was negatively correlated with conductivity (r = - 0.697). Total hardness was positive correlated with conductivity (r = 0.541), TDS (r = 0.766) and DO (r = 0.883). Conductivity has significantly correlated with TDS (r = 0.895) and T. hardness (r = 0.541) ($P < 0.05$).

Table (4): Correlation analysis between different chemical parameters measured in studied sites.

	Temp.	*pH*	*Cond.*	*TDS*	*DO*	*T. hard.*
Temp. °C	1					
pH	0.412	1				
Cond.	-0.697*	-0.171	1			
TDS	-0.350	0.206	0.895***	1		
DO	0.139	0.454	0.299	0.495	1	
T. hardness	-0.061	0.615*	0.541*	0.766**	0.883***	1

* = significant; ** = highly significant; *** = very highly significant.

Discussion

Physico-chemical parameters

Temperature values recorded during the investigation period which ranged 16.15 ± 3.8 to 17.95 ± 3.3 °C were found to be less suitable for marine algal growth. This range is low when compared to the optimum temperature (30 °C) for better marine flora growth (Glynn, 1991). This may be attributed to the influence of surface seawater by the air temperature. This agrees with Sridhar *et al.*, (2008) who proved the positive significant correlation between air temperature and surface temperature.

The variations in pH values showed a little fluctuation between studied sites. This was found in full agreement with Sridhar *et al*. (2008) findings. The results showed that, E.C and TDS took the same trend, where they look like in their optimum range (25 – 40 $\%_o$). A pronounced decrement in DO values were detected in sewage polluted sites, particularly, S3, where free-floating *Ulva* bloom was detected . These results were found to be close to that recorded by Kenis *et al*., (1972) who cited that the average concentration of dissolved O_2 is about 5.5 mg/L at the point of sewage discharge and about 7 to 8 mg/L for unpolluted surface waters at shoreline locations and Podbielkowski (1996)who revealed that excessive growing and drying away can cause oxygen deficiency, leading to sudden death of organisms, including fish.

Reviewing to the statistical analysis, the chemical variation between sites was non-significant, proving the efficiency of the biological monitoring than the investigated chemical parameters. In spite of chemical tests are easy to run, they are not very revealing because pollutants are seldom discharged continuously, and their presence may be missed by sampling at an inappropriate time. Similar findings were confirmed by Żbikowski *et al.* (2007) who pointed out that, organisms not only concentrate elements from the surrounding environment, but they may also represent a moving time-averaged value for the relative biological availability of macroelements at each site studied. Also, Marin *et al*., (2013) reported that, macroalgae are indicators able to characterize the water bodies.

Biological analysis

Algal frequency and abundance

The direct observation showed that, along the rocky shores of the studied area of Libyan coastline, the most abundant and important herbivore associated with algae in the low intertidal zones, is *Patella*. There is a considerable variation in the epizoic algal composition in the upper half of the rocky intertidal zone. This may be attributed to the preference of *Patella* to more than one algal species in the investigated sites. This was found in full agreement with Lubchenco (2005) findings, who reported that the marine herbivorous controls the abundance and type of algae in high intertidal region. The most frequent epizoic algal species associated with limpets were recorded as *E. intestinalis* and *U. lactuca* (comprising 42 % for each one); *B. fruticulosa* (comprising 28 %), followed by *G. puisillum* and *Ectocarpus. siliculosus* (comprising 14% for each species). So, it was concluded that *Patella* can detect the kinds of algae which associated with it.

Food Preference

It was noticeable that *Patella* prefer *Enteromorpha* and *Ulva* than other algal species, this is may be attributed to their lacking to neither structural nor chemical means of deterring *Patella*. This is in full agreement with Lubchenco (2005), who revealed that *Patella* prefer ephemeral small and tender species like *Enteromorpha* and *Ulva spp.* In the same way, juvenile algae with thinner, smaller, and have more delicate tissues, than adults, are often preferred by limpets (Van Alstyne 2001). In contrary, the encrusting *Ralfsia* and algae that synthesize secondary metabolism such as terpenes, phenolic and nitrous compounds which deter grazing, digestive inhibitors or toxins (McQuaid and Froneman, 1993) were avoid by limpets.

According to Lubchenco (1978) the herbivores can potentially increase or decrease species diversity of their food. This was found proper with the attained results where, high *Patella* grazing pressure on the previous mentioned species resulted in their potential decrease on the surrounding substrate.

In addition, algae save their kind through a phoretic relationship with *Patella* that transfers algal spores to a new substrate, where gametes and spores begin to reproduce in massive quantities, that causes substrate and water to turn green.

Host preference

Owing to *Patella* sp. consistency, rough wide flat shell surface, the tendency of algae to obtain their nitrogenous compounds from *Patella* excreta and their needs for calcium element from *Patella* shell, attract algal species to settle on it. This can originate successful association and phoretic relationship. These results were found in full agreement with Buschbaum (2000) who cited that excretion of gastropod would facilitate the development of ephemeral algae, and with Dayton (1973) who had observed that *Enteromorpha* in tide pools releasing swarmers (spores or gametes) during low tide which may increase the probability that offspring will recruit near their parents or away from them via gastropods. In contrast, it was noticed that, the smooth surface, spiral like shell shape and active moving of snails obstruct such association.

Spatial distribution of algal species

The associated algal species inhabiting polluted sites was found to belong to Chlorophytra (*E. intestinalis* and *U. lactuca*), Rhodophyta (*G. puisillum*) and Phaeophyta (*Ectocarpus siliculosus*) whereas, *B. fruticulosa* (Rhodophyta) was restricted to clean sites either in association or free living. Totally, 4 epizoic taxa were found to inhibit the polluted sites, in opposition to, only one species (*B. fruticulosa*) was recorded in the clean site. In similar, Diez *et al*., (1999) recorded that *B. fruticulosa* prefers growing in the clean water. Consequently, it is may be used as a biomarker for the clean water. Generally, the results showed that anthropogenic influence indirectly affected the algal abundance and species number. Correspondingly, Gorostiaga and Diez**,** (1996) reported that environmental factors stress decreasing species richness and algal abundance.

Ephemeral alga, *E. intestinalis* that synchronized in time and place of appearance with *U. lactuca*, was noticeable in sites S2, S3 and S6. This may be attributed to the similar environmental conditions such as the nature of rocks, wave strength and organic contaminants of these sites. Similarly, Wilhelmsen and Reise, (1994) and Albrecht, (1998) reported that ephemeral algae are dominated by *Enteromorpha* species inhabiting intertidal flat zones.

Pollution condition

The companionship of *E. intestinalis* and *U. lactuca* in their appearance as free floating or associated with *Patella* and the linkage between them and polluted sites, emphasized their similar behavior and their needs to the same organic nutrients as well as their role in biomonitoring of pollution. In accordance with North (1972), Chlorophyta efficiently grow in seawater enriched with organic nutrient and high content of N and P offered by sewage effluent particularly in S3, S4 and S6. The same author reported that, the occurrence of certain algal genera (e.g. *Gelidium* and *Ulva*) and invertebrates in polluted inshore waters may be related to the direct uptake and utilization of dissolved amino acids found in organic wastes.

Enteromorpha intestinalis bloom appeared during winter and substituted by *Ulva* bloom in spring at S3, this may be due to the change in environmental conditions especially sewage pollution. Fletcher, (1996) stated that**,** an excessive growth of green algae derived from the eutrophication of coastal waters, become an alarming problem of world-wide distribution**.** Moreover, Diez *et al*. (1999) proved that, *Gelidium pusillum* becomes more competitive when certain eutrophication levels are exceeded.

Conclusion

It concludes that *B. fruticulosa* prefer growing in clean seawater, whereas *E. intestinalis*; *U. lactuca* and *Gelidium pusillum* grow efficiently in high eutrophication levels. Consequently, the last four species can be used as bioindicators for sewage pollution whereas, the presence of *B. fruticulosa* indicating a good water quality. The non-significant chemical variation confirmed the potentiality of the biological monitoring.

Plate (1) : *Ulva* and *Gelidium* growing on *Patella*

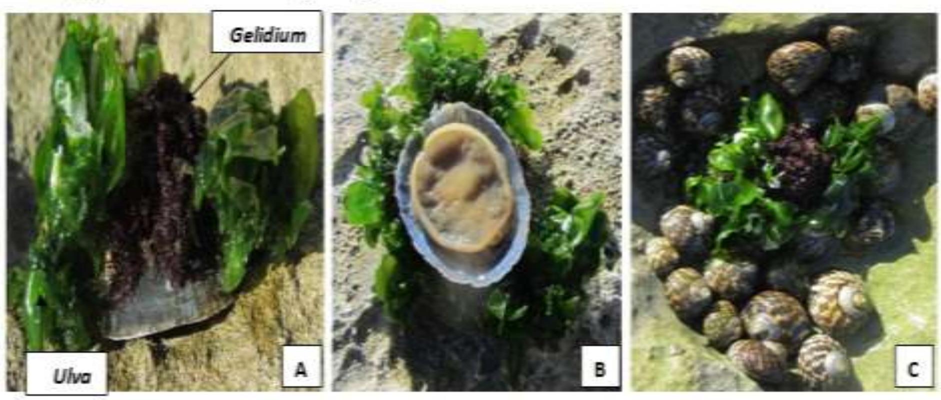


Plate (2) : *Enteromorpha* attached on *Patella*

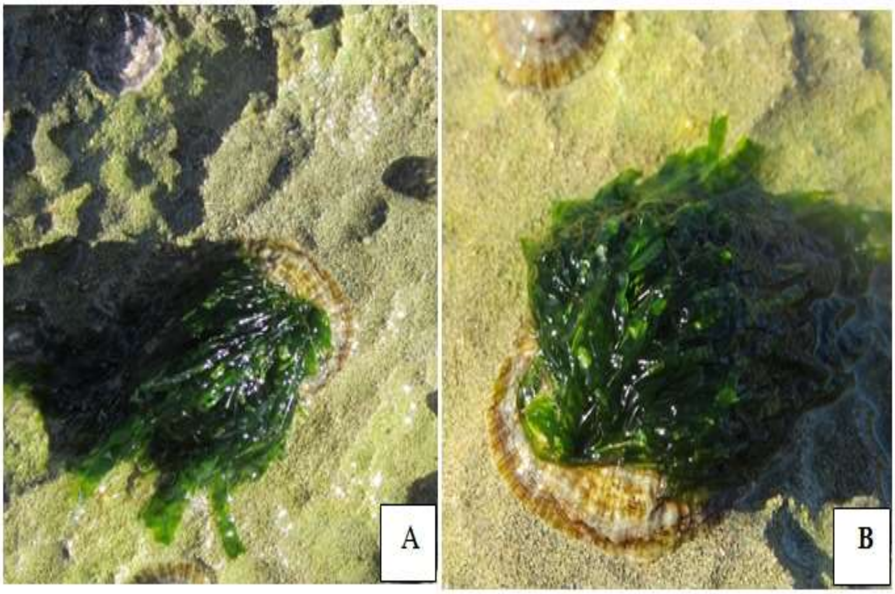


Plate (3) : *Boergeseniella* associated with *Patella*

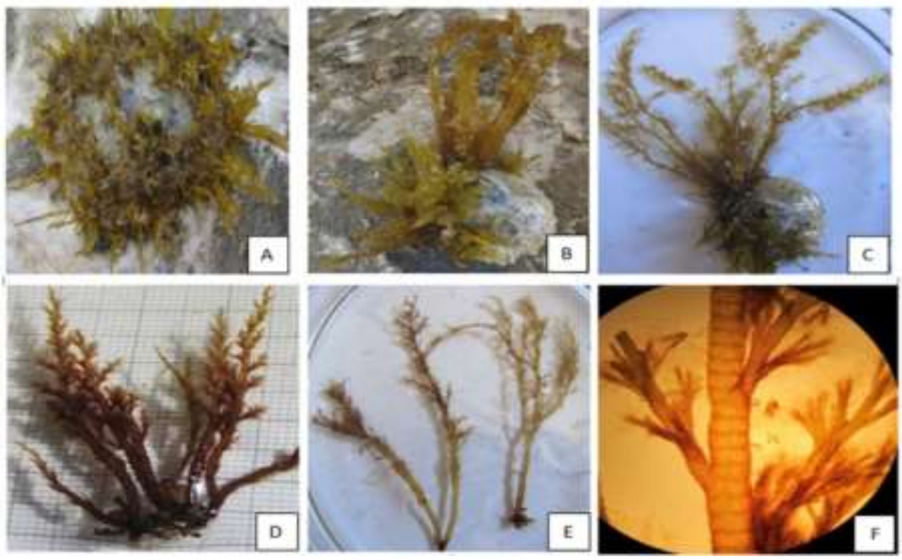


Plate (4): *Gelidium* associated with *Patella*

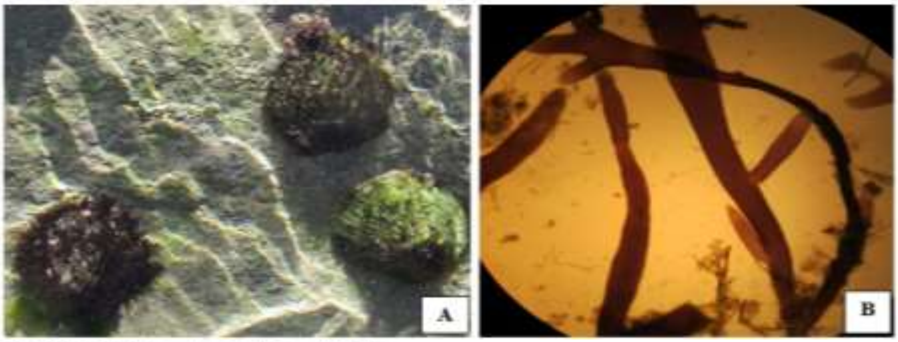
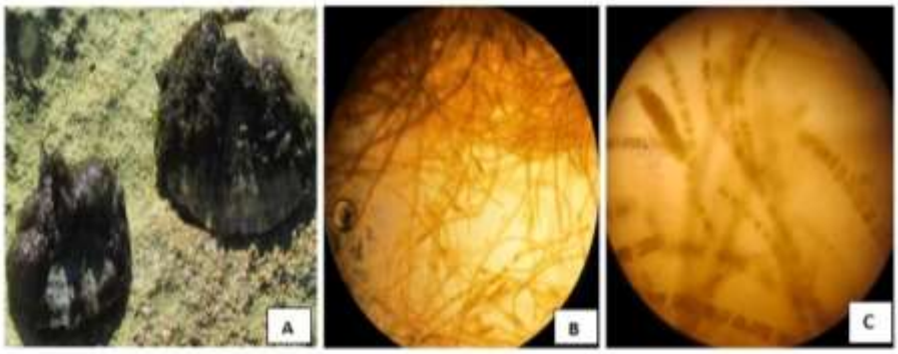


Plate (5): *Ectocarpus* growing on *Patella*



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الملخص العربي

دراسات على علاقة التعايش بين بعض أنواع الطحالب البحرية والبطلينوس باتيلا تريبيناتا قاطن مناطق المد والجزر بساحل البحر المتوسط – الجبل الأخضر، ليبيا.

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أجريت هذه الدراسة على بعض أنواع الطحالب البحرية المرتبطة بالتعايش مع البطلينوس من نوع **باتيلا تريباناتا** التي تعيش على الشواطئ الصخرية للساحل الشمالي الشرقي لليبيا للمرة الأولى. ولقد تم جمع العينات من سبع أماكن تقع على الشواطئ الصخرية من رأس هلال حتى الحنية خلال شتاء وربيع 2012 .ولقد أوضحت النتائج وجود اختلاف بسيط نسبيا في متوسطات درجة الحرارة، والتوصيلية الكهربية، والأملاح الكلية الذائبة، والعسر الكلي والاوكسجين الذائب بين المحطات محل الدراسة. ومثلت أنواع الطحالب المرتبطة بالبطلينوسات في موضع الحنية الملوث بأربع أنواع ينتمي نوعان منها إلي الطحالب الخضراء Chlorophyta ونوع واحد لكل من الطحالب الحمراء Rhodophyta والطحالب البنية Phaeophyta. وعلي الجانب الأخر، فقد سجل نوع واحد من الطحالب الحمراء علي البطلينوس القاطن للمناطق النظيفة بمنطقة سوسة. وبرهنت النتائج أن الأنواع *Ulva*،*Enteromorpha*، *Ectocarpus* و *Gelidium* المرتبطة بالبطلينوس هي السائدة في الأماكن الملوثة، بينما اختفت في الأماكن النظيفة . كما أوضحت النتائج أن نوع *Boergeseniella fruticulosa* يفضل مياه البحر النظيفة (غير الملوثة)، حيث نمت إما علي البطلينوس أو الوسط المحيط، حيث تتنبأ النتائج بكونها دليل حيوي واعد علي عدم تلوث مياه البحر. كما أثبتت النتائج علاقة تبادل المنفعة بين الباتيلا و أنواع الطحالب سريعة الزوال في منطقة الرصد، مؤكدة كفاءتها كدلائل بيولوجية.