Chapter 5
Phytoplankton

5.1. SPECIES DIVERSITY

Fish production in Egypt depends largely on the Egyptian shallow water bodies such as Lake Burullus. The role of phytoplankton as a main source of fish nutrition is well known, and in order to develop the fish economy it is necessary to study well the phytoplankton and the factors affecting its standing crop and productivity. Lake Burullus was investigated limnologically (e.g. Darrag 1974, 1983) and phytoplanktonically (e.g. Kobbia 1982, El-Sherif and Aboul Ezz 1988, Samaan *et al*. 1988, El-Sherif 1989, El-Sherif 1993, Zalat and El-Sheekh 1999, Radwan 2002).

The phytoplankton community of Lake Burullus is considered rich, both in density and species richness, but most of the species are fresh or brackish water forms. From the survey of the literature on phytoplankton assemblages of Lake Burullus, there is a large variation among the researchers in the species composition and density depending on the surveyed station, water depth, sampling season, water quality, environmental condition and water pollution of the lake (Tables 5.1, 5.2, 5.3). For example, Kobbia (1982) recorded 49 species belonging to 6 algal divisions (during one year at three stations and different depths): 14 species of Chlorophyta, 19 of Cyanophyta, 12 of Bacillariophyta, 2 of Cryptophyta, and one species for each of Chrysophyta and Dinophyta. On the other hand, El-Sherif (1993) recorded 113 species distributed among algal divisions as follows: 52 species of Bacillariophyta, 41 of Chlorophyta, 15 of Cyanophyta, 2 of Euglenophyta (*Phacus setosa* France and *Euglena granulata*

(Klebs) Lemm.), 2 of Dinophyta (*Gymodinium* and *Peridinium* spp.) and one Cryptophyta (*Cryptomonadales* sp.).

Table 5.1. **List of Bacillariophyta (i.e. Diatoms) recorded in Lake Burullus (after Kobbia 1982, El-Sherif *et al*. 1989 and Zalat & El-Sheekh 1999).**

Species	Kobbia (1982)	El-Sherif *et al*. (1989)	Zalat & El-Sheekh (1999)
Division: Bacillariophyta			
Class: Bacillariophyceae			
A- Subclass: Centrales			
Order: Aulocosirales			
Family: Aulocosiraceae			
1- *Aulocoseira ambigua* (Grunow) Simonsen	-	-	+
2- *Aulocoseira distans* (Ehre.) Simonsen	-	-	+
3- *Aulocoseira granulata* (Ehre.) Simonsen	-	-	+
4- *Aulocoseira granulata var. angustissima* Simonsen	-	-	+
5- *Aulocoseira islandica* Simonsen	-	-	+
6- *Aulocoseira italica* (Ehre.) Simonsen	-	-	+
7- *Aulocoseira* sp.	+	+	-
8- *Aulocoseira varians* Agardh	-	+	-
Order: Bidulphiales			
Family: **Bidulphiaceae**			
9- *Bidulphia laevis* Ehrenberg	-	+	-
10- *Hyalodiscus laevis* Ehrenberg	-	+	-
11- *Plagiogramma interruptum* (Gregory) Ralfs	-	-	+
12- *Podosira montagnei* Kützing	-	+	-
Family: **Thalassiosiraceae**			
13- *Cyclotella kutzingiana* Thwaites	+	-	+
14- *Cyclotella meneghiniana* Kützing	-	+	+
15- *Stephanodiscus minutulus* (Kützing) Grunow	-	-	+
16- *Thalassiosira rotula* Menu.	-	+	-
17- *Thalassiosira* sp.	-	-	+
B- Subclass: Pennales			
Order: Fragilariales			
Family: Fragilariaceae			
18- *Asterionella japonica* Cleve	-	+	-
19- *Fragilaria brevistriata* Grunow	-	-	+
20- Fragilaria construens (Ehrenberg) Grunow	+	-	-

Table 5.1. Cont. 1.

Species	Kobbia (1982)	El-Sherif *et al.* (1989)	Zalat & El-Sheekh (1999)
21- *Fragilaria pinnata* Ehrenberg	-	-	+
22- *Synedra nana* Meister	-	-	+
23- *Synedra tabulata*(Agardh) Kützing	-	+	+
24- *Synedra ulna* (Nitzsch) Ehrenberg	+	+	+
25- *Synedra reumpens* Kützing	-	+	-
26- *Tabellaria flocculosa* (Rapenhorst) Kützing	+	-	-
Order: : Achanthales			
Family: Achanthaceae			
27- *Achnanthes brevipes* Agardh	-	-	+
28- *Cocconeis placentula* Ehrenberg	-	+	-
29- *Cocconies sp.*	+	-	-
30- *Rhoicosphenia curvata* Grunow	-	+	-
Order: : Naviculales			
Family: Naviculaceae			
31- *Amphiprora paludosa* Smith	-	+	-
32- *Amphiprora surireeoides* Henedy	-	-	+
33- *Caloneis bacillium* (Grunow) Cleve	-	-	+
34- *Calonies silicula* Cleve	-	+	-
35- *Diploneis didyma* Ehrenberg	-	+	-
36- *Diploneis elliptica* (Kützing) Cleve	-	-	+
37- *Gyrosigma attenuatum* Kützing	-	-	+
38- *Mastogolia braunii* Grunow	-	+	-
39- *Mastogolia elliptica* (Agardh) Cleve& Schmidt	-	+	-
40- *Mastogolia smithii* Thwaites	-	+	-
41- *Navicula atomus* Kützing	+	-	+
42- *Navicula cincta* (Ehrenberg) Ralfs	-	-	+
43- *Navicula cocconeiformis* Gregory	-	-	+
44- *Navicula cryptocephala* Lange-Bertalot	-	+	+
45- *Navicula cuspida* Kützing	-	+	+
46- *Navicula decussis* Ostrub	-	-	+
47- *Navicula digitatoradiata* Gregory	-	-	+
48- *Navicula gastrum* Ehrenberg	-	-	+
49- *Navicula gracilis* Ehrenberg	-	+	-
50- *Navicula gregaria* (Ralss) N. Britchard	-	+	-
51- *Navicula humerosa* Breb.	-	+	-
52- *Navicula mutica* Kützing	+	-	-

Table 5.1. Cont. 2.

Species	**Kobbia (1982)**	**El-Sherif *et al.* (1989)**	**Zalat & El-Sheekh (1999)**
53- *Navicula pupula* Kützing	-	-	+
54- *Navicula radiosa* Kützing	-	-	+
55- *Navicula schizonemoids* H. van Heruck	-	+	-
56- *Navicula* sp.	-	+	-
57- *Navicula spicula* Cleve	-	-	+
58- *Navicula viridula* Kützing	-	+	-
59- *Navicula yarrensis* Grunow	-	+	-
60- *Pinnularia acrosphaeria* Rabenhorst	-	-	+
61- *Pinnularia maior* (Kützing) Rabenhorst	-	-	+
62- *Pinnularia microsauron* var. *brebissonii* Mayer	-	-	+
63- *Pinnularia* sp.	+	-	-
64- *Pleurosigma angulatum* Quekett	-	-	+
65- *Pleurosigma decorum* Smith	-	+	-
66- *Pleurosigma elongatum* Smith	-	+	-
67- *Pleurosigma macrum* W.Smith	-	+	-
68- *Pleurosigma salinarum* Grunow	-	-	+
69- *Stauroneis anceps* Ehrenberg	-	-	+
70- *Stauroneis smithii* Grunow	-	-	+
Family: Gomphonemaceae			
71- *Gomphonema clevei* Fricke	-	-	+
72- *Gomphonema constrictum* Ehrenberg	-	+	-
73- *Gomphonema gracilis* Ehrenberg	-	-	+
74- *Gomphonema interiactum* Kützing	-	+	-
75- *Gomphonema lanceolatum* Ehrenberg	-	-	+
76- *Gomphonema olivacum* Kützing	-	+	-
77- *Gomphonema parvulum* Kützing	-	-	+
78- *Gomphonema subclavatum* Grunow	-	+	-
79- *Gomphonema truncatum* Ehrenberg	-	-	+
Order: Bacillariales			
Family: Bacillariophyceae			
80- *Bacillaria paradoxa* Gemlin	-	+	+
81- *Bacillaria sp.*	+	-	-
82- *Nitzschia acuminata* W.Smith	-	+	-
83- *Nitzschia amphibia* Grunow	-	+	-
84- *Nitzschia angustata* Grunow	-	-	+
85- *Nitzschia apiculata* (Gregory) Grunow	-	+	+
86- *Nitzschia closterium* Smith	-	+	-

Table 5.1. Cont. 3.

Species	Kobbia (1982)	El-Sherif *et al.* (1989)	Zalat & El-Sheekh (1999)
87- *Nitzschia frustulum* Hustedt	-	+	+
88- *Nitzschia granulata* Grunow	-	-	+
89- *Nitzschia levidensis* var. *salinairum* Grunow	-	-	+
90- *Nitzschia longissima* (Breb.) Ralfs	-	+	-
91- *Nitzschia microcephala* Grunow	-	+	+
92- *Nitzschia obtusa* W.Smith	-	+	+
93- *Nitzschia palea* (Kützing) W.Smith	-	+	+
94- *Nitzschia panduriformis* Gregory	-	-	+
95- *Nitzschia perminuta* (Grunow) Peragallo	-	-	+
96- *Nitzschia punctata* (Smith) Grunow	-	+	-
97- *Nitzschia reversa* W.Smith	-	+	-
98- *Nitzschia scalaris* (Ehrenberg) W.Smith	-	-	+
99- *Nitzschia sigma* (Kützing) W.Smith	-	+	+
Order: Surirellales			
Family: Surirellaceae			
100- *Campylodiscus clypeus* Ehrenberg	-	+	-
101- *Campylodiscus echeneis* Ehrenberg	-	+	+
102- *Campylodiscus placentula* Ehrenberg	-	-	+
103- *Campylodiscus placentula* var. *euglypta* Ehrenberg	-	-	+
104- *Cymatoplura solea* (Brebisson) W.Smith	-	-	+
105- *Surirella striatula* Turpin	-	+	-
Order: Cymbellales			
Family: Cymbellaceae			
106- *Amphora coffeaeformis* (Agardh) Kützing	-	+	-
107- *Amphor ovalis* Kützing	-	+	+
108- *Amphora venata* Kützing	-	-	+
109- *Cymbella affinis* Kirtx	-	+	-
110- *Cymbella microcephala* Grunow	+	-	-
111- *Cymbella minuta* Hilse	-	-	+
112- *Cymbella silesiaca* Bleisch	-	-	+
113- *Cymbella* sp.	+	-	-
114- *Cymbella turgida* Gregory	-	+	+
Order: Ropalodiales			
Family: Ropalodiaceae			
115- *Epithemia smithii* Carruthers	-	-	+

Table 5.1. Cont. 4.

Species	**Kobbia (1982)**	**El-Sherif *et al*. (1989)**	**Zalat & El-Sheekh (1999)**
116- *Epithemia sorex* Kützing	-	-	+
117- *Epithemia turgida* Gregory	-	-	+
118- *Epithemia zebra* (Ehrenberg) Kützing	-	+	+
119- *Rhopalodia acuminata* Kramer	-	-	+
120- *Rhopalodia gibba* (Ehrenberg) O. Müller	-	+	+
121- *Rhopalodia gibba* var. *ventricosa* (Kützing) Grunow	-	-	+
122- *Rhopalodia gibberula* (Ehrenberg) O. Müller	-	+	-
123- *Rhopalodia rhopala* (Ehrenberg) Hustedt	-	-	+
Order: Chaetocerales			
Family: Chaetoceroaceae			
124- *Chaetoceros compressus* Lauder	-	+	-
Order: Eunotiales			
Family: Eunotiaceae			
125- *Eunotia* sp.	-	-	+
Total	**12**	**59**	**75**

Table 5.2. **List of Chlorophyta recorded in Lake Burullus (after Kobbia 1982 and El-Sherif *et al*. 1993).**

Species	**Kobbia 1982**	**El-Sherif *et al*. 1993**
Division: Chlorophyta		
Class: Chlorophyceae		
Order: Volvocales		
Family: Chlamydomonaceae		
1- *Carteria cordiforme* (Carter) Diesing	-	+
2- *Chlamydocapsa planctonica* Ehren.	+	-
3- *Chlamydomonas reinhardtii* Dang	-	+
Family: Volvocaceae		
4- *Eudorina* sp.	+	-
5- *Pandorina morum* (Muell.) Bory	-	+
6- *Phacotus lentcularis* Ehren.	+	-
Order: Tetrasporales		
Family: Palmellaceae		
7- *Sphaerocystis schroeteri* Chodat	-	+

Table 5.2. Cont. 1.

Species	Kobbia 1982	El-Sherif *et al*. 1993
Family: Coccomyxaceae		
8- *Elakatothrix biplex* Wille	+	-
Family: Ulothrichaceae		
9- *Geminella minor* (Naeg.) Heering	-	+
Order: Cladophorales		
Family: Cladophoraceae		
10- *Cladophora* Sp.		
Order: Oedogoniales		
Family: Oedogoniacea		
11- *Oedogonium* sp.	-	+
Order: Chlorococcales		
Family: Hydrodictyaceae		
12- *Pediastrum boryanum* (Turp.) Meneghini	-	+
13- *Pediastrum duplex* Meyen	-	+
14- *Pediastrum simplex* (Meyen) Lemmermann	-	+
15- *Pediastrum tetras* (Ehrenb.) Ralfs	-	+
Family: Botryococcaceae		
16- *Botryococcus braunii* Kuetzing	+	-
Family: Oocystaceae		
17- *Ankistrodesmus falcatus* var. *acicularis* (A.Braun)	-	+
18- *Ankistrodesmus falcatus* var. *mirabile* (West&West)	-	+
19- *Ankistrodesmus falcatus* var. *spirilliformis* G.S.West	-	+
20- *Ankistrodesmus setigerus* (Schrod.) G.S.West	-	+
21- *Chlorella* sp.	+	-
22- *Chodatella subsala* Lemm.	-	+
23- *Dictyosphaerium pulchellum* Wood	-	+
24- *Francia droescher* (Lemm.) G.M.Smith	-	+
25- *Kirchneriella lunaris* (Kirch.) Moebius	-	+
26- *Kirchneriella microscopica*	+	-
27- *Monoraphidium capriornutum* Nag.	+	-
28- *Nephrocytium limneticum* (G.M.Smith) G.M.Smith	-	+
29- *Oocystis borgei* Snow	-	+
30- *Oocystis* sp.	+	-

Table 5.2. Cont. 2.

Species	**Kobbia 1982**	**El-Sherif *et al*. 1993**
31- *Selenastrum gracile* Reinch	-	+
32- *Tetraedron minimum* (A.Braun) Hansgirg	-	+
33- *Tetraedron proteiforme* (Turn.) Brunnthaler	-	+
34- *Westella botryoides* (W.West) de Widemann	+	-
Family: Scenedesmaceae		
35- *Actinastrum hantzschii* Lagerheim	-	+
36- *Cruigenia maritima*	+	-
37- *Cruigenia quadrata* Morren	-	+
38- *Cruigenia tetrapedia* (Kirch.) West&West	-	+
39- *Scenedesmus acuminatus* (Lagerh.) Chodat	-	+
40- *Scenedesmus armatus* (Chodat) G.M.Smith	-	+
41- *Scenedesmus bijugatus* (Turp.) Kuetz.	-	+
42- *Scenedesmus bijugatus* Var. *alternans* Hansg.	-	+
43- *Scenedesmus diagonals* S.Fang	-	+
44- *Scenedesmus opliensis* Rich	-	+
45- *Scenedesmus quaricauda* (Turp.) Breb	-	+
46- *Scenedesmus spinosus*	+	-
47- *Tetrastrum stturogeniaeforme* (Schroeder) lemm.	+	-
48- *Tetrastrum triagulare*	+	-
Order: Zygnematales		
Family: Zygnemataceae		
49- *Spirogyra hassalli* (Dnner) Petit	-	+
Order: Desmidiales		
Family: Desmidiaceae		
50- *Closterium parvulum* var. *angustum* **W.& G.S.West**	-	+
51- *Cosmarium elgungii* Racib	-	+
52- *Cosmarium galeatum* **W.& G.S.West**	-	+
53- *Cosmarium subcrenatum* Hanzach	-	+
54- *Cosmarium sublateraundulatum* **W.& G.S.West**	-	+
55- *Cosmarium subtunidum* Nordst	-	+
Family: Chlorococcateae		
56- *Golenkinia radiata*	-	+
Total	14	41

Table 5.3. **List of Cyanophyta (blue-green algae) recorded in Lake Burullus (after Kobbia 1982 and El-Sherif *et al*. 1993).**

Species	**Kobbia 1982**	**El-Sherif *et al*. (1993)**
Division: Cyanophyta		
Class: Myxophyceae		
Order: Chrococcales		
Family: Chrococcacea		
1- *Aphanotheca* sp.	+	-
2- *Aphanocapsa pulchra* (Keutz.) Rabenhorst	-	+
3- *Chroococcus dispersus* (Keissl.) Lemmermann	-	+
4- *Chroococcus limneticus* Lemmermann	+	-
5- *Chroococcus tenuis* A.Braun	-	+
6- *Chroococcus turgidus* (Kütz.) Naegeli	+	+
7- *Coelosphaerium confermis* Naegeli	-	+
8- *Dactylococcopsis irrigularis* G.M.Smith	-	+
9- *Gleocapsa* sp.	+	-
10- *Merismopedia minima* Beck	-	+
11- *Merismopedia punctata* Meyen	-	+
12- *Merismopedia tenuissima* Lemmermann	+	-
13- *Microcystis aeruginosa* Kützing	+	+
Order: Nostocales		
Family: Nostocaceae		
14- *Anabaenopsis circularia* (G.S.West) Wol&Miller	-	+
15- *Anabaena* sp.	-	+
16- *Aphanizomenon* sp.	+	-
17- *Aulosira laxa* Kirchner	+	-
18- *Nostoc ellipsosporum* (Desmaz.) Rabenohorst	+	-
19- *Nostoc microscopicum* Carmichael	+	-
20- *Nostoc verrucosum* Vaucher	+	-
Family: Scytonemaceae		
21- *Plectonema* sp.	+	-
Family: Rivulariaceae		
22- *Rivularia* sp.		
23- *Gleotrichia* sp.		
Order: Oscillatoriales		
Family: Oscillatoriaceae		
24- *Anabaenobsis tanganyikae* Miller		

Table 5.3. Cont. 1.

Species	**Kobbia 1982**	**El-Sherif *et al*. (1993)**
25- *Lyngbya limnetica* Lemmermann	-	+
26- *Lyngbya major* Meneghini		
27- *Lyngbya* sp.	+	-
28- *Oscillatoria agardhii* Comont	+	-
29- *Oscillatoria brevis*		
30- *Oscillatoria chalybea* Mertens		
31- *Oscillatoria formosa* Bory	+	-
32- *Oscillatoria lacustris* (Kleb) Geit	-	+
33- *Oscillatoria limnetica* Lemmermann	+	+
34- *Oscillatoria princeps* Vaucher	-	+
35- *Oscillatoria simplissima*		
36- *OscillatoriaTenius* C.A.Agardh		
37- *Phormidium limosum*	+	-
38- *Spirulina* sp.	+	-
39- *Isocystis* sp.	+	-
Total	19	15

The study of El-Sherif *et al.* (1989) on the ecology of Bacillariophyta in Lake Burullus indicated the presence of 59 species (Table 5.1), where *Nitzschia* spp. and *Cyclotella meneghiniana* were the dominant diatom species. Recently, Zalat and El-Sheekh (1999) recorded 75 diatom species, 48 of them were not recorded in the previous studies. They found that *Cyclotella meneghiniana* was the most dominant species (73 - 89% of the total diatom assemblages). From the above historical review, it is evident that the phytoplankton community in general, and that of diatoms in particular, changed from 1982 till 1999 and these changes in number and dominant species should be taken into consideration for further studies in the lake in order to explore the reasons of these changes.

The summing up of all the recorded species in one checklist indicates the presence of 226 species distributed as follows: 125 species belonging to Bacillariophyta (55.3 %), 56 species to Chlorophyta (24.8 %), 39 species to Cyanophyta (17.2 %) and 6 species to other divisions (2.7 %) (Fig. 5.1).

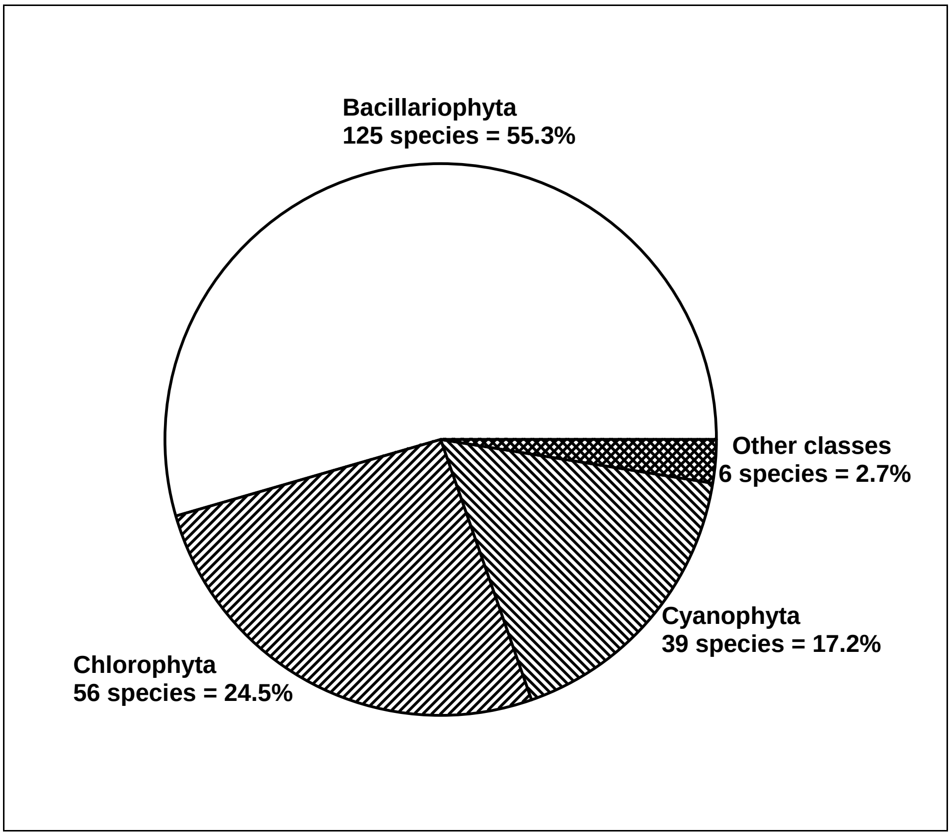

Fig. 5.1. **Contribution of algal divisions to the phytoplankton of Lake Burullus.**

5.2. DENSITY AND BIOMASS

El-Sherif (1989) indicated that Bacillariophyta represented the major bulk of the phytoplankton and formed 69.0% of its total biomass, although it ranked numerically as the second important group with 31.1% of the total phytoplankton counts. Chlorophyta was numerically the dominant group as it formed about 58.9% of the total phytoplankton counts, yet it contributed only 16.2% of the total phytoplankton biomass. Similarly the biomass of Cyanophyta was comparable to that of Chlorophyta and it constituted about 14.8% of the total phytoplankton biomass, but it contributed 8.8 % of the total phytoplankton counts. The highest phytoplankton biomass was recorded in the western sector of the lake, as a result of the increased values of diatoms, while the lowest biomass was in the eastern sector (Table 5.4).

Table 5.4. **Average biomass (mg l^{-1}) and their frequency (%) of the different algal groups in Lake Burullus (after El-Sherif 1989).**

Phytoplankton	**Sector**			**Average**	**%**
	East	**Middle**	**West**		
Bacillariophyta	1.273	1.142	2.440	1.618	69.0
Chlorophyta	0.125	0.512	0.505	0.381	16.2
Cyanophyta	0.129	0.387	0.526	0.347	14.8
Total	1.527	2.041	3.471	2.346	100

The monthly fluctuations of the total phytoplankton biomass, as estimated by El-Sherif (1989), indicated that the eastern and middle sectors of the lake showed maximum biomass in early autumn (September). Relatively high values were also recorded during winter (February) in the eastern sector and spring (March) in the Middle sector. The highest abundance peak in the western sector was recorded during summer (June), beside smaller ones in September and December. Most of these peaks were attributed to diatoms (Fig. 5.2). The following is a brief description of the distribution of different algal divisions recorded in the Lake Burullus (after El-Sherif 1989):

5.2.1. Bacillariophyta

Diatoms contributed about 69 % of the total weight of phytoplankton (average 1.618 mg l^{-1}). The western sector had the highest diatoms biomass, due to the dominance of *Nitzschia palea, Nitzschia reversa, Cyclotella meneghiniana, Melosira varians, Pleurosigma* sp. and *Synedra ulna*. The other two sectors had more or less comparable biomass of diatom, but showing different frequencies. The main diatoms comprised *Cyclotella meneghiniana* and *Synedra ulna* (Fig. 5.3).

5.2.2. Chlorophyta

Members of Chlorophyta contributed about 16.2% of the total weight of phytoplankton (average 0.381 mg l^{-1}). The highest biomass appeared in the middle and western sectors, showing the same dominant species (*Pediastrum simplex, Pediastrum boryanum, Scenedesmus quadricauda, Scenedesmus bijugatus, Oocystis borgei, Geminella minor* and *Dictyospherium pulchellum*), but with different frequencies. The eastern sector had a low green algal biomass, where *Oocystis borgei, Geminella minor* and *Dictyospherium pulchellum* formed the main bulk of chlorophytes

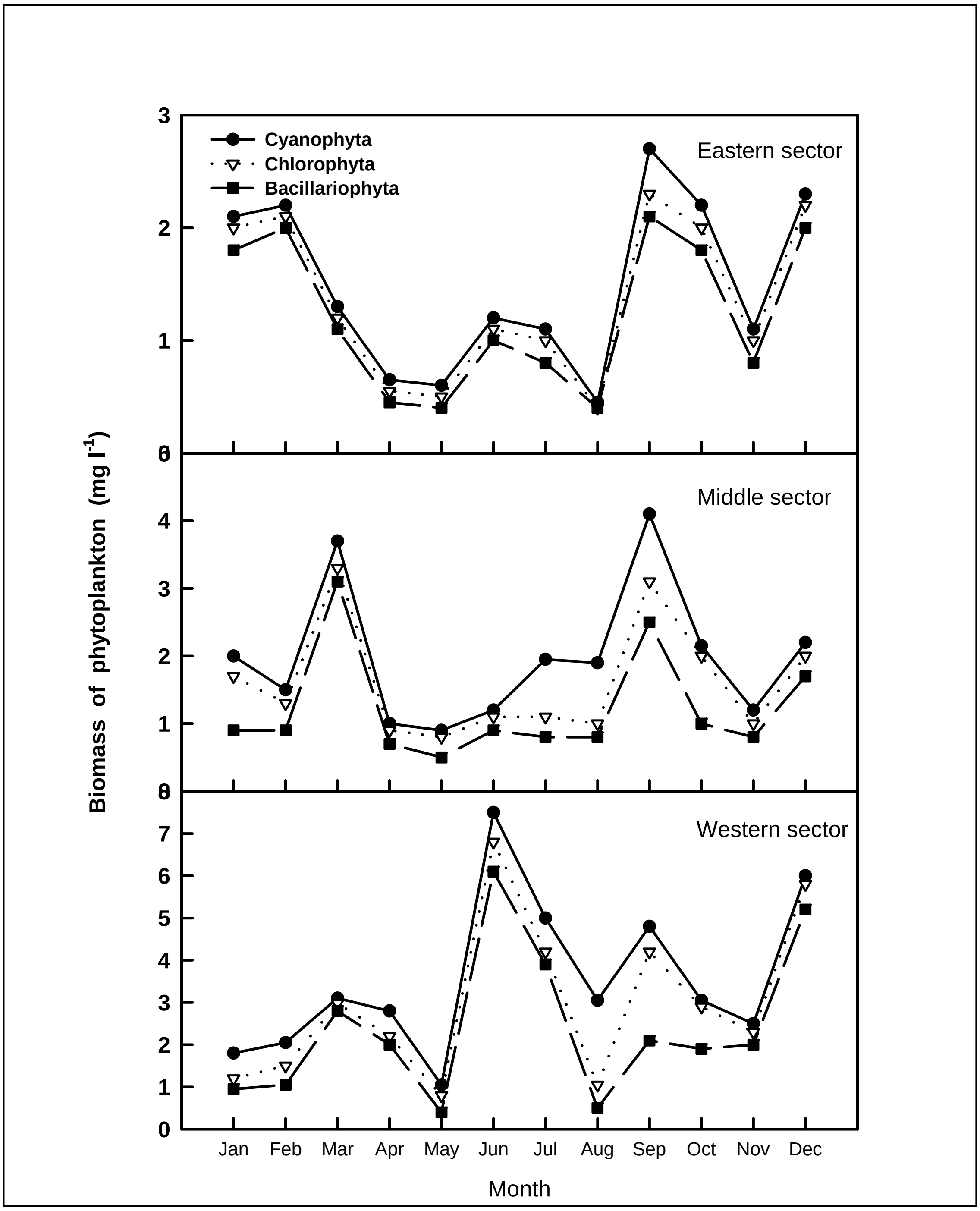

Fig. 5.2. **Seasonal variation in the phytoplankton biomass (mg l^{-1}) recorded in the three sectors of Lake Burullus (El-Sherif 1989).**

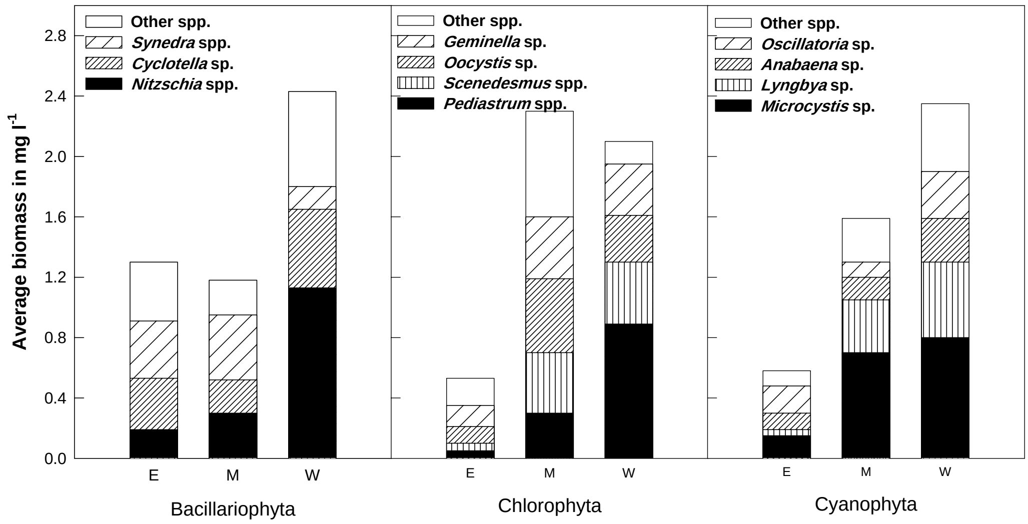

Fig. 5.3. **Average blooms of the different groups of phytoplankton (mg l^{-1}) recorded in the three sectors of Lake Burullus. E: eastern, M: middle and W: western (El-Sherif 1989).**

5.2.3. Cyanophyta

The blue green algae, as a whole constituted about 14.8% of the total weight of phytoplankton (average 0.347 mg l^{-1}). The western sector harbored the highest value of 0.526 mg/l due to the dominance of *Microcystis aeruginosa*, *Lyngbya limnetica*, *Anabaena* sp. and *Oscillatoria limnetica*. Their total biomass decreased gradually towards the eastern sector but showing similar algal composition.

The study of El-Sherif (1993) indicated that the phytoplankton standing crop had a remarkable decline to about 1.04 x 10^6 units/l and it represented about 1/3 of the records obtained during the period 1978-1979 (see El-Sherif 1989). The phytoplankton was represented mainly by Bacillariophyta (49.1% of the total number) and Chlorophyta (31.6%), while Cyanophyta (1.7%). Euglenophyta (2.6%), Dinophyta (2.2%) and Cryptophyta (12.7%) were infrequently observed. The increased counts of Cryptophyta was attributed to a bloom of *Cryptomonadales* sp., which was confined to the polluted area in front of Baltim city during May; this was met with lowest species diversity in the lake. The highest phytoplankton counts were recorded in spring and summer at Baltim city and were dominated by the diatoms *Nitzschia* spp. and *Cyclotella meneghiniana*, the green algae *Scenedesmus*, *Ankistrodesmus* and *Tetraedron* spp., beside the cryptophycean alga *Cryptomonadales* sp. Generally, the lake is regarded as unpolluted habitat except at Baltim station which is characterized by the highest phytoplankton diversity.

In general, Lake Burullus tends to mesotrophy as regards to phytoplankton production. This is attributed to the decreased amount of the drainage water flowing into the lake, and the increased density of the submerged hydrophytes, particularly *Potamogeton pectinatus*. Thus the heavy growth of this hydrophyte should be controlled to increase the phytoplankton production (El-Sherif 1993).

5.3. EPIPHYTES

Samaan *et al*. (1988) emphasized the importance of epiphytic flora in the Egyptian Delta lakes as they contribute in assessing their biological productivity of these lakes. Epiphytes also constitute important food items for the genus *Tilapia* which represents the most dominant fish inhabiting these lakes (Al-Kholy and Abdel-Malek 1972, and El-Sarraf 1976). The lakes in north Nile Delta are shallow and usually sustain extensive areas covered with dense growth of hydrophytes which in turn serve as good support for epiphytes. The hydrophytes in Lake Burullus are represented mainly by *Potamogeton pectinatus* which constituted about 85% of the biomass of submerged plants in the lake (El-Sherif 1983, Shaltout & Al-Sodany 2000). Its distribution was confined to the southern margins beside the outlets of the land drains as well as in the eastern sector. Other submerged plants of minor importance are *Potamogeton crispus, Ceratophyllum demersum* and *Najas armata*.

The study of Samaan *et al*. (1988) on the epiphytes growing on *Potamogeton pectinatus* in Lake Burullus indicated that this submerged hydrophyte supports a rich epiphytic algae, most of them are limnetic forms and can survive both planktonic and attached conditions. Altogether about 45 species were recorded which included 27 species of Bacillariophyta, 15 of Chlorophyta, 12 of Cyanophyta and one species of Rhodophyta.

5.3.1. Bacillariophyta

Diatoms represented the main group of epiphytic algae on *Potamogeton pectinatus*. The more dominant species were *Cocconeis placentula*, *Mastogloia elliptica*, *Mastogloia smithii*, *Rhopalodia gibba*, *Rhopalodia gibberula* and *Synedra ulna*. On the other hand, *Nitzschia frustulum*, *Nitzschia microcephala, Nitzschia sigma* and *Epithemia sorex* were less frequent. The other species persisted as rare species. All these diatoms were also recorded in the plankton of the lake (El-Sherif 1983, 1989, 1993).

Cocconies placentula was the most dominant species which appeared all the year round with a maximum frequency in the winter and early spring. It grows firmly attached to the substratum by a gelatinous pad which resists strong water currents. This species is cosmopolitan, oligohalobus- halophilous form (Salah 1960). In addition, *Mastogolia smithii* and *Mastogolia elliptica* were frequently met with all the year round but attaining high peaks on the host plant in May. *Mastogolia smithii* is regarded as indifferent form (Peterson 1943), while *Mastogolia elliptica* is considered as a mesohalobous species.

Rhopalodia gibba appeared as a dominant epiphyte in April and June, while it persisted as a frequent or rare diatom in the other months. *Rhopalodia gibberula* was also dominant in June, otherwise it was rarely observed throughout the rest of the year. The two species were rarely recorded in the plankton. *Rhopalodia gibba* is regarded as oligohalobous halophilous diatom, while *Rhopalodia gibberula* is indifferent form (Salah 1960). *Synedra ulna* was more frequent on the host plant in late autumn and early winter, but it appeared also frequently in the plankton. This species is regarded as indifferent form (Peterson 1943).

The frequent species of the genus *Nitzschia* comprised *Nitzschia frustulum, Nitzschia microcephala* and *Nitzschia sigma*. The first one was more frequent in May, September and October, the second in November and the third during June and July. The three species were also frequently observed in the plankton. *Nitzschia frustulum* and *Nitzschia microcephala* are regarded as oligohalobous halophilous diatoms, while *Nitzschia sigma* is considered as mesohalobous (Salah 1960). *Epithemia sorex* appeared also frequently on *Potamogeton* during February, June, July and November; while it remained rare in the other months. This species is regarded as an oligohalobous halophilous diatom.

Other daitoms that persisted as rare epiphytes throughout most of the year were *Synedra tabulata, Rhoicosphenia clirvata, Nitzschia palea, Nitzschia apiculata, Epithemia zebra, Amphora coffeoformis, Amphora ovalis, Cymbella affinis, Gomphonema constrictum, Gomphonema subculvatum, Gomphonema gracile, Mastogloia braunii, Pleurosigma elongatum, Navicula cryptocephela, Navicula schizonemoides, Camplyodiscus clypeus* and *Diploneis didyma*. Most of them are oligohalobous halopilous species except *Synedra tabulata, Nitzschia apiculata, Amphora coffeoformis* and, *Mastogloia braunii* which are mesohalobous species (Samman *et al*. 1988).

5.3.2. Chlorophyta

The epiphytic green algae in the lake were represented by the filamentous genera *Oedogonium, Spirogyra* and *Cladophora,* as well as two cellular species of the genera *Closterium* and *Cosmarium*. *Oedogonium* appeared frequently in summer and autumn, and remained rare in the other seasons. The other chlorophytes persisted as rare or very rare epiphytes throughout most of the year except *Closterium* sp. which was restricted to the winter.

5.3.3. Cyanophyta

The epiphytic cyanophytes belonged mostly to the order Oscillatoriales as represented by the genera *Oscillatoria* and *Lyngbya*, and order Nostocales as represented by genera *Anabaena, Anabaenopsis, Gloeotrichia* and *Rivularia*. 5 species of *Oscillatoria* were recorded on *Potamogeton pectinatus*, (*O. brevis, O. tenius, O. simplissima, O. chalybea* and *O. limnetica*). The latter species dominated the other cyanophytes particularly in summer (June). *Lyngbya limnetica* and *Lyngbya major* appeared as frequent epiphytes in spring, but remained rare in the other seasons. The other species appeared as rare or very rare epiphytes during the whole year except *Anabaenopsis tanganyikae* which showed a peak in June.

5.3.4. Rhodophyta

Compsopogon sp. was the only red alga recorded as epiphyte on *Potamogeton pectinatus*. It was frequent in July, otherwise it persisted as a rare form during most of the year and disappeared in winter (Samman *et al*. 1988). This species is a marine alga, which may have invaded the lake through the sea outlet and attached on *Potamogeton pectinatus*.

In general, the maximum frequency of the total epiphytes occurred in winter mainly due to diatoms, and in summer where it consisted chiefly of diatoms and blue green algae. Another small peak occurred in autumn and also was dominated by diatoms and cyanophytes. These peaks were associated with a minimum growth of *Potamogeton*, and consequently reflect an inverse relationship between the growth rates of both two forms of plant life.

5.4. COMPARISON WITH OTHER NORTH AFRICAN LAKES

In a recent study on the phytoplankton communities of nine North African lakes that were investigated within the framework of CASSARINA Project (3 lakes in each of Egypt, Tunisia and Morraco), Fathi *et al*. (2001) indicated that the three Egyptian lakes in Nile Delta (Manzalla, Burullus and Edku), which are alkaline sites with salinities less than 2 gm l^{-1}, are composed of Cosmopolitan algal species and have larger density and more species diversity than the other lakes. Lake Burullus comes in the first regarding the density and diversity (43 species), however this figure of species richness as determined by Fathi *et al*. (2001) underestimates the algal flora of this lake (some 226 species, as indicated in the present treatise). The relatively high density and species diversity of the Egyptian Nile Delta lakes are despite enrichment problems and substantial land reclamation occurring in the recent decades.

Fathi *et al.* (2001) concluded that, although phytoplankton plays a significant food-web role in all the productive CASSARINA lakes, they are in the Delta lakes a major ecosystem component that contributes to important fisheries status. Further disturbance and pollution of these sites could therefore begin to seriously degrade the quality of phytoplankton community by encouraging greater blue-green abundances with consequent increased threats to water quality. Only by curbing current pollution levels and preventing further losses of open water areas can these lakes continue to function as diverse and usefully productive ecosystems. The threat of climate change (e.g. Jeftic *et al.* 1992) and human usage demands on these important wetlands requires urgent water management activities.

5.5. SUMMARY

The phytoplankton community of Lake Burullus is considered rich, both in density and species richness, but most of the species are fresh or brackish water forms. From the survey of the literature on phytoplankton assemblages of Lake Burullus, there is a large variation among the researchers in the species composition and density depending on the surveyed station, water depth, sampling season, water quality, environmental condition and water pollution of the lake. The summing up of all the recorded species in these studies in one checklist indicate the presence of 226 algal species distributed among the algal groups as follows: 125 species of Bacillariophyta (55.3 %), 56 species of Chlorophyta (24.8 %), 39 species of Cyanophyta (17.2 %) and 6 species of other groups (2.7 %).

Bacillariophytes (i.e. diatoms) represented the major bulk of the phytoplankton biomass (69.0% of its total biomass), although it ranked numerically as the second important group (31.1% of the total phytoplankton counts). On the other hand, Chlorophytes came in the second order in case of the biomass (16.2%), but in the first order regarding the density (58.9% of the total counts). Cyanophytes contributed 14.8% of the total biomass and 8.8% of the total counts. The other groups had a minor contribution. The highest phytoplankton biomass was recorded in the western sector of the lake and the lowest in the eastern sector.

The monthly fluctuations of the total phytoplankton biomass indicated that the maximum biomass was attained in early autumn (September) in the eastern and middle sectors. Relatively high values were also recorded during winter (February) in the eastern sector and spring (March) in the Middle sector. On the other hand, the highest biomass in the western sector was recorded during summer (June), beside smaller peaks in September and December. The temporal trend of the three major algal groups are quite similar.

Regarding the phytoplankton production, Lake Burullus tends to mesotrophy. This may be attributed to the decreased amount of drain water flowing into the lake, and the increased density of the submerged hydrophytes, particularly *Potamogeton pectinatus*.

The estimation of epiphytic algal communities growing on the hydrophytes in the Egyptian lakes is of prime importance in assessing their organic production. In Lake Burullus, *Potamogeton pectinatus* constituted about 85% of the total biomass of the submerged plants. The previous studies indicated the presence of 45 epiphytic species growing on this hydrophyte, most of them are limnetic forms, but can survive both planktonic and attached situations. These species are distributed among algal groups as follows: 27 Bacillariophytes (diatoms), 15 Chlorophytes, 12 Cyanophytes and 1 Rhodophyte.

The comparison between the phytoplankton communities of nine North African lakes (3 lakes in each of Egypt, Tunisia and Morraco), indicates that the three Egyptian lakes in Nile Delta (Manzalla, Burullus and Edku), which are alkaline sites with salinities less than 2 gm l^{-1}, are composed of cosmopolitan algal species and have larger density and more species diverse than the other lakes. Lake Burullus comes in the first regarding the density and diversity.

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5.7. PLATES OF PHYTOPLANKTON: 5.1 – 5.11

(after Palmer 1980)

Bacillariophyta (Diatoms): 5.1 – 5.5

Plate 5.1.
Fragilaria
Stephanodiscus
Achnanthes
Gomphonema parvulum
Gomphonema

Plate 5.2.
Cyclotella meneghiniana
Cyclotella

Navicula
Pinnularia
Surirella
Stauroneis

Plate 5.3.
Asterionella
Asterionella japonica
Melosira
Nitzschia closterium
Nitzschia palea

Plate 5.4.
Tabellaria flocculosa
Tabellaria
Chaetoceros
Cocconeis placentula
Cymbella

Plate 5.5
Melosira granulata
Navicula
Synedra
Synedra ulna

Chlorophyta: 5.6 – 5.10

Plate 5.6
Botryococcus braunii
Oocystis borgei
Scenedesmus
Scenedesmus quadricauda
Sphaerocystis schroeteri
Oedogonium

Plate 5.7
Ankistrodesmus falcatus var. acicularis
Ankistrodesmus falcatus
Chlamydomonas reinhardtii
Chlamydomonas
Phacotus lenticularis
Tetraedron

Plate 5.8
Chlorella
Closterium
Cosmarium
Dictyosphaerium

Plate 5.9
Elakatothrix
Golenkinia radiata
Pediastrum boryanum
Pandorina morum
Spirogyra

Plate 5.10
Eudorina
Cladophora
Carteria
Chodatella

Cyanophyta: 5.11 – 5.12

Plate 5.11
Lyngbya
Phormidium
Rivularia
Aphanizomenon

Plate 5.12
Spirulina
Anabaena
Oscillatoria

Euglenophyta
Plate 5.13
Phacus
Euglena
Rhodophyta
Compsopogon