Egypt. J. Aquat. Biol. & Fish., Vol. 4, No.2 : 183 -210 (2000) *ISSN 1110-6131*

WEEKLY STRUCTURE AND ABUNDANCE OF PHYTOPLANKTON IN BOUGHAZ EL-MAADIYA, EGYPT

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(Received : February17, 2000)

Key words: Phytoplankton, Sea–Lake connection, brackish water.

ABSTRACT

Phytoplankton structure and abundance were studied weekly in Boughaz El-Maadiya, a channel connecting between Lake Edku and the Mediterranean Sea at Abu Kir Bay. The study extended from the end of April to end of October 1997 at four locations representing different ecological conditions.

Weekly changes were observed in both the structure and standing crop of phytoplankton due to changes of current direction towards the Lake or the Sea. The Majority of the recorded species were fresh or brackish water forms, while 39 species were marine. Diatoms were the most diversified group (77 spp.), followed by green algae (46 spp.), blue greens (30 spp.), Euglenophyceae (16 spp.) and dinoflagellates (13 spp.). The standing crop showed abnormal wide weekly variations between 10×10^3 and 36.8×10^6 units l^{-1} for numerical density and 10.6-124.7 $\mu g\ l^{-1}$ for chlorophyll a. Diatoms occupied the first order of abundance, constituting 54.5-81.6 % at different locations and then green algae (16.3-41.8 %). Both groups displayed obvious weekly variations, while other groups showed intermittent flash appearance with markedly lower densities. The species diversity as well as species richness were high, indicating spatial and temporal variations. Cluster analysis demonstrated three main groups of species that differed in their frequencies and abundance. The correlations between phytoplankton abundance and ecological parameters were oftenly insignificant reflecting strong role of the current regime on the phytoplankton distribution in Boughaz El-Maadiya.

INTRODUCTION

Phytoplankton, the primary biological component of aquatic ecosystem, is the most rapidly susceptible to any minute environmental changes. Boughaz El–Maadiya is a short narrow and shallow channel connecting Lake Edku to the Mediterranean Sea at Abu Qir Bay. Both water bodies are completely different in their ecological conditions. The water quality in Boughaz El–Maadiya suffers from irregular changes due to continuous mixing of Mediterranean sea water and very low brackish water of Lake Edku. Such process created unstable ecological characteristics in Boughaz El–Maadiya (Abdel-Aziz and Dorgham, 1999). Relative to such changeable conditions, it was necessary to follow up the dynamics of phytoplankton community in Boughaz El–Maadiya at short time intervals and very close locations.

According to the available literature, little is known about phytoplankton in Boughaz area. The previous studies were based mainly on monthly collection of samples (Gharib, 1983; Gharib and Soliman, 1998), which did not reflect the rapid changes of the ecological conditions (Abdel-Aziz and Dorgham, 1999) and the quantitative and qualitative structure of phytoplankton community in the study area.

MATERIALS AND METHODS

The present study was conducted during the period from the end of April to the end of October 1997, based on quantitative samples only. Four locations were selected representing different ecological conditions (Fig. 1), one at the Lake side (St. I), two inside Boughaz El-Maadiya (Sts. II & III) and one at the sea side (St. IV). Water samples were collected weekly from the surface water, preserved in neutralized formaline, and left 3-4 days for settling. After decantation, the phytoplankton species were identifed in the concentrated samples following Heurck (1896), Peragallo and Peragallo (1897-1908), Hustedt (1930), El-Nayal (1935;1936), Bachmann (1936), Allen (1937), Huber-Pestalozzi (1938), Cupp (1943), Hendey (1964) and Khunnah (1967). The standing crop was determined by numerical density according to Utermohl (1936) and concentration of chlorophyll a (Strickland and Parsons, 1972). The correlation coefficients between phytoplankton density and different ecological parameters were calculated. Species diversity was found following Shannon and Weaver (1963), species richness (Margalef, 1968) and (IBD) the index of biotal dispersity (Koch, 1957). Cluster analysis was also done according to Norusis (1993).

RESULTS

Community structure

Pronouncedly rich phytoplankton community (a total of 182 spp.) was found in Boughaz El–Maadiya during the present study. The great majority of the identified forms (143 spp.) were either fresh or brackish water and 39 species were purely marine. As it is usually found in marine and brackish water habitats, Bacillariophyceae comprized the highest number of species (77 spp.), but Dinophyceae showed remarkably low number(13 spp.). The fresh water Chlorophyceae, Cyanophyceae and Euglenophyceae were represented by 46 ,30 and 16 species, respectively.

The total number of species at the different stations (131-140 spp.) reflected high similarity of phytoplankton composition in most part of the study area (Sts. I,II& III) since the values of IBD (74.7-75%) were similar (Fig. 2). At the sea side St. (IV), the similarity was comparatively lower (61-67%). The numbers of diatoms and dinoflagellates assemblages at St. IV were larger than those at the other stations, while those of Chlorophyceae, Cyanophyceae and Euglenophyceae were lower (Table 1).

Standing crop

The phytoplankton density varied widely during the study period between 10×10^3 and 36.8×10^6 units l^{-1}. The mean densities at Sts. I – IV (1.38×10^6, 1.83×10^6, 1.95×10^6 and 2.59×10^6 units l^{-1} respectively) indicated pronounced variations. The sea side St. (IV) harboured the maximum density, while the Lake side (St. I) sustained the lowest density. Weekly variations were observed in the total phytoplankton density at each station. However, the patterns of abundance peaks were similar with differences in their timing (Fig. 3). Two peaks commonly appeared in mid May and the beginning of June in the whole area (4 June), and two additional peaks in early and late July at St. I, II and III. All peaks attained remarkably different values, those of May and June being the highest. Such pattern revealed that spring is still the season of highest phytoplankton production in Boughaz area as well in other Egyptian coastal waters. On the other hand, Boughaz area was characterized by high levels of nutrient salts, where nitrate varied between 0.42 and 41.95 µg at. l^{-1}, phosphate between 1.14- 6.9 µg at. l^{-1} and silicate: 3.2 - 165.5 µg at. l^{-1} (Table 2).

Chlorophyll a sustained oftenly remarkably high concentrations, in the whole area fluctuating between a minimum of 10.6 $\mu g\ l^{-1}$ at St. I and a maximum of 124.7 $\mu g\ l^{-1}$ at St. II. Similar to the numerical density, chlorophyll a suffered from wide temporal and spacial variations, but the timing of peaks was different. At St. IV, chlorophyll a fluctuated between 14.7 and 100.5 $\mu g\ l^{-1}$, whereas at Sts. I-III it fall within the ranges 10.6-112.8 $\mu g\ l^{-1}$, 15.7-124.7 $\mu g\ l^{-1}$ and 17.0- 111.6 $\mu g\ l^{-1}$ respectively. Again, the majority of chlorophyll a peaks appeared during spring and early summer, while from mid summer to the end of October the concentrations were markedly low (Fig. 3). The temporal distribution of chlorophyll a in Boughaz area showed biweekly fluctuation between increase and decrease during the study period.

The bulk of phytoplankton density was caused mainly by few species. Diatoms and green algae appeared to be the oftenly major components. *Cyclotella meneghiniana, Nitzschia palea* and *N. closterium* were the most dominant diatoms, while *Scenedesmus quadricauda, Sc. bijugatus, Sc. acuminatus* and *Crucigenia rectangularis* dominated among the green algae. Of the other groups, the dominant species were represented by relatively low density. Some species showed flash appearance with remarkably high counts such as *Skeletonema costatum, Rhizosolenia fragilissima* and *Chaetoceros affinis.*

Species succession

The dominance of species was exposed to clear temporal and spatial variations. At the end of April, with the seaward current, diatoms formed 35-69 % of total density, with the highest contribution at the sea side (St. IV) and the lowest at the lake side (St. I). *C. meneghiniana, N. closterium* and *N. palea* dominated at Sts. I, II, and III, and *Chaetoceros affinis* at St. IV. The density of green and blue green algae increased towards the lake from 30% to 52 % and 0.5 to 13% respectively, with the dominance of *Sc. quadricauda* and *Spirulina laxissima.*

During May, diatoms appeared as the most abundant group in Boughaz area with weekly variable contributions at each station. They oftenly decreased towards the lake, except the opposite trend in the third week (Fig. 4). *C. meneghiniana* and *N. palea* were the leading forms during May. However, On 7th of May, *Rh. fragilissima* and different species of *Chaetoceros* dominated at St. IV, forming 25% and 55% respectively of the total phytoplankton density. *Sk. costatum* showed also great abundance during May at St. IV constituting 95% of total phytoplankton. On the other hand, the green alga *Sc. quadricauda* followed the dominant diatoms in abundance during May.

In June, the contributions of the algal groups were approximately similar to that found in May. Cyanophyceae played greater intermittent role during June and less so the Euglenophyceae (Fig .4). During this month, phosphate supply was also high. *C. meneghiniana, N. palea* and *N.microcephala* were the leading diatoms and *Sc. quadricauda* and *C. rectangularis* among green algae.

In the first week of July, St. I was characterized by the minimal nutrient content, particularly silica, and greatest phytoplankton density. At this station, diatoms attained the maximum count (78%) compared to other stations, also with the dominance of *C. meneghiniana.* At the other stations, ammonia was high and green algae constituted up to 52 % at St. III. In the second and third weeks the roles of green algae increased towards the sea, forming 57% and 71% respectively at St. IV. In late July (23^{rd} -30^{th}), nitrate increased concomitant with a considerable decline in phosphate. Diatoms again became the leading group, constituting 46-82% of the total density at the sampled stations with the absolute dominance of *C. meneghiniana.*

In August, green algae became again the predominant (48-87%), while diatoms mostly ranked the second abundant group with two exceptions at Sts. I & III (Fig. 4). Cyanophyceae showed intermittently pronounced contributions (up to 12 %) and were mainly represented by *Spirulina* and *Oscillatoria*. Euglenophyceans played relatively large role in August, forming 6-32 % of the total count, particularly in the second week of August.

During the first half of September, green algae were still dominant in the whole area (61-88 %), replaced alternatively in late September and October by diatoms and blue-green algae. In mid October, salinity was comparatively high (15.8-22.3 PSU) in most Boughaz area, whereas Dinophyceae formed 10- 43% respectively of total phytoplankton and was dominated by *Peridinium trochoideum* and *Prorocentrum micans*.

Species diversity

Relatively high diversity of species was recorded most time. The highest values of diversity index at the four stations were similar (3.04-3.1), while the lowest varied between 0.12 and 1.39. The range of index variations was the widest at St.IV and narrowest at St. I. Pronounced weekly variations appeared from May to July at all stations, whileas small weekly changes were detected from August to October (Fig. 5).

The species richness of phytoplankton community was characterized by high values during most of the present study, varying between a minimum of 1.11 and a maximum of 4.52 in the whole area. Beside clear spacial changes, weekly variations in species richness were also observed at each station (Fig. 5). Contradicting to diversity index, the narrowest variation range of species richness (1.72-3.25) was found at the sea side station, while the widest range (1.11-4.52) at St. III. The diversity index showed significant correlation with the species richness (r=0.392-0.5476 at n=26– 27), however, figure 5 shows direct weekly relationship between the two indices at different stations most time and inverse one in few occasions.

Cluster analysis

Cluster analysis of the most common and dominant species in Boughaz EL-Maadiya demonstrated three main groups at stations I, II and IV, while at station III no clear pattern was recognized (Figs. 6-9). Group I (A& B) oftenly comprised perennial or semi–perennial species which appeared at each station most of the study period and caused the main bulk of the total phytoplankton density. The occurrence of these species was reiterated 85-100 % of the total sampling times at St. I, 63-100 % at St. II and 63 –96 % at St. IV. There was a great similarity in species composition of group I at all stations, but their population densities and temporal peaks differed markedly (Tables 5-7).

Groups II (A, B and/or C) and III (A,B, C) included species appeared in 30 –67 % of the collected samples, but they played limited role in the phytoplankton density. Distribution of these species inside the cluster groups and the timing of their peaks showed pronounced variations between stations (Tables 5-7).

DISCUSSION

The Phytoplankton community of Boughaz El-Maadiya was typically of brackish water, which usually comprises fresh, brackish and marine forms with different contributions. Since Boughaz El- Maadiya is a connection between the seawater at Abu Qir Bay and freshwater in Lake Edku, the current regime seems to be one of the main factors controlling the community structure and abundance in the area.

The weekly field observations of the surface current during the present study revealed the prevalence of fresh water current most time.

Oppositely, the sea water intermittently invades the adjacent part of the Lake. Weekly records of salinity in Boughaz El-Maadiya demonstrated such pattern of current regime (Abdel-Aziz and Dorgham, 1999). Daily changes of current direction were observed by Mohamed (1981) indicating dominance of the seaward current.

Due to prevalence of the freshwater current, many fresh and brackish water species were found at the seaside St. IV in most collected samples. Some of these species sustained dense populations, forming relatively high percentage of the total phytoplankton count, such as *Cyclotella meneghiniana, Scenedesmus quadricauda, Nitzschia palea, N. microcephala, Cyclotella glomerata and Scenedesmus bijugatus* (Table 7).

The total number of recorded species (182spp.) indicated a rich phytoplankton community in Boughaz area. The affinities of these species reflected the dominance of fresh and brackish water forms (143 spp.) due to the prevalence of the freshwater current most time. The IBD demonstrated high similarity (75%) in the community structure along the major part of Boughaz El-Maadiya (Sts. I, II and III), and comparatively lower similarity (61-65%) with the community of the sea side station (IV). However, the abundance and distribution of the existing algal groups showed pronounced weekly variations and alteration between the sampled stations. Similar pattern was also observed in the area for zooplankton distribution and abundance (Abdel-Aziz, 1999).

Associating with the prevailing seaward current the fresh and brackish water forms, *C. meneghiniana, N. palea* and *Sc. quadricauda* were the perennial leading species in the whole area. But with the Lakeward current, some marine species dominated the phytoplankton in certain occasions, particularly at St. IV, such as *Rhizosolenia fragilissima, Chaetoceros affinis* and *Skeletonema costatum.* The abundance of *C. meneghiniana* and *Sk. costatum*. in the area is an indication of eutrophication and low salinity waters (Smith and White, *1985; Werner, 1977; Mihnea, 1985;* Caroppo and Cardellicchio, 1995, Dorgham *et al*., 1987 and Dorgham, 1997).

The high concentrations of nutrient salts led to intensive growth of phytoplankton with average density of $1.94x10^6$ units/L and chlorophyll a of about 48 □g/L. These conditions are strong evidence of eutrophication in the study area, which may be related to similar conditions in Lake Edku (Gharib and Soliman, 1998). Both phytoplankton density and chlorophyll a concentration in Boughaz El-Maadiya suffered from wide temporal and spacial fluctuations, regardless of nearness of the sampled stations and shortness of the time intervals. Alternative biweekly increase and decrease of both parameters was the dominant pattern at all stations. Such pattern revealed a strong relationship between the current regime and the quick temporal variations of phytoplankton abundance in Boughaz El-Maadiya. It was frequently observed that, peaks timing of chlorophyll a did not coincide with those of total phytoplankton density, and the correlations between the two variables were mostly insignificant. However, signifacnt correlation was found between chlorophyll a and density of the green algae, which are usually characterized by higher chlorophyll content. This may indicate the role of phytoplankton composition in such correlation.

It could be generally supposed that, weekly abundance of phytoplankton in Boughaz El-Maadiya is intimately related to analogous variations occuring in both Abu Qir Bay and Lake Edku, but with irregular distribution in Boughaz area due to rapid changes of the current direction. Instability of the ecological conditions was the characteristic feature of Boughaz area (Abdel-Aziz and Dorgham, 1999). These short time variations were not recorded by Gharib (1983) and Gharib and Soliman (1998). This may explain the flourishing of Cyanophyceae and

Euglenophyceae in Boughaz area during summer. Cyanophyceae usually prefer the warm waters (Tilman and Kiesling, 1984; Komarkova and Hejzlar, 1996) and they are more characteristic to eutrophic waters than oligotrophic (Lund, 1969; Wetzel, 1975; Trimbee and Prepas, 1987).

Phytoplankton density showed significant correlations with the ecological parameters, especially salinity, temperature and secchi-depth. Such type of correlations did not demonstrate the actual effect of those parameters on the phytoplankton abundance, since the existing phytoplankton populations in Boughaz area at a certain time actually represent those of the lake and sea at that time. Consequently, the abundance and structure of phytoplankton community in Boughaz El-Maadiya is exposed to frequent changes at short time intervals and the dominance of species is controlled by the prevalence of either lakeward or seaward current in the area. However, phytoplankton density was significantly correlated with dissolved oxygen, which is a biproduct of the photosynthesis. Such process occurs wherever the phytoplankton exist regardless of the ecological conditions.

Species diversity and richness were mostly high in Boughaz El-Maadiya. Both indices showed pronounced weekly variations at the different stations reflecting rapid changes in the community structure. The highest richness at St. III may be resulted from aggregation of both freshwater and marine species in convergent area frequently formed at this station, due to confronting of the two noncoherent currents (Abdel–Aziz and Dorgham, 1999). On the other hand, the lowest species richness and highest diversity at St. IV may indicate the effect of the prevailing freshwater current on the marine phytoplankton and the increase of abundance of fresh water species. Whileas the lowest diversity of species at St. I may be attributed to the increase of the marine assemblage numbers carried in by the lakeward current. Margalef (1978) and

Reynolds (1980) supposed that nutrients and water column stability are the major environmental factors controlling phytoplankton diversity and seasonal succession. In the present study, nutrients were sufficiently high and therefore, the water column stability may be one of the factors influencing the diversity and species richness in Boughaz El– Maadiya. This was also in agreement with the observations of several authors (Jones, 1977; Harris and Piccinin, 1977; Harris, 1980; Haffner *et al.*, 1980; Wall and Briand, 1980). Structure and abundance of the phytoplankton community of Boughaz El–Maadiya is tightly related to those of the Sea and Lake and is oftenly controlled by the mixing of the sea and Lake waters. Margalef (1960) admitted that, the diversity index would be higher when two different communities mix together. A good relation was found between the diversity index and species number in Boughaz El-Maadiya. The low values of diversity index were accompanied by the dominance of one or two species and low richness, while high diversity coincided with the dominance of several species and high richness. This phenomenon was observed at all stations. In some occasions, the inverse relationship between diversity and richness may be attributed to the disturbance in the community structure caused by the current regime. Karentz and McIntire (1977) stated that the number of species and the degree of evenness are closely related to the species diversity.

The differences in structure of the cluster groups between very close stations at short time intervals may also reflect rapid changes of the current direction and consequently instability of the ecological conditions and of phytoplankton community structure and abundance.

ACKNOWLEDGEMENT

The authors are deeply grateful to Dr. Mamdouh Fahmy, Associate Professor of Marine chemistry, National Institute of Oceanography and Fisheries, Alexandria, for nutrients data.

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Table(1) :Numbers of genera and species of different groups at the sampled stations .

Groups	Station I		Station II		Station III		Station IV	
	Genus	Species	Genus	Species	Genus	Species	Genus	Species
Bacillariophyceae	26	53	20	42	21	49	30	62
Chlorophyceae	23	40	21	41	22	40	19	35
Cyanophyceae	15	24	14	26	16	27	10	21
Dinophyceae	5	7	6	10	4	6	6	11
Euglenophyceae	3	13	4	12	4	12	2	11

Table(2) : Variation ranges and average values of physico-chemical parameters at different stations inBoughaz El-Maadiya during the period April – October ,1997.
(After Abdel-Aziz & Dorgham. 1999 and Fahmy, personal communication).

Parameter		Station I	Station II	Station III	Station IV
Temperature (°C)	range	19.5-28	19.5-28	19 - 27	19-27
Secchideph (cm)	range	35 - 80	30 - 90	30 - 90	30-100
dissolved oxygen (mlO_2.l^{-1})	range	2.01-4.71	1.95-5.89	1.92-5.54	1.92-4.89
Salinity	range	0.84-27.64	0.84-30.19	0.84-33.81	1.11-35.69
(PSU)	mean	3.168	4 . 804	5.202	10.558
pH	range	7.73-8.77	7.72-8.85	7.61-8.81	7.51-8.67
	mean	8.269	8 . 226	8.316	8.238
Nitrate	range	0.42-41.52	2.57-41.95	3.56-37.81	0.08-36.49
μ gat.l^{-1}	mean	26. 776	21.502	21.099	17.665
Nitrite	range	0.99-14.08	0.21-16.81	0.69-16.84	0.32-9.15
μ gat.l^{-1}	mean	6 .95	4.72	5.14	4.227
Ammonia	range	0.0-69.9	0.4-10.30	0.4-10.25	0.4-9.90
μ gat.l^{-1}	mean	9.553	5.142	5.368	5.758
Phosphate	range	1.14-6.90	1.26-5.7	1.2 - 6.3	1.26-5.28
μ gat.l^{-1}	mean	4 . 218	3.063	3.705	3.318
Silicate	range	3.2-163.5	24.1-164.1	28.8-153.5	23.3-165.5
μ gat .l^{-1}	mean	93 . 575	99.33	99.31	95.43

Table (3):Percentage of the different algal groups in the phytoplankton population at different stations.

Groups	*Station I*	*Station II*	*Station III*	*Station IV*
Bacillariophyceae	54.9	54.4	67.1	81.6
Chlorophyceae	40.6	41.8	29.6	16.3
Cyanophyceae	3.0	2.5	2.0	1.2
Dinophyceae	0.3	0.4	0.3	0.6
Euglenophyceae	1.2	0.9	1.0	0.3

Table(4):-Correlation coefficients between phytoplankton abundance and physico-chemical parameters.
•significant at p=0 1.~:p=0 05,?:p=0.02,!:p=0. 01.O:0.001

	Station I	Station II	Station III	Station IV
cell counts and chlorophyll	~0.414	O0.6523	0.2362	0.1325
counts of diatoms and chl.	~0.4163	O0.6427	0.2068	0.1074
Counts of green algae and chl.	•0.393	O0.6239	•0.3348	•0.3596
Counts of blue green and chl.	•0.3561	0.3632	0.2322	0.2408
cell counts and Secchidisc	-0.167	-0.1886	-0.1755	-0.0871
Total count and salinity	-0.047	-0.2287	-0.0045	-0.1607
Counts of diatoms and salinity	-0.0733	-0.1904	-0.0184	-0.144
Counts of green algae and salinity	-0.1365	-0.2645	0.0905	-0.2053
Counts of blue-green algae and salinity	-0.1853	~0.3484	-0.2559	-0.2975
counts of Euglenophyceae and salinity	-0.2322	-0.2917	-0.2454	~0.4418
counts of Dinophyceae and salinity	0.2188	!0.514	0.2599	0.0806
counts of diatoms and oxygen	!0.6197	O0.6924	!0.5561	•0.3412
counts of green algae and oxygen	O0.6749	O0.7701	?0.5126	!0.5762
counts of blue-green algae and oxygen	O0.7242	0.3241	•0.4361	0.237
counts of Euglenophyceae and oxygen	0.3154	0.1876	-0.0869	-0.0391
counts of Dinophyceae and oxygen	-0.2058	-0.2549	-0.1123	0.1507
Total counts and oxygen	O0.6619	O0.7415	!0.5656	•0.3861
Counts of diatoms and silicate	-0.3173	-0.2425	-0.0367	•-0.4163
Counts of green algae and silicate	-0.174	-0.302	-0.2045	0.0374
counts of blue-green algae and silicate	-0.1707	-0.0107	0.1161	0.1314
counts of Euglenophyceae and silicate	-0.3095	-0.1775	-0.0377	0.2770
counts of Dinophyceae and silicate	0.0617	-0.1042	0.0405	-0.0109
Total counts and silicate	-0.2916	-0.2647	0.0897	-0.2373
Counts of diatoms and ammonia	-0.1175	-0.0091	-0.1555	-0.179
Counts of green algae and ammonia	-0.2181	0.265	-0.0575	-0.0831
Counts of blue-green algae and ammonia	-0.2601	0.265	0.0915	0.1856
Counts of Euglenophyceae and ammonia	-0.1124	0.0919	0.3776	0.3229
Counts of Dinophyceae and ammonia	-0.306	0.2137	0.3134	-0.230
Total counts and ammonia	-0.1553	-0.1728	-0.1187	-0.1497
Counts of diatoms and nitrite	-0.275	0.0699	-0.0903	!-0.5707
Counts of green algae and nitrite	0.0313	0.0975	-0.2529	-0.3361
Counts of blue-green algae and nitrite	•-0.3858	-0.0024	-0.0881	-0.1069
Counts of Euglinophyceae and nitrite	-0.1089	0.206	-0.1285	-0.1069
Counts of Dinophyceae and nitrite	0.0306	0.0233	-0.1413	0.0848
Total counts and nitrite	-0.2032	-0.0871	-0.1466	-0.1274
Counts of diatoms and nitrate	~-0.4511	0.0744	-0.1207	?-0.5316
Counts of green algae and nitrate	-0.1953	-0.1957	-0.2477	-0.3005
Counts of blue-green algae and nitrate	-0.1865	-0.2661	-0.0116	-0.0677
Counts of Euglenophyceae and nitrate	0.0928	0.1739	0.1559	0.2971
Counts of Dinophyceae and nitrate	0.1362	-0.0946	?-0.5420	0.2017
Total counts and nitrate	•-0.3874	-0.2102	-0.1618	-0.462
counts of diatoms and phosphate	- 0.349	-0.3692	- 0.2839	-0.2364
counts of green algae and phosphate	- 0.3689	-0.2959	+-0.4852	-0.3157
counts of blue green algae and phosphate	- 0.184	-0.3455	- 0.4344	-0.0836
counts of Euglenophyceae and phosphate	0.0572	0.0666	- 0.0140	0.2519
counts of Dinophyceae and phosphate	- 0.1107	-0.208	- 0.0632	0.0281
Total counts and phosphate	- 0.362	-0.3595	- 0.3562	- 0.2942

Table (5).Species composition of the main groups of Dendrogram given for St.I in (Fig.6), their frequency of occurrence, contribution to total count and timing of peaks.

Species	Frequency of times	% of total count	Timing of peaks
I A			
Scenedesmus quadricauda	27	13.8	May, June, July, Aug, Sep., Oct.
Sc. Bijugatus	27	3.6	June, July, Oct.
Cyclotella meneghiniana	26	20.1	May, July
Crucigenia rectangularis	26	4.6	June, Oct
Selenastrum gracile	26	1.9	May, June, Oct
Nitzschia palea	26	15.3	May, June, Oct.
N. closterium	24	7.0	May, Oct.
Actinastrum hantzschii	23	4.3	June, July
I B			
Kirchneriella contorta	19	0.5	April, May
Chroococcus minutus	18	0.4	April May, June
Scenedesmus acuminatus	20	1.5	April, May, June, Oct.
Tetraedron minimum	20	0.4	June, July
Crucigenia quadrata	21	0.7	June, Aug., Oct.
Kirchneriella lunaris	19	0.4	April, May, Oct.
Tetraedron muticum	16	0.4	June, July
Microcystis aeruginosa	17	0.1	June
Ankistrodesmus falcatus	23	0.7	April, May, June
Oscillatoria limnetica	23	0.6	April, June, July, Oct.
Chroococcus dispersus	21	0.5	May, July
Gymnodinium sp.	21	0.2	July, Aug., Sept., Oct.
Spirulina laxissima	21	0.5	April, Sep., Oct.
Crucigenia tetrapedia	18	1.6	April., Oct.
II			
Pediastrum duplex	16	1.0	April, May, June, July
Coelastrum microporum	14	1.2	April, June, July
Pleurosigma macrum	14	0.2	July
Scenedesmus dimorphus	14	1.3	June, July, Oct
Nitzschia microcephala	18	1.9	April, May, Oct
Navicula gregaria	18	1.4	May, June
Cyclotella glomerata	16	5.7	May, June, July, Oct
Pediastrum tetras	12	0.4	April, June
Chlorella vulgaris	15	0.4	June, Oct
III A			
Navicula gracilis	8	0.1	May
Amphiprora paludosa	10	0.6	July
Synedra ulna	11	0.2	May
Euglena caudata	13	0.1	July, Oct
Navicula creptocephala	8	0.1	July, Oct.
III B			
Oocystis borgei	10	0.3	Oct.
Euglena ehrenbergi	11	0.1	Aug., Oct.
Euglena acus	16	0.4	July, Aug., Oct.
Phacus curvicauda	13	0.1	July, Aug., Oct.
Oscillatoria irrigua	9	0.1	July, Aug.
Phacus longicauda	10	0.1	July, Oct.
III C			
Pediastrum simplex	8	0.3	April, May, Sept.
Merismopedia punctate	8	0.1	May, June
Anabaenopsis acicularis	9	0.1	April, Oct.
Dactylococcopsis acicularis	11	0.1	April, Aug., Oct
D. irregularis	11	0.1	April, July, Aug

Table (6).Species composition of the main groups of Dendrogram given for St.II in (Fig.7), their frequency of occurrence, contribution to total count and timing of peak.

Species	Frequency of times	%of total count	Timing of peaks
I A			
Cyclotella meneghiniana	27	23.6	May . July
Scenedesmus quadricauda	27	14.1	May
Selenastrum gracil	27	1.6	April,May,June,Oct.
Scenedesmus bijugatus	26	4.4	April,May,June,July,Aug.,Sept .
Nitzschia palea	25	16.8	April,May,June,July
Actinastrum hantzschii	26	4.1	May. July . Aug.
Ankistrodesmus falcatus	24	0.6	July
Chroococcus dispersus	25	0.4	May .July . Oct
Crucigenia rectangularis	24	4.7	May. June. Sept . Oct.
Tetraedron minimum	23	0.4	June,July. Oct
Spirulina laxissima	22	0.5	April . Sept . Oct
Oscillatoria limnetica	24	0.5	April .June. July. Aug . Sept
Scenedesmus acuminatus	22	1.8	May,June .July. Oct.
Crucigenia tetrapedia	22	1.3	April,June.Aug .Sept.,Oct
Nitzschia closterium	22	4.1	April. May. June
Navicula gregaria	22	0.7	May. June. Sept
Nitzschia microcephala	17	3.7	April. May. June. July
I B			
Crucigenia quadrata	22	1.3	April. May. June . Oct.
Kirchnerlella lunaris	16	0.4	April. June
Sphaerocystis schroeteri	17	0.7	May. June . July
II A			
Pediastrum simplex	9	0.6	April ,May. June
Chlorella vulgaris	15	0.2	Sept.
Oocystis borgei	10	0.2	July
II B			
Nitzschia apiculata	8	0.1	July
Phacus longicauda	10	0.04	July
Anabaenopsis circularis	9	0.01	July. Aug
Euglena ehrenbergi	13	0.1	July. Aug
Phacus curvicauda	10	0.02	July
Tetraedron caudatum	11	0.1	June
Euglena caudata	16	0.2	Oct
E . granulata	14	0.2	April. Aug . Sept
E . acus	16	0.3	July . Aug . Oct
II C			
Staurastrum cuspidatum	11	0.1	June. Oct
Dactylococcopsis acicularis	13	0.1	July. Oct
Merismopedia punctata	10	0.1	July
Navicula creptocephala	10	0.1	May. Oct
Synedra ulna	12	0.1	April. May
Nitzschia frustulum	10	0.2	May
Pleurosigma macrum	14	0.1	Aug.
Microcystis aeruginosa	20	0.3	April. May . July
Navicula elliptica	8	0.1	Oct
III A			
Scenedesmus dimorphus	17	0.8	June. July
Kirchneriella contorta	18	0.4	June. July
Chroococcus minutus	16	0.2	June
III B			
Tetraedron muticum	13	0.2	June
Pediastrum tetras	11	[illegible]	June. July. Sept
Gymnodminum sp.	17	0.2	June July. Oct

Table(7).Species composition of the main groups of Dendrogram given for St.IV in (Fig.9), their frequency of occurrence, contribution to total count and timing of peak.

Species	Frequency of times	%of total count	Timing of peaks
IA			
Cyclotella meneghiniana	25	8.0	April,May,June,July,Sept.,Oct
Scenedesmus quadricauda	26	5.7	May
Nitzschia palea	24	7.9	May, June
N. closterium	24	1.7	April,May,June,July,Sept
Scenedesmus bijugatus	24	1.6	July
Actinastrum hantzschii	20	1.3	July , Aug.
Selenastrum gracile	25	1.0	July, Oct.
Kirchneriella contorta	22	0.3	April, May
Crucigenia rectangularis	21	1.0	May,Sept.
Oscillatoria limnetica	22	0.3	Oct.
Ankistrodesmus falcatus	23	0.2	May, Oct.
Spirulina laxissima	20	0.4	May,Sept.
Crucigenia quadrata	20	0.8	May,Sept.
Scenedesmus acuminatus	21	0.7	May, Oct.
Crucigenia tetrapedia	17	0.7	Oct.
Kirchneriella lunaris	18	0.1	Sept.,Oct.
Tetraedron minimum	20	0.1	June
I B			
Scenedesmus dimorphus	16	0.3	May
Coelastrum microporum	15	0.6	May, June
Nitzschia microcephala	18	2.2	May,June, July, Oct.
Cyclotella glomerata	15	1.7	May,July, Sept.
Sphaerocystis schroeteri	10	0.5	July
II			
Navicula elliptica	8	0.3	Oct.
Pleurosigma macrum	9	0.1	July
Navicula gregaria	13	0.2	May,June
Euglena acus	13	0.1	Oct.
E. caudata	10	0.04	Oct.
Staurastrum cuspidatum	8	0.01	Oct
Gymnodinium sp.	16	0.1	Oct
III A			
Nitzschia sigma	9	0.05	May, July
Biddulphia rhombus	9	0.05	June,July
Pediastrum duplex	9	0.1	May
III B			
Navicula creptocephala	11	0.04	May, Oct
Synedra ulna	8	0.02	Oct.
Navicula mutica	10	0.1	May,Oct.
Dactylococcopsis acicularis	9	0.01	July
Phacus curvicauda	8	0.02	Aug.
Tetraedron caudatum	10	0.03	Sept.
Anabaenopsis circularis	8	0.01	Sept.
III C			
Chlorella vulgaris	13	0.1	Oct.
Euglena granulata	17	0.1	Aug.
Pediastrum tetras	9	0.2	July
Oocystis borgei	10	0.2	July
Chroococcus dispersus	18	0.1	May, July
Microcystis aeruginosa	10	0.03	May
Ankistrodesmus falcatus	23	0.2	July, Oct
Chroococcus minutus	10	0.1	July
Tetra[illegible] *muticum*	13	0.05	July

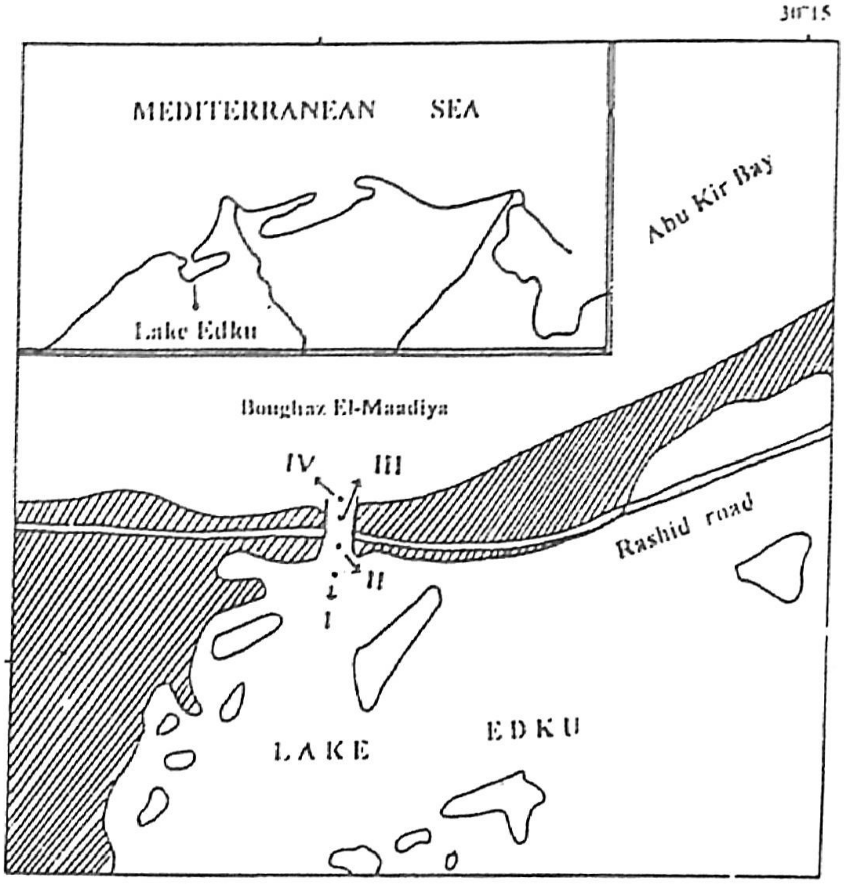

Fig.1.The study area and positions of sampling stations.

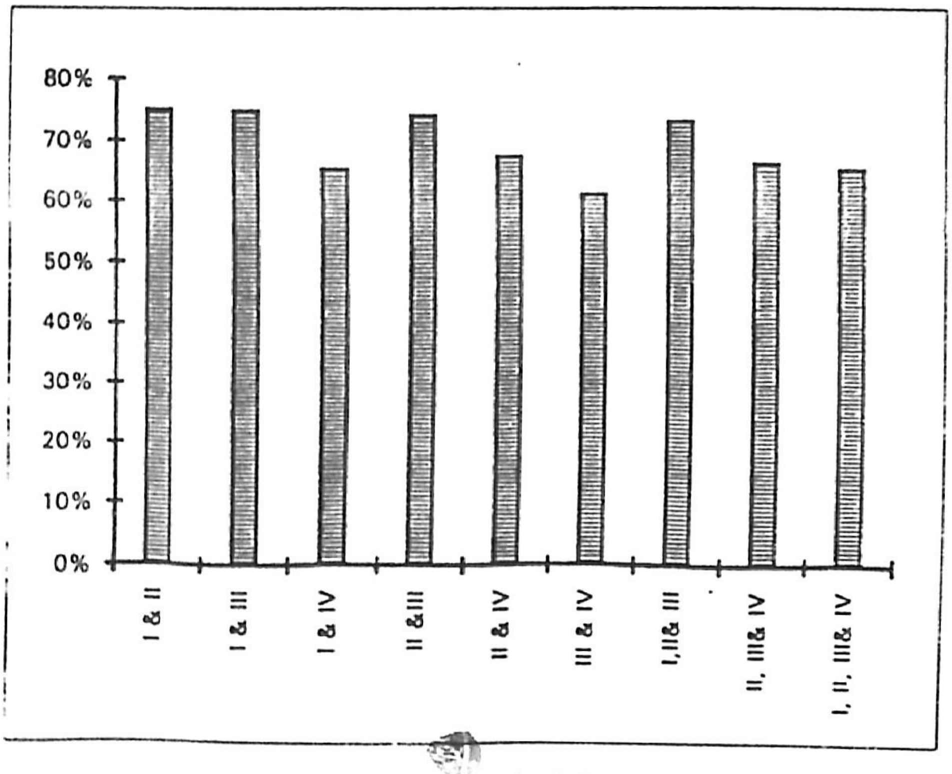

Fig 2- Variations of Index of Biotal dispersity (IBD) for phytoplankton communities at different stations

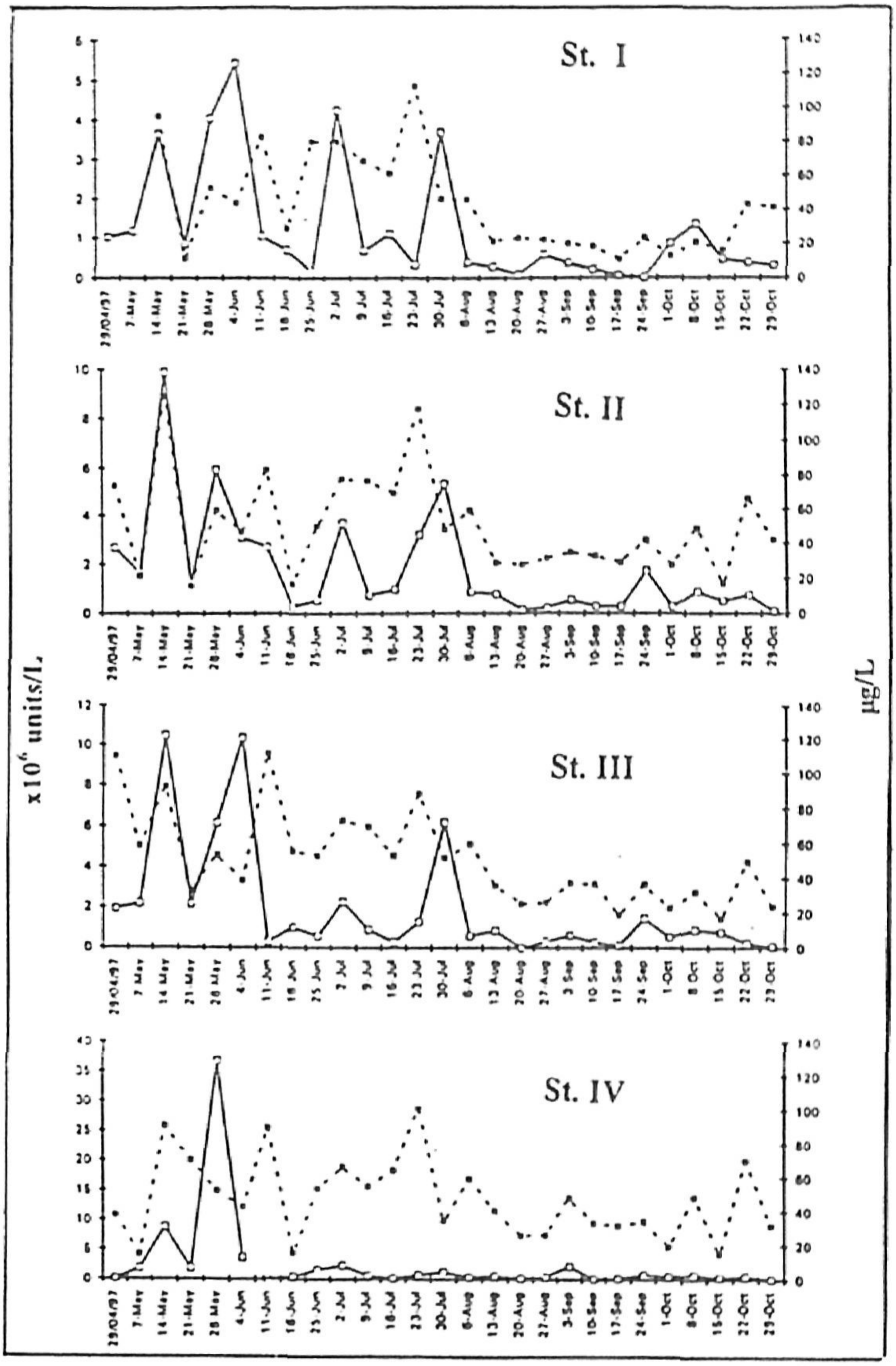

Fig. 3- Weekly records of phytoplankton crop at different stations
.... Chlorophyll a, o—o density

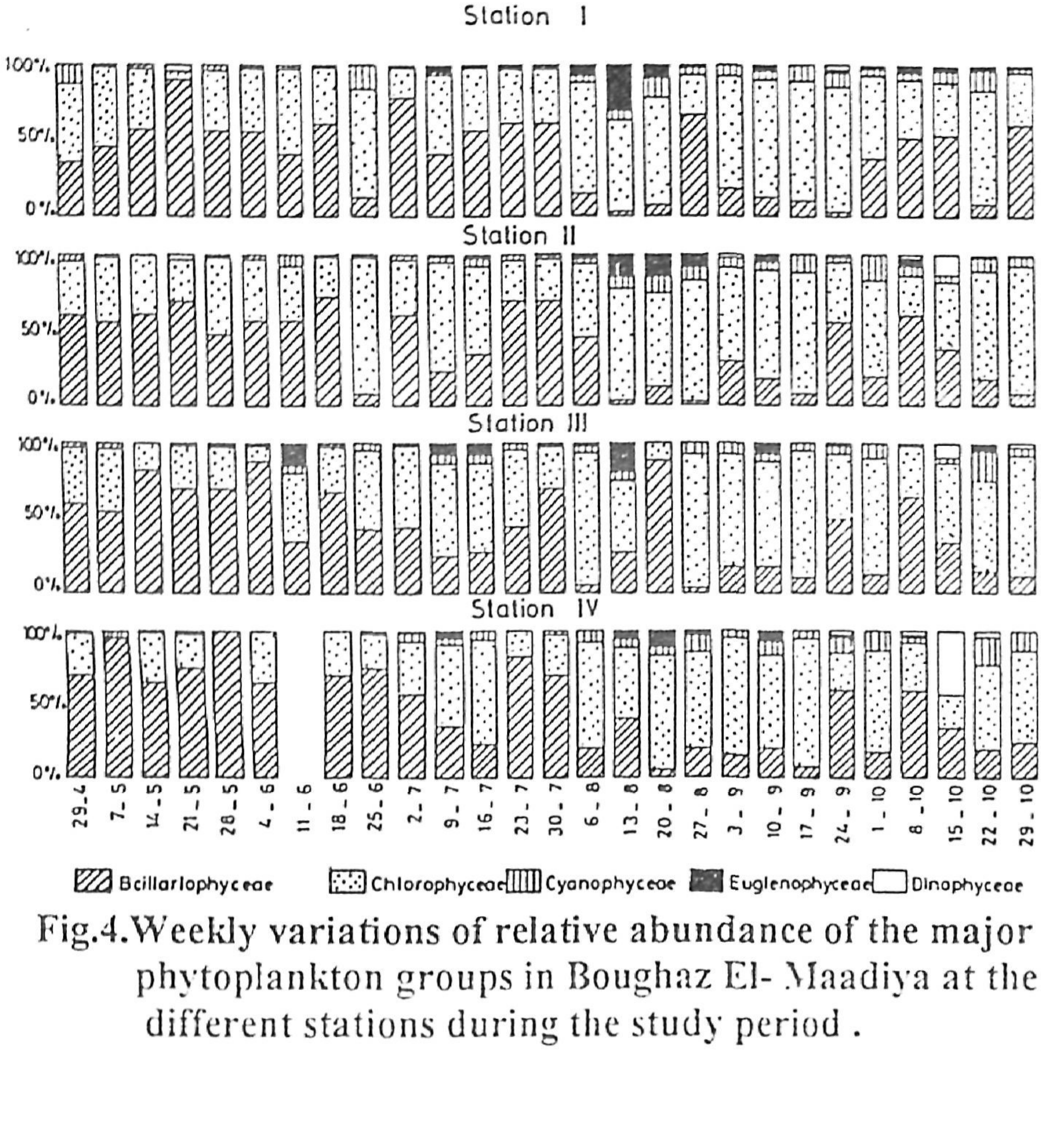

Fig.4.Weekly variations of relative abundance of the major phytoplankton groups in Boughaz El- Maadiya at the different stations during the study period .

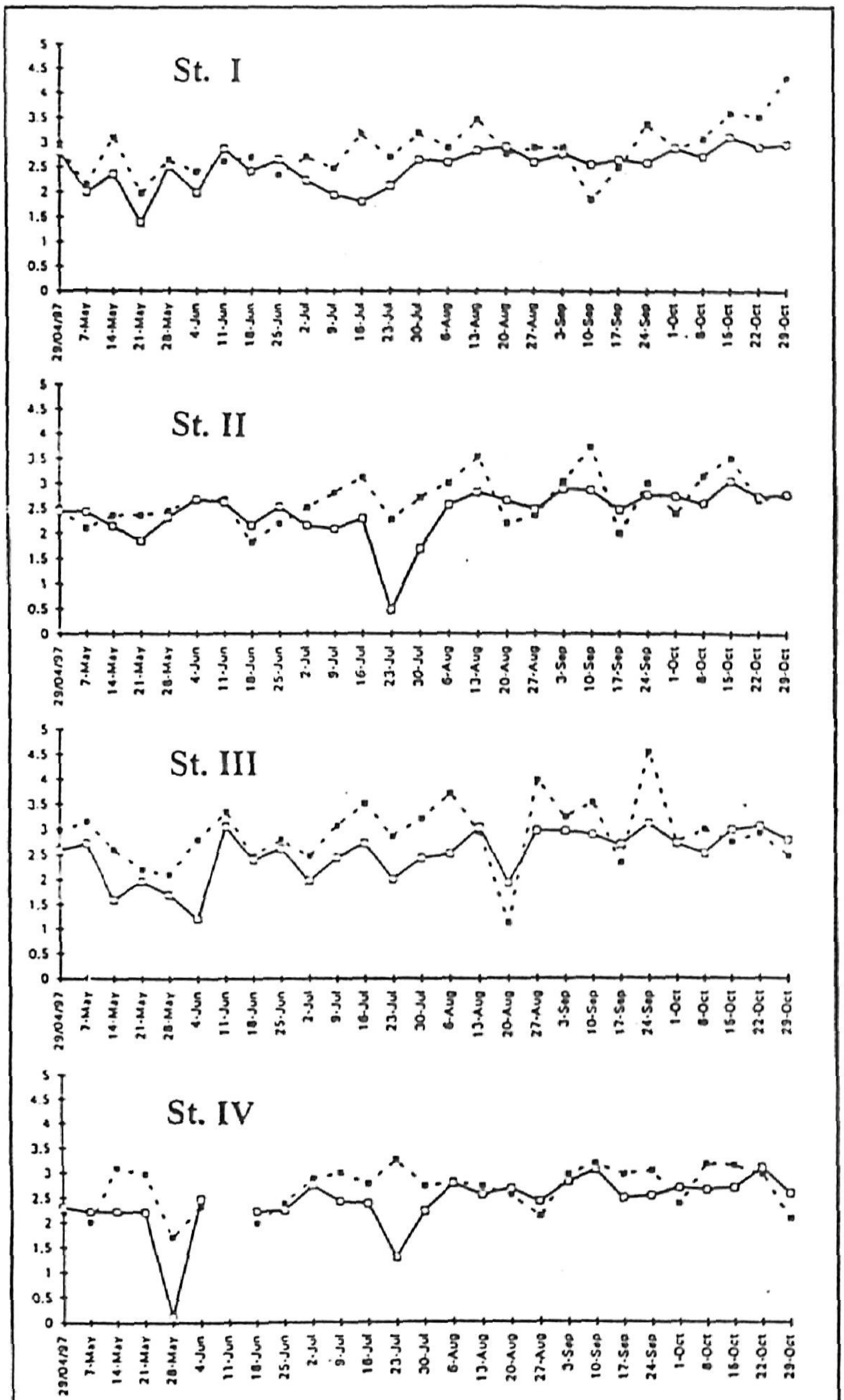

Fig. 5- Weekly values of diversity index (o———o)
and species richness (• - - - - - •) at different stations.

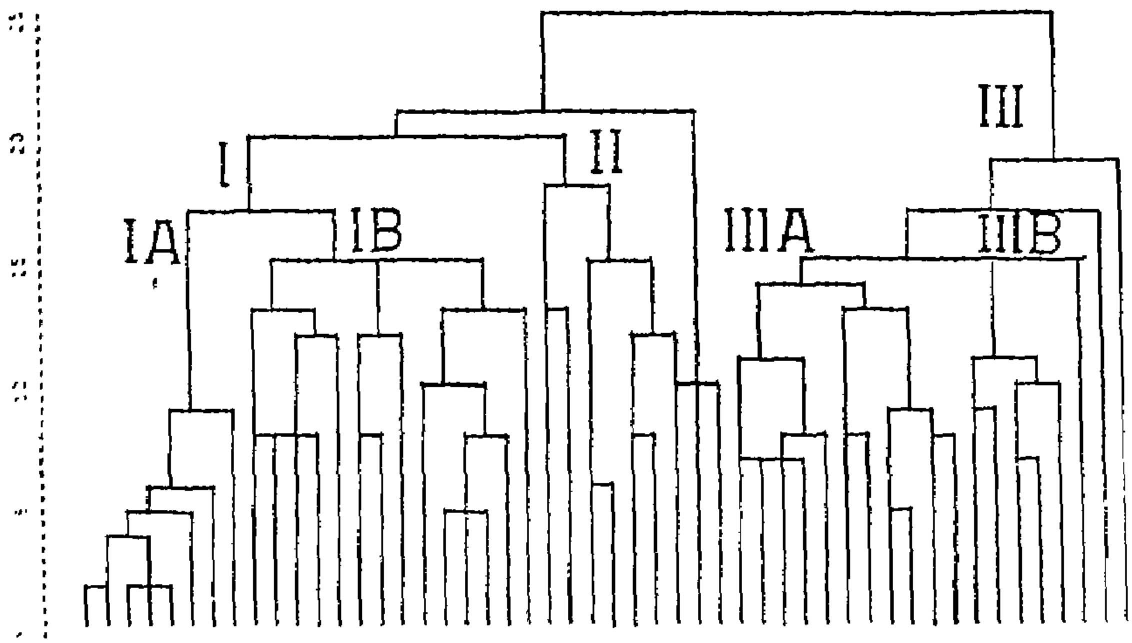

Fig.6 Dendrogram of classification of the main groups at station I .

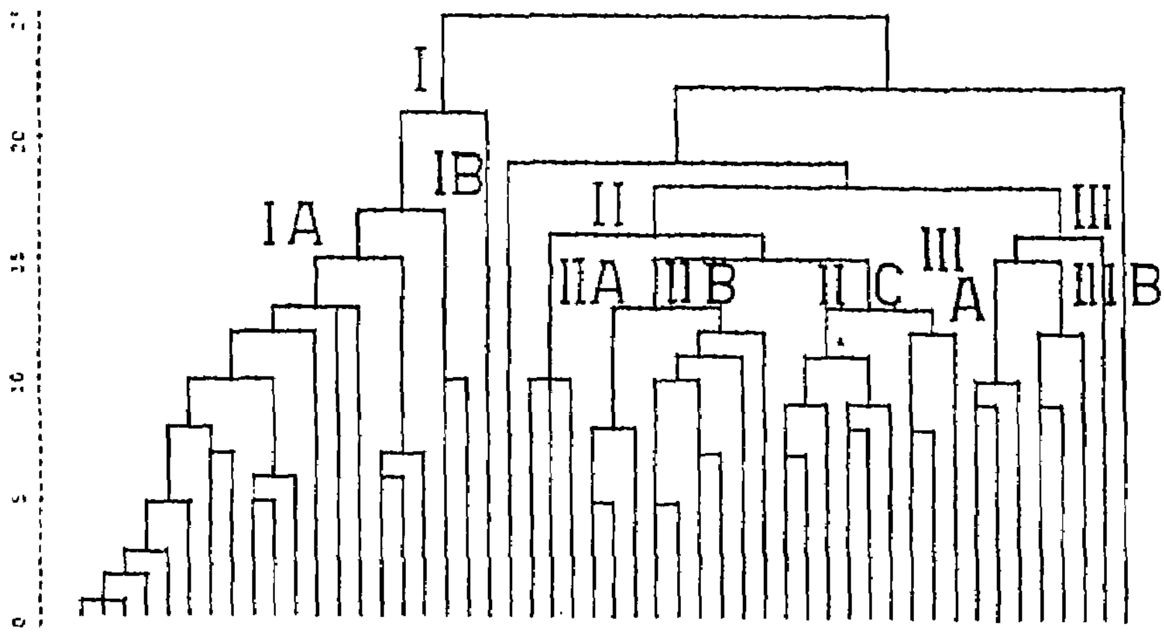

Fig.7.Dendrogram of classification of the main groups at station II .

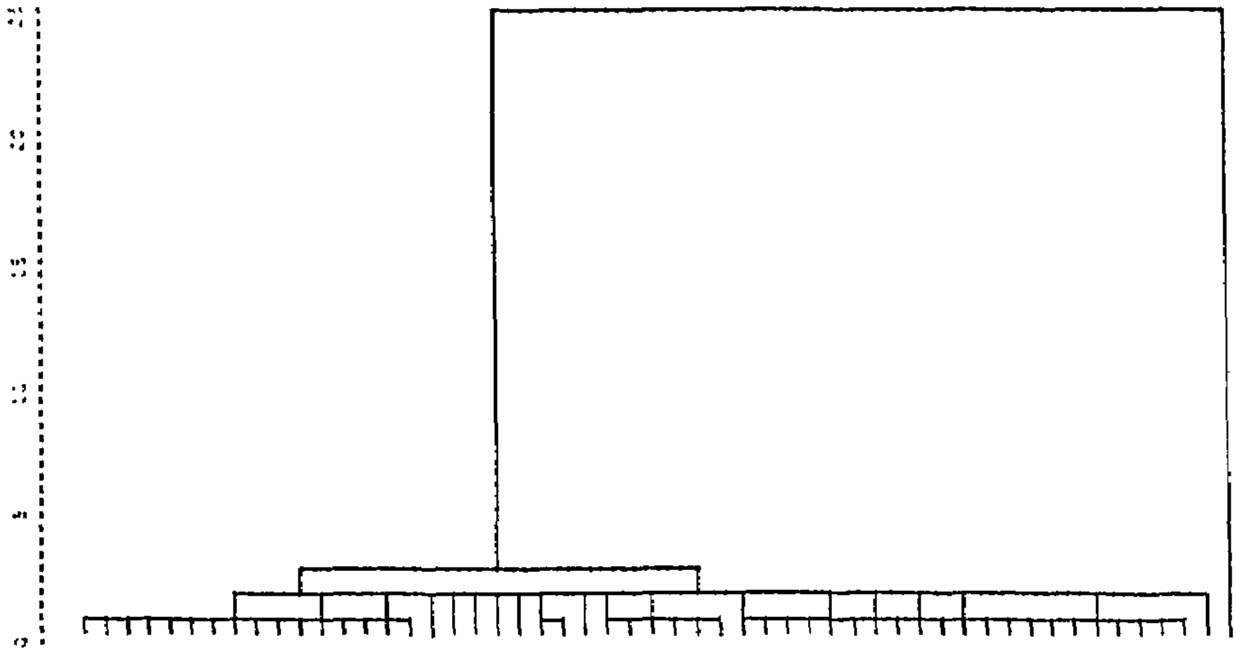

Fig.8.Dendrogram at station III.

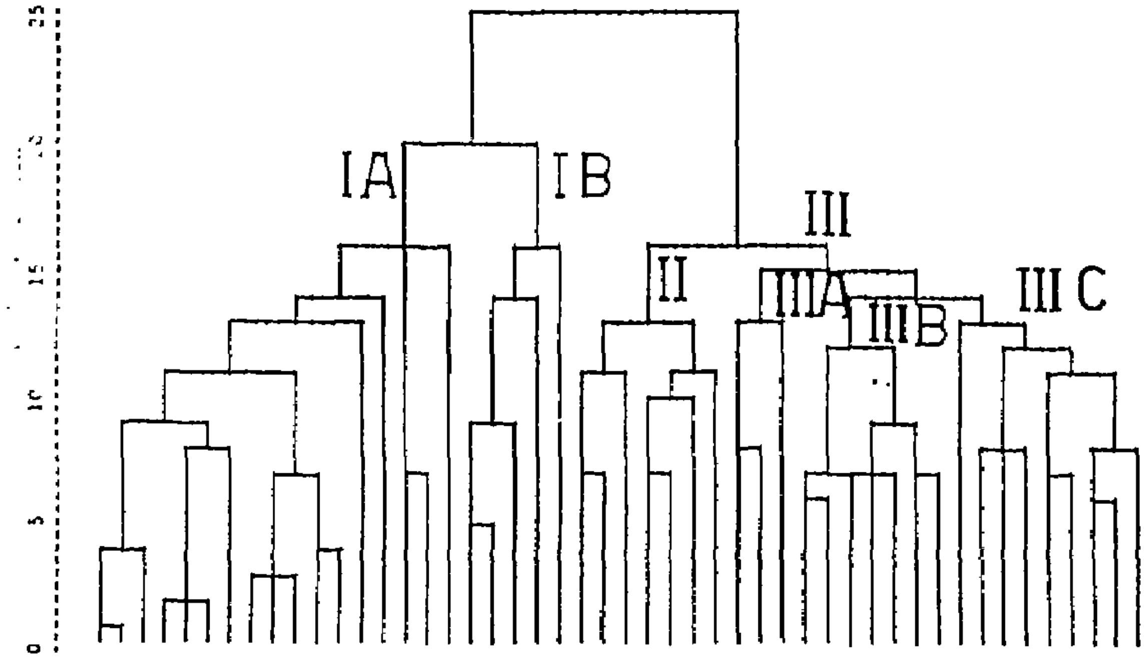

Fig.9 Dendrogram of classification of the main groups at station IV.