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SEASONAL VARIATIONS OF SEAWEEDS AT EL ARISH COAST OF MEDITERRANEAN SEA (EGYPT)

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Abstract

The real chance for establishing and studying the benthic seaweeds communities at ElArish coast was modified directly to human activity at ElArish sandy shore. Seaweeds vegetation and community at ElArish coast were studied seasonally from April 2000 to March 2001. Eighty species were recorded from five sites along ElArish coast (15 km). These sites were found to include 28 species of green algae, 43 species of red algae and 9 species of brown algae. The environmental factors were studied as air & water temperature, salinity, pH, turbidity, pollution sources, water current, rocks and their slope. The distribution of most of the floristic composition and vegetation groups not much influenced by most of the environmental factors and seasons. There were predominant and opportunistic species all over the year. Some species were recorded once for one season in each site, then disappeared during the rest of the study period. Seaweeds increased at the sites which overlooked directly on the sea. It was also apparent that seaweeds, especially red algae, increased toward the east of ElArish coast, so, the shore tend to be more clearly (non polluted area).

Introduction

The ecology of marine algae along the Mediterranean sea shore of ElArish is still fragmentary. The Mediterranean algal flora is composed partly of endemic species of North and South Atlantic species and partly of an increasing number of immigrant species from the Red Sea. Cinelli (1985) mentioned that the biogeography of the Mediterranean is strictly linked to its geological record, and that the changes occurred in the succeeding periods have caused frequent and large variations in salinity and temperature. These fluctuations in ecological factors were of fundamental importance also in the dispersal and distribution of indigenous species and their relative potential for speciation. Several biogeographically elements are present in the Mediterranean, including Cosmopolitan , Circumtropical , Atlantic (boreal and tropical) , Indopacific and endemic or "Mediterranean " (paleo – and neoendemic) .

The marine flora of Egyptian Mediterranean coastline, especially the region of Alexandria, was fairly studied by Rayss (1955), Aleem (1948, 1950, 1951, 1992, and 1993) and others. The Northern coast of Sinai is an important region of Sinai Peninsula. It lies at the eastern basin of the Mediterranean (Levantine nanism). The coast line from ElArish to Rafiah region is characterized by sandy shore texture (Abd ElMalek *et al*., 1971, Abd El Salam and Mohamed,

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1971; El Mahdy and Mohamed, 1975). The seaweeds of ElArish area is still to a large extent unknown. Some investigations were made on the phytoplankton and seagrasses by Ehrlich (1975 a, b; 1978) and Lipkin (1972, 1977). Por *et al*. (1972) mentioned that the Mediterranean littoral coast was mostly neglected, except for several expeditions to the sirbonian lagoon (Sabkhat el Bardawil). He investigated only the plankton and benthos profiles at North coast of Sinai Peninsula (Gaza, Rafiah, and ElArish).

The present investigation aims to study the vegetation of seaweeds which established on the hard substrates at ElArish coast as well as the diversity of algal communities at this area of the Mediterranean.

Study area

The investigated area covers about 15 Km of ElArish coastline, extending from ElRisa in the east to ElArish power plant in the west. Five sites were selected to represent the tongues of rocks, which protect ElArish coast (Map, 1). The selected sites –from west- are:

Site I: The inlet of the electrical power plant. It is surrounded by highly artificial rocks, but there is a channel to permit an appreciable amounts of seawater penetrated in the inlet from the open sea. This lead to weak the water current. The site is polluted by oil resulting from the pumps uses.

Site II: Outside the inlet region. It is overlooked directly on the open sea. The water current is strong. The rocky shore is condensed and gradually sloping to a littoral zone. The region is still polluted by oil deposits and thermal effluents.

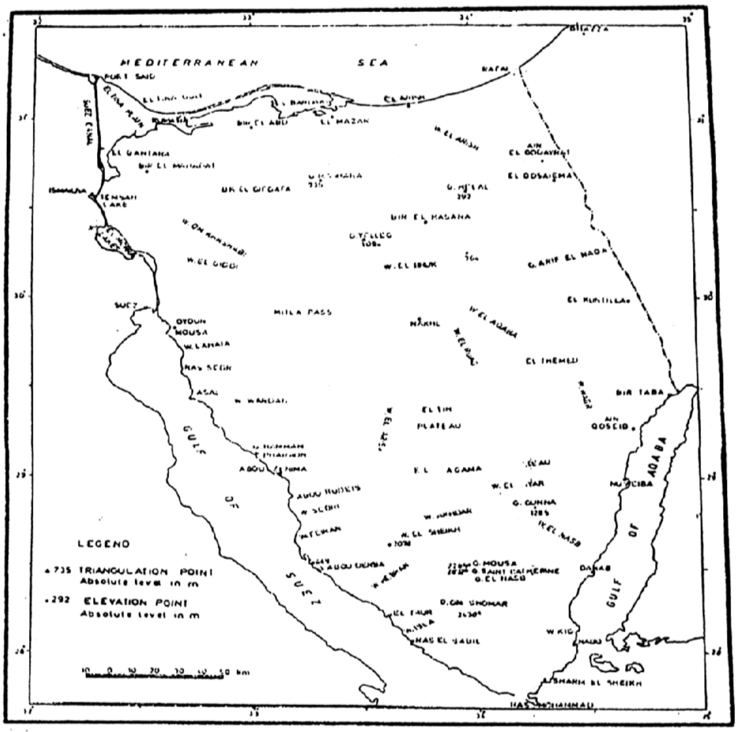
Site III: Beside the outlet of the electric power plant. The water current is strong to moderate. The rocks were slightly scattered through Spring, Summer and Autumn, then condensed through the Winter season.

Site IV: ElArish port. It is strengthened by concrete blocks to protect the port entrance. The water exchange between the harbor and the open sea takes place through branch channels. Therefore, the water current tends to weak.

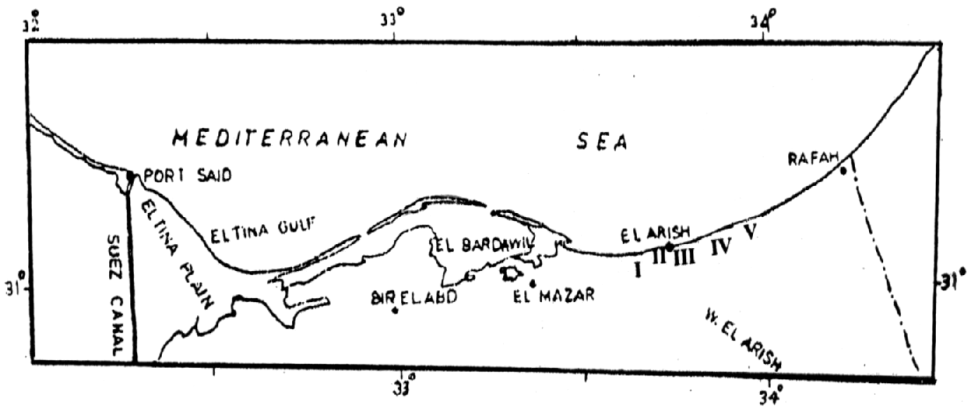
Site V: ElRisa area. It is directly overlooked on the open sea. It is characterized by many tongues of highly condensed rocks which extended from the shore to inside the sea. ElRisa region is away from any pollution stresses.

Materials and Methods

Seaweed samples were collected seasonally during the period from April 2000 to March 2001. The algal specimens are preserved in 4% formalin in seawater. Subsequent examination and identification were carried out as described by: Fritsch (1935a, b); Papenfuss (1968); Cribb (1983); Womersley (1984, 1987) and Aleem (1993). The most effective hydrographic factors were determined by using a thermometer for air and surface water temperature, a hand Refractometer (ATAGO S / Mill Chem. Lab. Scientific Products Ltd) for salinity, digital pH meter (Teleko AQUAMETR N 5211) for pH and a turbidimeter (Orbeco- Hellige Digital Direct- Reading TURBIDIMETER) for turbidity.



Map of Sinai Peninsula



Map (1): The studied sites in El Arish region at the North of Sinai.

Data analysis

Plant cover is estimated quantitatively. The cover data were transformed using seven- point scale: 0.1= 1, 2= 1- 10, 3= 10- 15, 4= 15- 25, 5= 25- 50, 6= 50- 75 and 7= 75- 100%. Twenty Stands were located to representing 5 sites in 4 seasons. Tow way Indicator Species Analysis (TWINSPAN) was used for the classification of the entire data (80 species x20 stands) using species cover estimates. Detrended Canonical Correspondence Analysis (DCCA) was used to ordinate vegetation with the environmental variables (Ter BraaK, 1988). The intraset correlation is measured using CANOCO (Ter Braak, 1990) for interpretation the environmental variables and ordination axes. Environmental variables were estimated as water & air temperatures, salinity, turbidity, pH, water current, slope, stones and pollution sources.

Statistical analyses

Simple linear regression was carried out to assess the interrelationship between measured environmental parameters and species richness. Two- Way Analysis of Variance (Two-Way ANOVA) was performed to investigate the variation between seasons and sites. All statistical analyses were carried out by using SPSS statistical software version 9.1 and Microsoft Excel XP professional (2003).

Results and Discussion

The changes in biogeography process such as salinity and temperature are caused limiting the distribution of communities, species composition and relative degree of complexity and stability. These changes have permitted, at different times, the introduction of floristic element from boreal and tropical zones. Table (1) shows that the seasonal variation in surface water and air temperatures at the selected sites. Water temperature fluctuated between 14ºC in winter at site II and 30ºC in summer at site III. Site III recorded higher temperature values compared with the other sites allover the study period. This may be attributed to the effluent from the outlet of ElArish electric power plant. Water temperature data showed non-significant among the studied (F=2.60, *p*=0.089), while highly significant variation was registered at the different seasons (F=134.44, *p*=0.000***). Maximum air temperature (33 ºC) was recorded at site V in spring while the minimum one was 16ºC in winter at sites II and III. Significant variation in air temperature among the five studied sites were recorded (F=3.95, *p*=0.028**), in the mean time, significant variation in air temperature at different seasons were also registered (F=167.17, *p* =0.000***).

Table (1): Seasonal variation of water and air temperatures (ºC) in the selected sites at ElArish coast during the period 2000-2001

Season / Site	Spring		Summer		Autumn		Winter	
	w	a	w	A	w	a	w	a
I	20	30	29	27	25	23	15	18
II	20	30	28	27	24	23	14	16
III	23	31	30	28	26	22	20	16
IV	22	32	29	27	22	25	16	19
V	22	33	29	27	23	26	17	19

Where, w=water; a=air

The mean environmental parameters in the selected sites were recorded in Table (2). The average of surface water salinity ranged between 40 – 44‰. Sarà (1985), Fredj and Laubier (1985) and Maruitou – Apostolopoulou (1985) recorded that surface water salinity of Mediterranean increases eastward, reaching 39‰ in the eastern basin. The salinity values along ElArish coast have been significantly arise. This may be attributed to the changes of climate conditions of the world. The pH was slightly alkalinity; it ranges between 8.4 and 8.6. Sites IV (ElArish port) and V (ElRisa) registered the minimum levels of turbidity (1.5 N.T.U.), while the maximum value was 8.5 N.T.U. at the site I. The highly level of turbidity may attribute to the pollution in this area and the movement of pumps in the inlet of ElArish power plant. It appeared that the environment at ElArish tend to be more clearly toward the east coast.

Table (2): Mean environmental parameters in the selected sites at ElArish coast during the period 2000-2001

Parameter / station	Salinity ‰	pH	Turbidity N.T.U.	Pollution	Slope	Rocks	Water current
I	40	8.5	8.5	Oil	-	Scattered	Weak
II	44	8.6	6.6	Oil	Gradually	Condensed	Strong
III	40	8.6	6.0	Thermal	-	Moderate	Strong
IV	44	8.4	1.5	-	-	Scattered	Weak
V	44	8.5	1.5	-	Gradually	condensed	strong

Both Lipkin (1972) and Aleem (1983) recorded 21 Indo – Pacific species found in Eastern Mediterranean. Safriel and Lipkin (1972) mentioned that the marine algae are represented on the Israeli Mediterranean coast by migration. The red sea migrants have been carried by the East Mediterranean current over the 200 km rock less coast of the Sinai Peninsula from the mouth of canal at Port-Said to the first rock exposures on the Eastern coast of the Mediterranean at Ashgelon. However, the rock pavements and tongues constructions at ElArish coast could be recorded in this work as new actions to human activity. The rocky substrates are useful to protect the coastal line of ElArish shore from erosion. This rocky shore is giving a chance to establish favorable growth of algal communities on the hard substrates.

Studies on the relative composition of the algal flora along ElArish coast at the selected sites revealed the presence of about 80 species belonging to three algal divisions (Table, 3). These were represented by 28 species of Chlorophyta (35%), 9 species of Phaeophyta (11%) and 43 species of Rhodophyta (54%). Fig. (1), shows the average contribution of taxa belonging to the three algal divisions. It appears that the red algae are the major group followed by the green algae then finally by the brown algae.

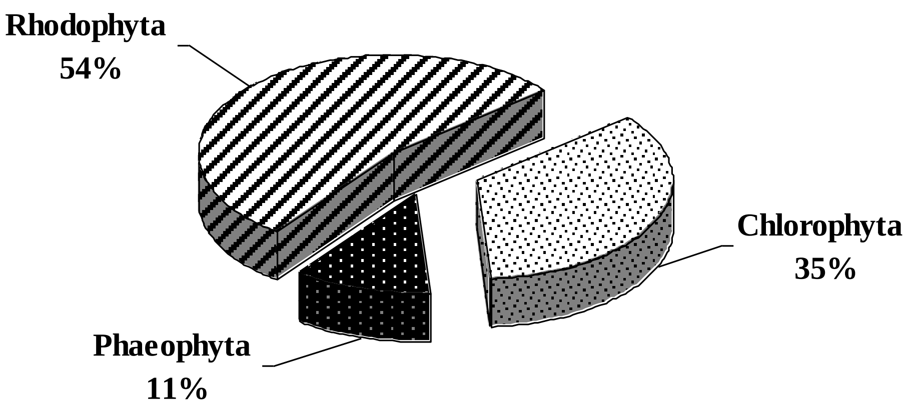


Figure (1): The total percentage recorded of the three algal divisions at the studied sites.

Seasonal temperature and studied parameters variations may affect the species composition of the ecosystem, causing migration, periodic appearance and disappearance of species by formation of resting or active – life stages. The distributions of seaweeds and species richness along ElArish coast are affected by the seasonal variations. This effect is clearly shown in (Fig. 2). The highly yield of red algae was recorded in Autumn and Winter at site V while the green algae were mostly seen nearest to the different seasons. In general, at ElArish coast, winter was the best season floristically for seaweeds, whereas summer season was the lowest one. Variations in species richness appeared non-significant among the four studied seasons (F=1.65, p= 0.228), while the variations in species among the studied sites were found to be highly significant (14.04, p=0.000***).

Linear regression trend line showed the relationship between various environmental parameters and species richness (Fig. 3). Air and water temperatures are directly proportional to species richness (non-significant). It is recorded (R=0.02, p=0.931) for air temperature and (R=0.222, p=0.346) for water temperature. It was found that species richness increased with increase the salinity at all sites (R=0.495, p=0.026*). It showed significant decrease with increased turbidity (R=-0.557, p=0.010**). As pH at the selected sites increase the number of species per unit area significantly increase (R=0.503, p=0.023*). On the other hand, both current and stones showed highly significant with the number of species (R=0.721, 0.721; p=0.000***, p=0.000***), respectively.

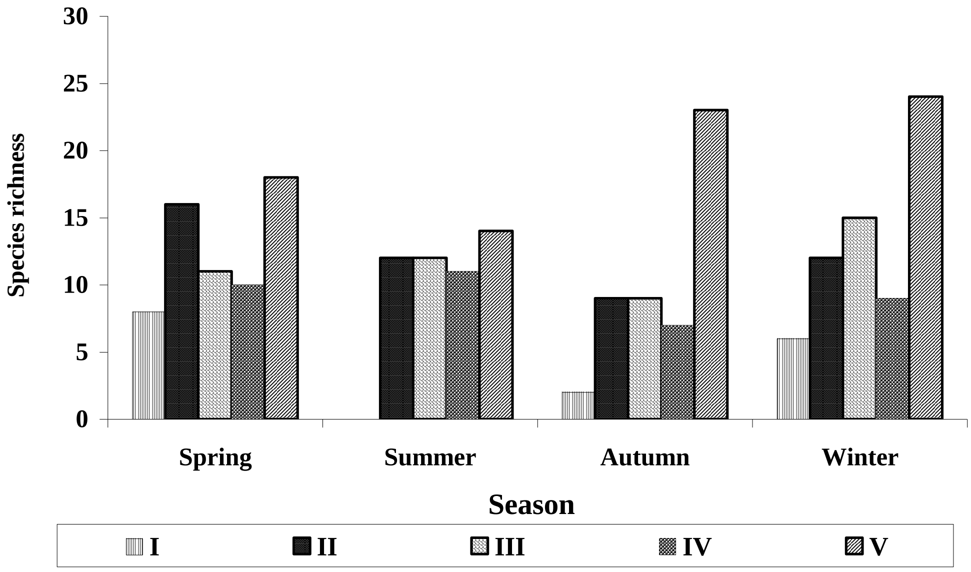


Figure (2): Species richness in the different seasons at the selected sites.

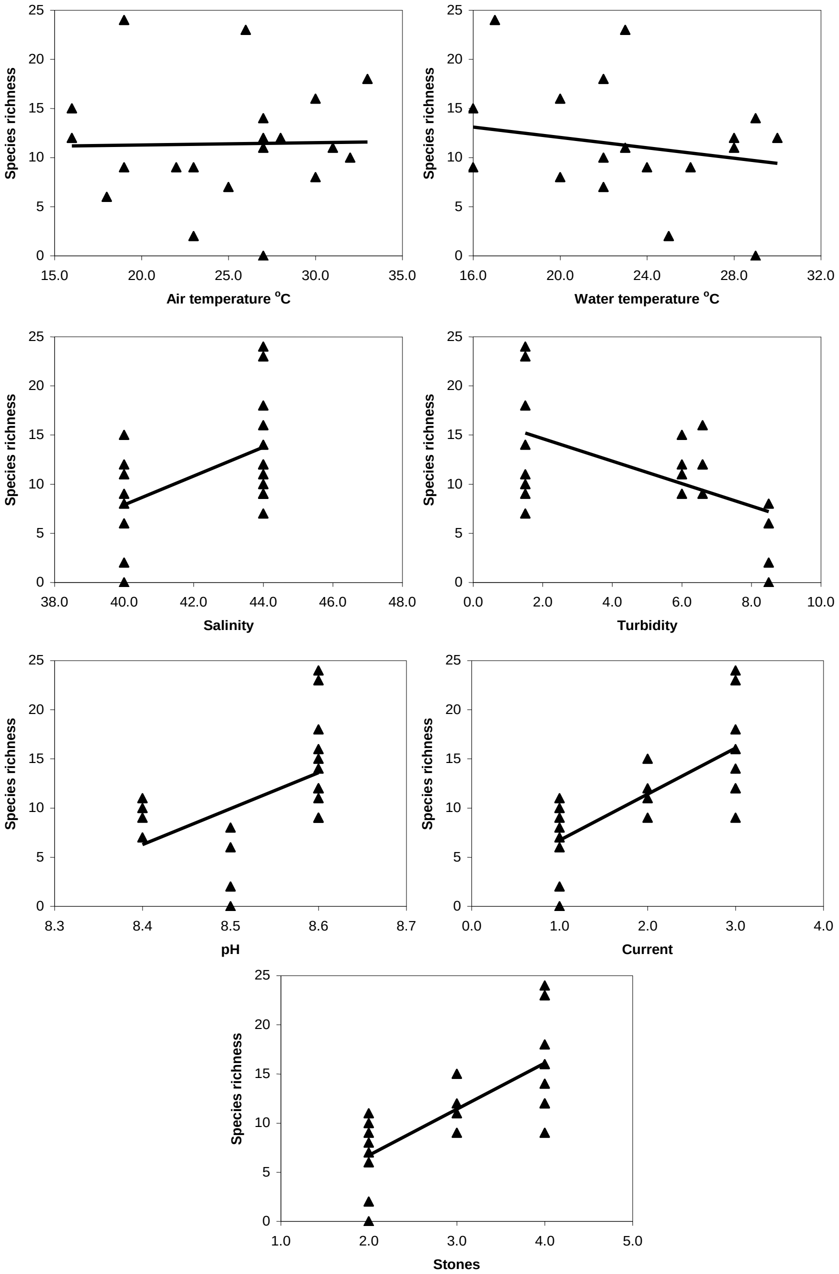


Figure (3): Linear regression trend line showing the relationship between various environmental parameters and species richness.

Green algae (*Cladophora prolifera, C. crystalline, Enteromorpha compressa, E. flexuosa, E. prolifera, E. ralfsii* and *E. ramulosa*), brown algae (*Giffordia indica*) and red algae (*Bangia fuscopurpurea, Erythrotrichia carnea, Gelidium crinale, Jania adhaerens* and *Hypnea cornuta*) were the most predominating species allover the investigation period in all sites. These species could be termed as the "opportunistic" species (Fig. 4).

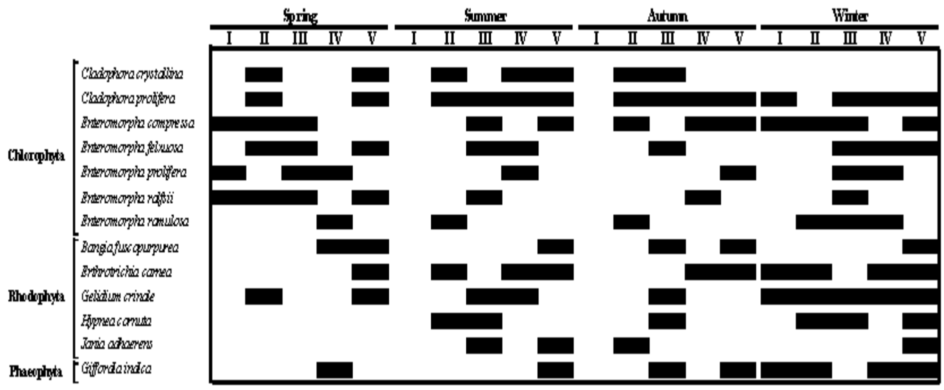


Figure (4): Distribution of the most dominant species among the studied sites at different seasons.

High variation of additional species of *Cladophora* (12 species) and *Enteromorpha* (10 species) is a characteristic feature of ElArish vegetation. This might be attributed to the existence of more favorable conditions for the growth of the above mentioned different algal species.

Some algal species, especially red and brown algae, were characteristic to each site. The alga was sometimes recorded one time collection seasonally, then, it was not found in the area again (Table 3). This may have resulted from favorable conditions for the particular species existing for a short time and then the conditions returned to normal, the species disappeared.

The more tolerant species to high levels of water temperature were at the site III in summer (30ºC). This may related to the fact that these species exposed to thermal stress from the outlet fluent site of ElArish power plant (El-Shoubaky, 2000). These species were: the green algae (*Chaetomorpha linum, Cladophora patentiramea, Enteromorpha compressa, E. flexuosa, E. ralfsii* and *Rhizoclonium kochianum*), the red algae (*Gelidium crinale, Herposiphonia sp., Hypnea cornuta, Jania rubens* and *Polysiphonia variegata*) and the brown alga (*Sphacilaria tribuliodes*).

Based on the TWINSPAN outcome (Hill, 1979) the analysis obtained (Fig., 5) divided the species into 8 clusters or groups, each cluster representing a specific plant community according to the most abundant characteristic species that reached the highest cover and may be the rarely species. The highest clusters were represented in groups B and D which recorded 23 and 20 species respectively, followed by the groups: H (12 spp.), G (11 spp.), C (6 spp.), F (4spp.), A (2 spp.) and E (2 spp.). Each group is characterized into differentiated community types. The communities of the group (B) were *Cladophora, Ceramium, Hypnea, Laurencia* and *Scytosiphon.* Group (D) showed more appearance to different species of *Cladophpra* (6 spp.) and the red alga *Erthrotrichia.* The dominancy of *Enteromorpha* (7 spp.) characterized the community in group G, in addition to *Jania adhaerens, Hypnea cornuta* and *Polysiphonia variegate* (the most differentiated community types at this group).

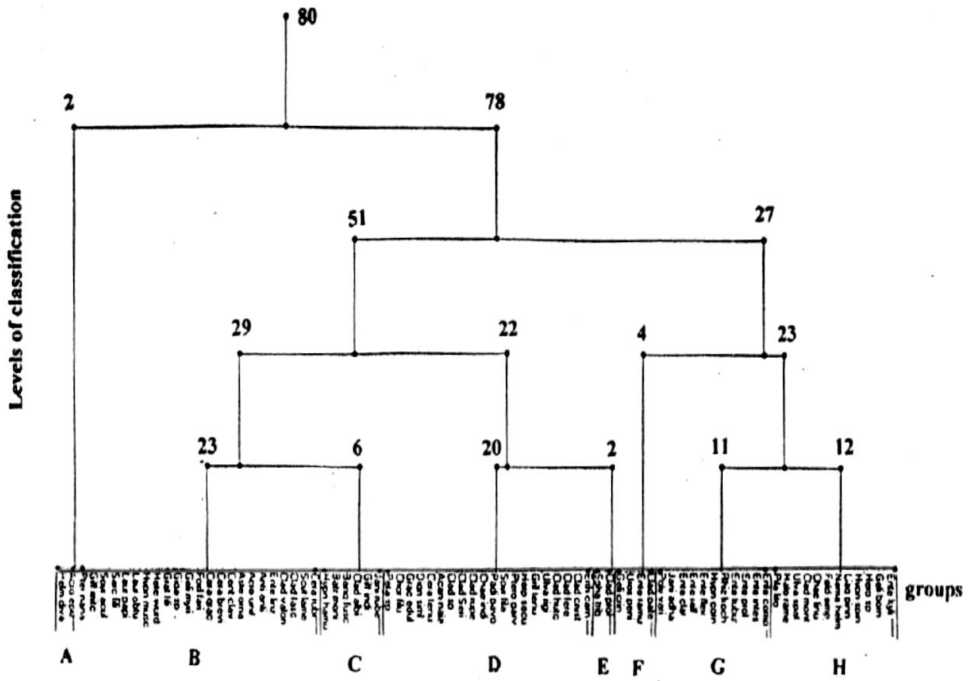


Figure (5): The classification of stands according to TWINSPAN.

The twenty stands are separated to 5 levels and 7 groups corresponding to the seasons and species. Each level is characterized to differentiate community type (Fig. 6). The seasons are not much effect on the appearance of most species.

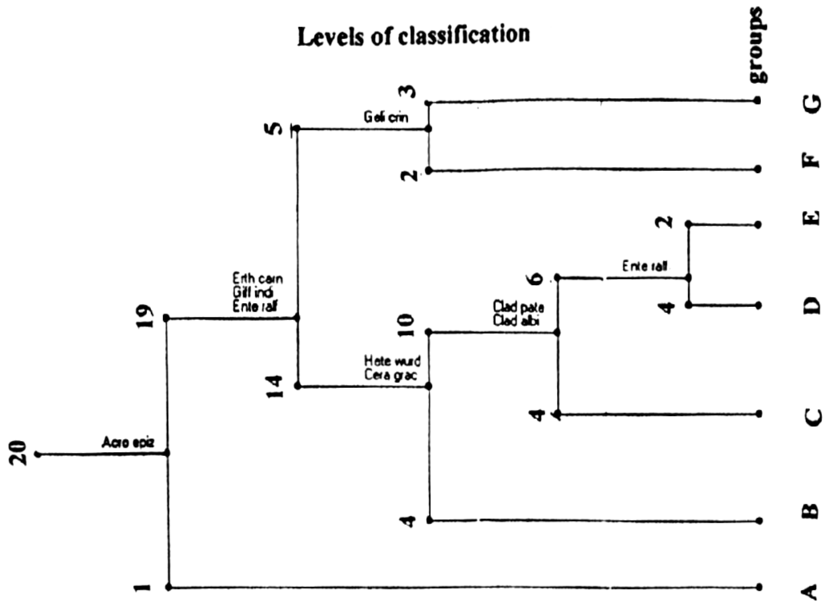


Figure (6): The classification of species according to TWINSPAN.

The ordination diagram produced by DCCA is shown in Fig. (7) for species and Fig. (8) for stands to summarize the relationships between species or seasons and the environmental parameters. The length and the direction of an arrow representing a given environmental variable provide an indication, of the importance and direction of the gradient of the environmental chance for that variable, within the set of factors measured. Species in groups (B, C, D, E, F& G) are associated with salinity, turbidity and water temperature while those of groups A and H are weakly influenced. This may indicate that floristic composition and vegetation groups at the study area reflect that the distribution of the most plant species is not much influenced by most of the environmental factors and seasons.

Cinelli (1985) mentioned that the cosmopolitan species (warm water or bipolar) in the Mediterranean may be few. The brown alga *Scytosiphon lomentaria* – bipolar cosmopolitan – is widely distributed in the Arctic Ocean, North Atlantic and North Pacific, Mediterranean and other places. Now, this alga can be settled in ElArish coast at the Eastern basin of the Mediterranean.

Some circumtropical species as *Hypnea musciformis, Centroceras clavulatum, Digenia simplex,* etc, were recorded at ElArish coast. It may be attributed to the most of circumtropical species that have a wide distribution in tropical and subtropical regions.

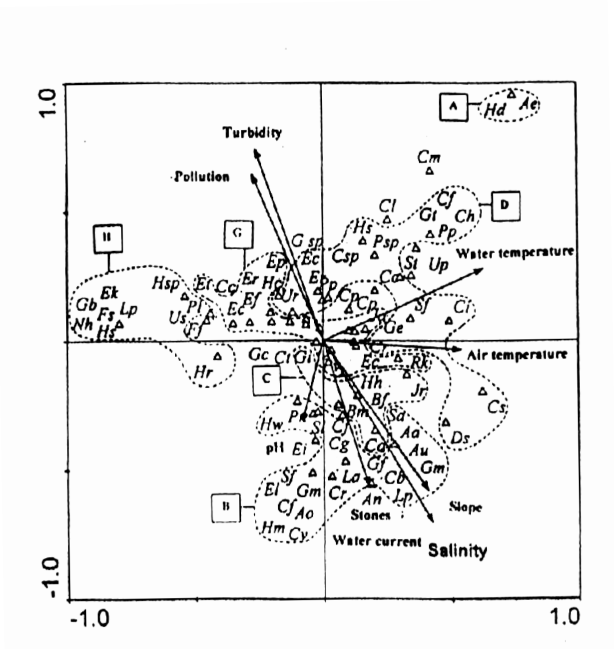


Figure (7): Species/Environmental variables relationship.

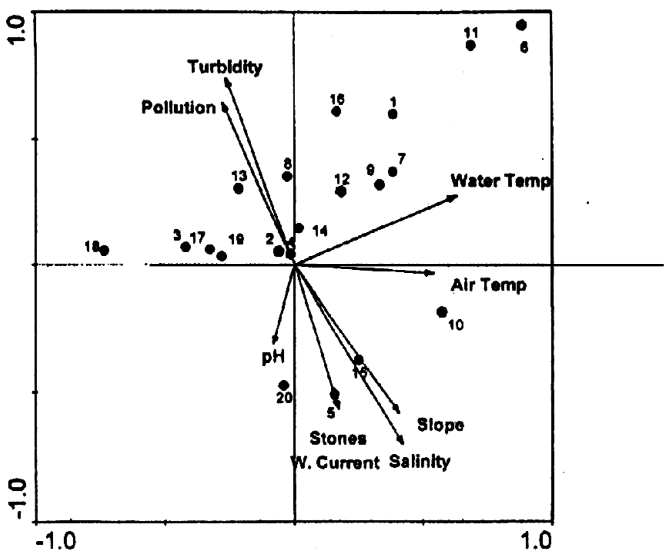


Figure (8): Stands/Environmental variables relationships.

Table (3): Algal species recorded during the study period (Spring 2000-Winter 2001) at the selected sites

Chlorophyta:	Where each species represent
1- *Chaetomorpha indica* Kützing	:Ci: Chae indi
2- *C.linum* (**M**üll.) Kützing	:Cl: Chae linu
3- *Cladophora albida* (Huds.) Kützing	:Ca: Clad albi
** 4- *C. crystallina* (Kütz.) Hamel	:Cc: Clad crys
* 5- *C. fascicularis* (Mert.) Kützing	:Cf: Clad fasc
* 6- *C. feredayi* Harvey	:Cf : Clad fere
* 7- *C. hutchinsioides* van den Hoek &Womersley sp. Nov	:Ch: Clad hutc
8- *C. montageane* Kützing	:Cm: Clad mont
9- *C. patentiramea* Montagne	:Cp: Clad pate
**10- *C. prolifera* (Roth) Kützing	:Cp: Clad prol
11- *C. rupestris* (Linn.) Kützing	:Cr: Clad rupe
*12- *C. serica* (Hudson) Kützing	:Cs: Clad seri
*13- *C.valonioides* Sonder	:Cv: Clad valo
14- *C.* sp.	:Csp Clad sp.
15- *Enteromorpha clathrata* (Roth) Grevile	:Ec: Ente clat
**16- *E.compressa* (Linn.) Kützing	:Ec: Ente comp
**17- *E. flexuosa* (wulf) Agardh	:Ef: Ente flex
18- *E. intestinalis* (Linn.) J. Agardh	:Ei: Ente inte
*19- *E. kylinii* Bilding sensu Dawson	:Ek: Ente kyli
*20- *E. linza* (Linn.) J. Agardh	:El: Ente linz
**21- *E. prolifera* Agardh	:Ep: Ente prol
**22- *E. ralfsii* Bilding	:Er: Ente ralf
**23- *E. ramulosa* (J. E. Smith) Hooker	:Er: Ente ramu
24- *E. tubulosa* (Kützing)	:Et: Ente tube
25- *Rhizoclonium kochianum* Kützing	:Rk: Rhiz koch
*26- *Ulva rigida* C. Agardh	:Ur: Ulva rigi
*27- *Ulva spathulata* Papenfuss	:Us: Ulva spat
28- *Urospora penicilliformis* Areschoug	:Up: Uros peni
Rhodophyta:	
*29- *Acanthophora najadiformis* (Delile) Papenfuss	:An: Acan naja
*30- *Antithamnion antillanum* Boergesen	:Aa: Anti anti
*31- *Acrochaetum epizooicum* Aleem, nov. sp.	:Ae: Acro epiz
*32- *A. unifilum* Levring	:Au: Acro unif
*33- *Asterocystis ornata* (C. Agardh) Hamel	:Ao: Aste orna
**34- *Bangia fuscopurpurea* (Dillwyn) Lyngbye	:Bf: Bang fusc
*35- *Batrachospermum moniliformae* Roth	:Bm: Batr moni
36- *Centroceras clvulatum* (C. Ag.) Montagne	:Cc: Cent clav
*37- *Ceramium brevizonatum* Peterson	:Cb: Cera brev
38- *C. gracillimum* (Harv.) Mazoyer	:Cg: Cera grac
*39- *C. rubrum* (Hudson) C. Agardh	:Cr: Cera rubr
*40- *C. tenuissimum* (Mertens) Okamura	:Ct: Cera tenu

Table (3): Continued

*41- *Digenia simplex* (Wulfen) C. Agardh	:Ds:	Dige simp
**42- *Erthrotrichia carnea* (Dillwyn) J. Ag	:Ec:	Erth carn .
*43- *Fosliella farinose* (Lamouroux) Foslie	:Ff:	Fosl fari
*44- *Gelidiella borntii* (Weber-van Bosse) Feldmann of Hamel	:Gb:	Geli born
*45- *G. myrioclada* (Børgs.) Feldmann et Hamel	:Gm:	Geli myri
**46- *Gelidium crinale* (Tumer) Lamouroux	:Gc:	Geli crin
*47- *Gigartina* sp.	:Gsp.:	Giga sp.
48- *Gracilaria edulis* (J. Ag.) Silva	:Ge:	Grac edul
*49- *Grateloupia filisina* (Lamouroux) C. Ag.	:Gf:	Grat fili
*50- *Griffithsia tenuis* C. Agardh	:Gt:	Grif tenu
51- *Halosaccian ramentaceum* kützing	:Hr:	Halo rame
*52- *Helminthora divaricata* J. Ag.	:Hd:	Helm diva
53- *Herposiphonia secunda* (C. Ag.) Ambronforma tenella	:Hs:	Herp secu
54- *H.* sp.	:Hsp.:	Herp sp.
55- *Heterosiphonia wurdemannii* (Bailey& Harvey) Falkenberg	:Hw:	Hete wurd
**56- *Hypnea cornuta* (Lamouroux) J. Ag.	:Hc:	Hypn corn
57- *H. hamulosa* (Turn.) Montagne	:Hh:	Hypn hamu
*58- *H. musciformis* (wulfen) Lamouroux	:Hm:	Hypn musc
*59- *H. spinella* (C. Agardh) Kuetzing	:Hs:	Hypn Spin
**60- *Jania adhaerens* Lamouroux	:Ja:	Jani adha
61- *J. rubens* (Linnaeus) Lamouroux	:Jr:	Jani rube
62- *Laurencia obtusa* (Hudson) Lamouroux	:Lo:	Laur obtu
*63- *L. papillosa* (C. Agardh) Grevile	:Lp:	Laur papi
*64- *Liagora pinnata* Harvey	:Lp:	Liag pinn
65- *Nemalion helminthoides* (Velley) Butters	:Nh:	Nema helm
66- *Polysiphonia variegata* (Agar.) Zanardini	:Pv:	Poly vari
67- *Pterocladia nana* Kamura	:Pn:	Pter nana
*68- *P. parva* Dawson	:Pp:	Pter parv
*69- *Sarconema filiformis* (Sonder) Kylin	:Sf:	Sarc fili
70- *Spyridia filamentosa* (Wulf) Harvey	:Sf:	Spyr fila
*71- *S. aculeata* (Schimper) Kützing	:Sa:	Spyr acul
Phaeophyta:		
*72- *Chorda filum* Lamouroux	:Cf:	Chor filu
*73- *Feldmannia simplex* (Crouan & Crouan) Hamel	:Fs:	Feld simp
**74- *Giffordia indica* (Sond.) Papenfuss et Chihara	:Gi:	Giff indi
*75- *G. mitchelliae* (Harvey) Hamel	:Gm:	Giff mitc
*76- *Padina Pavonica* (Linn.) Thivy.	:Pp:	Padi pavo
*77- *Petalonia* sp.	:Psp.:	Peta sp.
*78- *Pilayella litoralis* (Linn.) Kjellman	:Pl:	Pila lito
79- *Scytosiphon lomentaria* (Lyngbye) Link	:Sl:	Scyt lome
80- *Sphacilaria tribuloides* Meneghini	:St:	Spha trib

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التغيرات الموسمية للطحالب البحرية على ساحل العريش بالبحرالأبيض المتوسط (مصر)

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قد كانت الفرصة الحقيقية لدراسة الطحالب البحرية على ساحل العريش نتيجة للنشاط العمراني. حيث تم دراسة الكساء والمجتمعات الطحلبية موسميا خلال الفترة من أبريل 2000 إلى مارس 2001 .

ويعتبر هذا النوع من الدراسة لأول مرة على ساحل العريش. وقد سجلت الدراسة 80 نوعا من الطحالب (43 نوعا من الطحالب الحمراء و28 نوعا من الطحالب الخضراء و9 أنواع من الطحالب البنية) وذلك من خمس مناطق على طول ساحل العريش والذي بلغ 15 كم.

ولقد تم دراسة العوامل البيئية المصاحبة مثل درجة حرارة الجو والماء ودرجة الملوحة وتركيز أيون الهيدروجين ودرجة التعكير وأنواع الملوثات وشدة تيار الماء وكمية الصخور ودرجة انحدارها.

وقد وجد أن معظم توزيع التكوينات النباتية ومجموعات الكساء الطحلبي لا تتأثر كثيرا بمعظم العوامل البيئية والمواسم. حيث وجدت أنواع متلائمة مع البيئة وموجودة بوفرة على مدار العام مدة الدراسة. إلا أن هناك أنواع مميزة لكل منطقة ظهرت مرة واحدة فقط لموسم واحد ثم اختفت بقية مدة الدراسة. كما أن الطحالب البحرية تزيد في المناطق المطلة مباشرة على البحر. أيضا وجد أن الأنواع وخصوصا الطحالب الحمراء تزيد كلما اتجهنا إلى الساحل الشرقي من العريش حيث المنطقة أقل عرضة للملوثات.