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INTERACTION BETWEEN MACROALGAE AND THEIR EPIPHYTAL AMPHIPODS ALONG ENVIRONEMNATL GRADIENT ON THE ROCKY SHORES OF ALEXANDRIA, EGYPT

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INTRODUCTION:

Rocky shore communities are ideal for biological monitoring purposes where they include both primary and secondary producers (Lundalv, 1987). The diversity and abundance of algal species along rocky coasts are important in providing significant feeding, nursery ground and refuge for ecologically and economically valuable species (Thayer et al, 1984), and thereby affects their distribution and abundance (Russo, 1990). Macroalgae constitute complex ecosystem and their diversity maintain distinct marine communities (Taylor 1995) by provision of complex habitats (Parker, 2001). Amphipods are particularly sensitive to variety of forms of marine pollution and thus are extremely useful bioindicators of alterations of marine environmental quality (Thomas, 1993). Variable amphipod species showed different preferred pattern for both current and algal substratum in both field and laboratory (Karez and Ludynia, 2003). The present study measured the changes in the structure of macroalgae and the associated amphipods along an environmental gradient, and assessed the changes due to anthropogenic influences by establishing a reference area. It also studied the effect of the heterogeneity provided by macroalgal biomass on the structure of the amphipods along an environmental gradient.

MATERIAL AND METHODS:

Four localities were investigated at Alexandria coast from the east to the west (Fig. 1). Abu-Qir in the east is far away from any direct sources of pollution. The undulated rock chains there naturally divide the sub tidal water into areas highly exposed to the wave action (AQe), as well as a sheltered one (AQs). Sidi-Gaber (SG), in the middle of Alexandria, it is exposed to the wave action and intermittently subjected to the wastewater discharge. At El-Mex, MXD located next to El-Umum outlet, which discharges of about 7 x 10^6 $m^3.d^{-1}$ agricultural drainage water and it is moderately exposed to the wave action. The second location at El-mex area (MX) was located at 200 m to the east of MXD and it was highly exposed area to wave action.

Quantitative samples of macroalgae and their associated fauna were collected monthly between September 1993 and August 1994 at depth about 2 m. At each locality, three quadrates of 25 × 40 cm were randomly collected and were frozen at -16 ºC until macroalgae and amphipods were sorted and identified. The wet weight of the macroalgae was determined. Physical and chemical parameters influence benthic community structure (salinity, dissolved Oxygen, pH, nitrate, nitrite and phosphate) was quantified for the water overlying the communities.

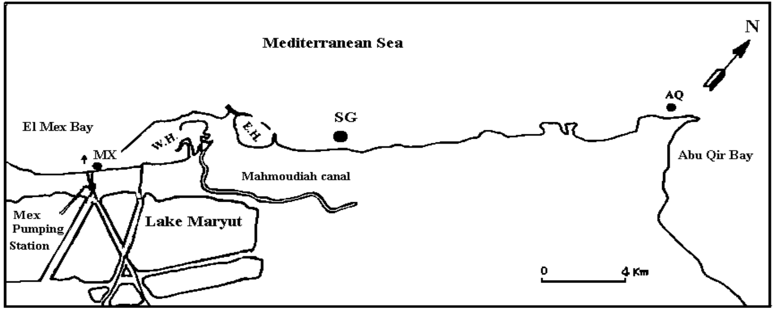

Figure 1. Map of the Study area showing the main sampling sites: AQ= Abu-Qir, SG= Sidi-Gaber and MX= El=Mex.

Shannon diversity index was measured for macroalgae and amphipods. Multivariate analysis of variance (MANOVA) was used to determine spatial fluctuations in the variables using space (stations) as sources of variation. Cluster analysis based on binary data (presence–absence of species) was conducted using the Dice similarity coefficient and further neighbor method performed for the amphipod species at the different sites over the study period. Stepwise Regressions were performed at the different sites to determine the most important predictors for amphipods at each site.

RESULTS:

The MANOVA for the measured environmental parameters showed significant gradient in some parameters from the unpolluted east (AQ) to the polluted west (MXD). The salinity significantly changed ($P<0.01$) from AQ (38.38 ‰) to MXD area (10.35‰). The dissolved Oxygen significantly decreased ($P<0.05$) from the east (6.05 ml $O_2.l^{-1}$ at AQ) to the west (2.94 ml $O_2.l^{-1}$ at MXD). The pH showed the same significant gradient ($P<0.01$). A total of 27 macroalgal species were recorded from the study area. The unpolluted AQS comprised 20 macroalgal species comparing with only three species at MXD. The macroalgal biomass showed significant gradient ($F= 14.8$, $P< 0.01$) with the variation in the water quality (Fig 2). The highest biomass (2.564 kg wwt.m2) was recorded from the exposed site at AQ while the lowest (0.847 kg wwt/m2) was recorded from MXD area. The red algae were the major contributor for the total biomass at AQe and its biomass significantly decreased ($F=31.7$, $P< 0.01$) toward the west.

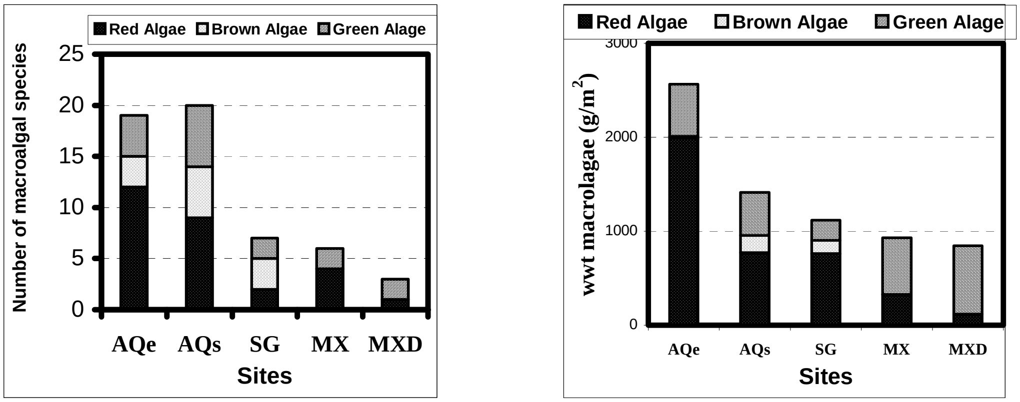

Fig.2 The variations of the species number and the biomass of the macroalgae at the different sites.

The species compositions and abundance of the amphipods was comparable to that of the macroalgae. The highest number of amphipod species obtained from AQs (22 species) and it decreased toward El-Mex (10 species). The abundance of the amphipods showed significant variations between sites where the exposed site (AQe) comprised the highest abundance of amphipods (9599 ind.m^2) while the unpredictable SG area comprised the lowest (668 ind.m^2).

The diversity index for the macroalgae showed significant gradient (F3.86, $p<0.05$) between locations, and reflected the degree of pollution. The highest diversity was observed at the sheltered location (AQs) and the lowest at highly polluted MXD. The diversity of the Amphipods behaved differently from the macroalgae and significantly changed between sites ($F= 42.9$, $p<0.01$). The highest diversity was recorded at AQs while the lowest was recorded from the highly exposed area of SG (Fig. 3).

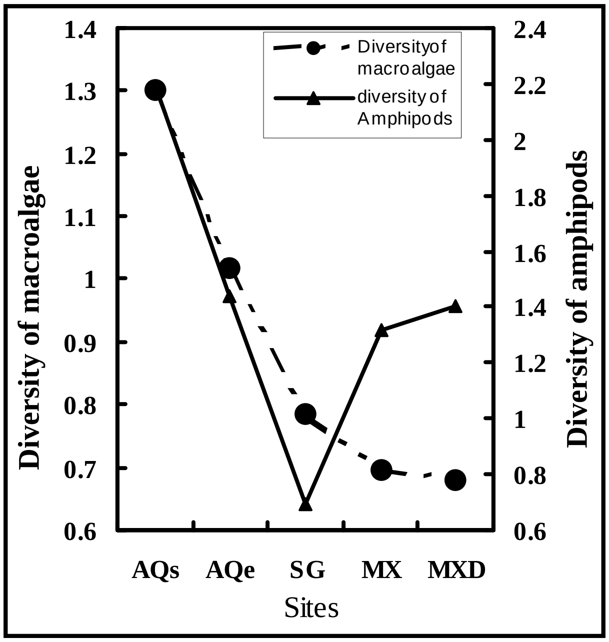

Fig.3. Diversity of macroalgae and their associated amphipods at the different locations.

The presence–absence cluster analysis clearly separated three groups on the highest level (fig. 4). The first group (I) included characteristic species for the exposed unpolluted environment. The second group (II) included characteristic species for the sheltered and unstressed environment and it includes. The third group included two subgroups, the first one (III) comprised the species that dominated the polluted area of MXD and the second subgroup (IV) comprised all the species that cannot infer significant preference for particular site.

Similarlysome macroalgal species (e.x. *D. dichotoma, P. capillacea, P. pavonia,*) were flourished only at the reference area (Abu-Qir) while others (*C. gracilis* and *G. latifolium*) dominated only at the polluted area of El-Mex. *U. fasciata* and *E. intestinalis* showed no preference for particular area and they were widely spread.

Stepwise regression analysis was used to determine the most important factors determining the abundance of the amphipods at the different locations. The wet red macroalgal biomass was the predictor for the amphipod abundances in the different exposed sites of AQe (R^2= 0.77, p<0.01), at SG (R^2= 0.65, p<0.01), and at MX (R^2= 0.81, p<0.01) while, the total macroalgal biomass (R^2= 0.72, p<0.01) was the predictor for at the sheltered area (AQs).

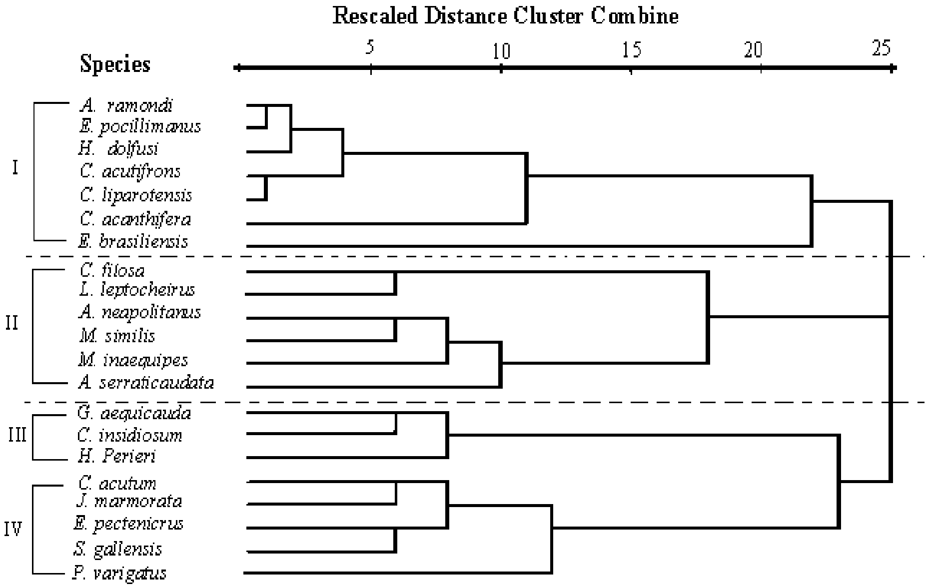

Figure 4. Dendrogram using the Dice similarity coefficient and further neighbor method for presence absence data of amphipods across year (four locations combined).

DISCUSSION:

Biological indices for the environmental stresses are more meaningful than chemical one. The diversity and density of benthic macroalgae can be used as a good indicator for the pollution. Our results indicated that the average vegetation biomass decreases with increasing the wastewater discharge. Sheltered low energetic area tended to have higher macroalgal diversity and lower density comparing with the exposed area. High densities of the firm and bushy red algae dominate the highly energetic unpolluted area, while the sheltered site tended to be flourished by sheet like macroalgae with few interstitial spaces.

The richness of the amphipods peaked at the sheltered site (AQs) that has greatest stability while the physical disturbance of the exposed environments prevented the establishment of diverse benthic communities. The lowest diversity and density of the amphipods were recorded from the SG area that characterized by high instability either from the intense wave action or from the intermittent discharge of wastewater that make the surrounding environment unpredictable. Four groups of amphipods were identified from the coastal water based on the distribution of the amphipods and could be used as indicator species for different environmental qualities including euryecious species which are indicator species for the polluted environment where neither fully marine species nor fresh water species could compete efficiently and tolerant species that were wide spread and showed no preference for particular environment.

Fluctuations in the amphipods abundance are attributed to changes in the macroalgal biomass in different studies. The results of the present study indicated that the biomass of macroalgae, rather than the pollution gradient was the most important factor influencing amphipod distributions. The firm bushy branching of red algae supported high amphipod abundances in the exposed unpolluted as well as polluted area and this may be due to the high interstitial spaces or microhabitats provided by the branching system. Branched algae supported higher densities of amphipods (Hacker and Steneck, 1990) by increasing habitat heterogeneity (Heck and Wetstone, 1977) and providing refuge from physical stress (Duffy and Hay, 1991).

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