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Functional Classification and Composition of Phytoplankton in Liman Lake

Elif Neyran Soylu[1,]*, Arif Gönülol[2]

[1]Giresun University, Faculty of Arts and Science, Department of Biology, 28049, Giresun, Turkey.
[2]Ondokuz Mayıs University, Faculty of Arts and Science, Department of Biology, 55139, Samsun, Turkey.

* Corresponding Author: Tel.: +90.454 2161255; Fax: +90.454 2164518;
E-mail: enkutluk@omu.edu.tr

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Abstract

Functional classification and composition of phytoplankton of Liman Lake were studied between January 2002 and December 2003. A total of 109 taxa belonging to Bacillariophyta, Chlorophyta, Cyanophyta, Dinophyta, Xantophyta, Chrysophyta and Cryptophyta were identified. The succession during 2002 began with R-Strategists (with a high surface to volume ratio, including blue-green algae with filaments like *Pseudanabaena limnetica* Lemmermann). This group was followed by C-Strategists (small green algae characterised with fast nutrient absorption, assimilation and replication ratios). This group was again followed by R-Strategists and at last C-Strategists became dominant.

Keywords: Liman Lake, phytoplankton, functional group, composition, C-S-R Strategists.

Liman Gölü Fitoplankton Kompozisyonu ve Fonksiyonel Sınıflandırması

Özet

Liman Gölü fitoplankton kompozisyonu ve fonksiyonel sınıflandırılması Ocak 2002 ve Aralık 2003 tarihleri arasında araştırılmıştır. Bacillariophyta, Chlorophyta, Cyanophyta, Dinophyta, Xantophyta, Chrysophyta ve Cryptophyta divizyolarına ait toplam 109 takson belirlenmiştir. Süksesyon 2002 yılında R-Stratejileri (yüksek yüzey alanı/hacim oranına sahip, *Pseudanabaena limnetica* Lemmermann gibi filamentli mavi yeşil algleri içeren) ile başlamıştır. Daha sonra bu grubu C-Stratejileri (hızlı besin absorpsiyonu asimilasyon ve ve replikasyon oranları ile karekterize edilen küçük yeşil algler) takip etmiştir. Sonra yine R-Stratejileri, onu takiben son olarak C-Stratejileri hakim olmuştur.

Anahtar Kelimeler: Liman gölü, fitoplankton, fonksiyonel grup, kompozisyon, C-S-R stratejileri.

Introduction

In order to more precisely describe the periodicity of phytoplankton assemblages in different kinds of water bodies, Reynolds (1984) described a number of species groups consisting of species that tend to have similar seasonal sequences. This approach was further evolved in to a comprehensive list of phytoplankton functional associations or functional groups (Reynolds *et al*., 2002; Reynolds, 2006). Then the application of functional classification, description of the typical misplacements and modification of the original habitat templates and species allocations were discussed by Padisak *et al*. (2009) by searching 67 articles closely related to the application of functional approach to phytoplankton. In this review, it is defined that this approach proved to be more useful for ecological purposes than the previously applied taxonomic grouping (Kruk *et al*., 2002; Salmoso and Padisak, 2007; Padisak *et al*., 2009).

Adapting the C-S-R concept was proposed by Grime (1979) for terrestial vegetation; Reynolds (1988) classified the phytoplankton species into three basic adaptive strategies based on their susceptibiliy to habitat disturbance, stress and utilisation of limited resources (Table 1): C (colonist-invasives), S (stress-tolerants) and R (ruderals). In this model, the C-Strategists dominate in lakes with low intensity of disturbance and stress. The C-Strategists comprise species adapted to rapid reproduction and a superior ability to dominate the environment, as soon as the conditions become sustainable, partial exploiting environments saturated with light and nutrients. The R-Strategists, which are predominant in environments with great vertical mixing, low stress are specialised tolerate turbulent transportation and light gradients. The S-Strategists species tolerate stress or survive in environments with a severe restriction of essential nutrients and develop in situations of low disturbance.

Functional groups consist of species with similar morphology and environmental requirements, but they do not necessarily belong to the same phylogenetic group. In contrast to long species lists or usage of dominant taxonomical groups, functional groups make it much easier to examine and compare the seasonal changes in various lake types and to evaluate the responses to environmental conditions and changes (Weithoff *et al*., 2001; Kruk *et al*., 2002; Naselli-Flores *et al*., 2003). The alphanumeric ascriptions help define the characteristics of the respondent phytoplankton but do not improve on dynamic resolution. Although there are many studies based on phytoplankton seasonality and ecology, little is known about the phytoplankton as regards functional approach. Therefore, the goal of the study is to evaluate the applicability of the C, S, R strategies and functional classification approach to freshwater phytoplankton assemblages and better understand the survival strategies of the most abundant species.

Materials and Methods

Model Development Methodology

Kızılırmak Delta is situated along the Black Sea coast of Turkey (latitude: 41°30' to 41°45' N; longitude: 35°43' to 36°08' E. Liman Lake is 10-20 km away from Bafra town in the Kızılırmak Delta. The lake's surface area is 270 ha. The three sites sampled are shown on Figure 1. St. 1 is located near the North edge of the Lake. The lake sediment is covered with sand and stones. St. 2 is located at the centre of the lake. The lake sediment is sandy. St. 3 is located in the Southeast of the lake. This site is covered with *Juncus* sp (Figure 1).

Samples were collected monthly with 2-litre capacity Hydro-Bios water sampler from surface and depth (1 m) to determine the density of the algae from January 2002 to November 2003 at three stations. Phytoplankton determinations were carried out on subsamples preserved in acetic Lugol's solution; a constant volume of 10 ml was sedimented in the counting chambers. Algal cells were counted on a Prior inverted microscope at 400 x magnification, following Lund *et al.* (1958). At least 200 individuals were counted. In the evaluations, the average of three countings from each stations was used. The remaining part of the water sample was filtered using Whatman GF/A fibre filter paper to identify the algae except Bacillariophyta, were identified in permanent slides under oil immersion at 1000 x magnification which had been prepared according to Round (1953). Taxonomic identifications were performed following John *et al.* (2003), Krammer and Lange-Bertalot (1991a; 1991b; 1999a; 1999b).

The functional groups of phytoplankton were classified according to the ecological concept of adaptive strategist (Grime, 1979; Reynolds, 1988; Olrik 1994) (Table 1) and the trait-separated functional groups (Reynolds *et al*., 2002; Padisak *et al*., 2009). In this classification system according to Reynolds *et al*. (2002) phytoplankton species are grouped into 33 functional groups nominated by alphanumeric codes and based on their survival strategies, tolerances and sensitivities. The functional groups of phytoplankton in Liman Lake were given at Table 2.

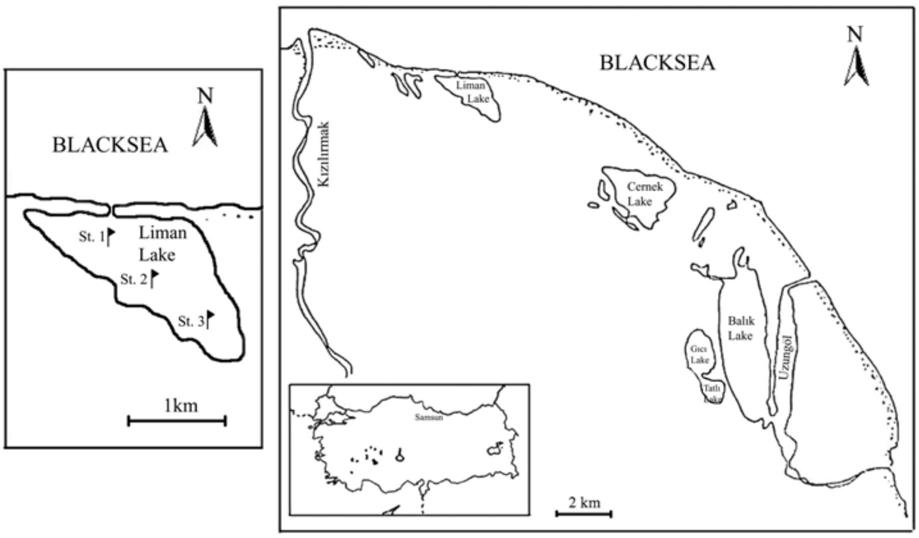

Figure 1. Map of the studied area and sampling stations.

Table 1. Basis for evaluation of three primary strategies in the evaluation of plants and phytoplankton (Grime, 1979; Reynolds, 2006)

	Habitat Productivity	
Habitat Duration	High	Low
Long	Competitors, invasive (C)	stress-tolerant (S)
Short	Disturbance-tolerant ruderals (R)	No viable strategy

Table 2. Trait-separated functional groups of phytoplankton in Liman Lake

Group	Habitat	Typical Representatives	Tolerances	Sensitivities
B	Vertically mixed, mesothrophic small medium lakes	*Cyclotella ocellata*	Light deficiency	pH rise, Si depletion stratification
D	Shallow, enriched turbid waters, including rivers	*Nitzschia* spp. *Fragilaria ulna*	Flushing	Nutrient depletion
N	Mesotrophic epilimnia	*Cosmarium venustum*	Nutrient deficiency	Stratification, pH rise
P	Eutrophic epilimnia	*Closterium* spp. *Staurastrum gracile*	Mild light and C deficiency	Stratification, Si depletion
S1	Turbid mixed layers	*Pseudanabaena limnetica*	Highly light deficient	Flushing
S2	Shallow, turbid mixed layers	*Spirulina laxa*	light deficient	Flushing
SN	Warm mixed layers	*Cylindrospermum stagnale*	Light-, nitrogen- deficient	Flushing
X1	Shallow mixed layers in enriched conditions	*Monoraphidium* spp. *Ankistrodesmus* spp.	stratification	Nutrient depletion
Y	Usually, small, enriched lakes	*Cryptomonas ovata*	Low light	phagothrophs
E	Usually small, oligotrophic, base poor lakes or heterothrophic ponds	*Dinobyron sertularia*	Low nutrients	CO_2 deficiency
F	Clear epilimnia	*Botryococcus braunii,* *Oocystis pusilla* *Kirchneriella lunaris* *Kirchneriella obesa*	Low nutrients High turbidity	CO_2 deficiency
G	Short, nutrient-rich water columns	*Eudorina elegans*	High light	Flushing, low total light
J	Shallow, enriched lakes ponds and rivers	*Pediastrum dublex* *Scenedesmus communis* *Tetraedron minimum*		Settling into low light
Lo	Summer epilimnia in mesotrophic lakes	*Peridinium cinctum* *Merismopedia punctata*	Segregated nutrients	Prolonged or deep mixing
M	Dielly mixed layers of small eutrophic, low latitude lakes	*Microcystis* spp.	High insolation	Mixing, poor stratification light
W1	Small organic ponds	*Euglena proxima* *Euglena oxyuris*	High BOD	Grazing
W2	Shallow mesotrophic lakes	*Trachelomonas* spp.	-	-

Results

A total of 109 planktonic algae were found: 39 Bacillariophyta, 27 Chlorophyta, 20 Euglenophyta, 15 Cyanophyta, 3 Dinophyta, 3 Xantophyta, 1 Chrysophyta and 1 Cryptophyta (Table 3). The succession during 2002 began with R-Strategists (with a high surface to volume ratio, including blue-green algae with filaments like *Pseudanabaena limnetica (*Lemmermann) Komárek. This group was followed by C-Strategists (small green algae characterised with fast nutrient absorption, assimilation and replication ratios). This group was again followed by R-Strategists and at last, C-Strategists became dominant.

Cyanophyta and Chlorophyta type phytoplankton were registered in Liman Lake. *Pseudanabena limnetica*, *Merismopedia punctata*, *Ankistrodesmus falcatus* and *Kirchneriella lunaris* were found to be dominant and subdominant in some months one by one. Bacillariophyta reached its the highest level contributing 53% of total organism numbers in May 2003 at St. 3. In this month, centric diatoms *Cyclotella ocellata* and *Melosira varians* were highly detected species with, 3975 ind/ml and 1125 ind/ml respectively (Figure 2).

The seasonal variations of total organism numbers was similar at surface and at 1 m in Liman

Table 3. Phytoplankton composition of the Liman Lake

CYANOPHYTA
Chroococcales
Chroococcus dispersus (Keissler) Lemmermann
Chroococcus distans (G.M.Smith) Komárková-Legnerová & Cronberg
Chroococcus pallidus Nägeli
Chroococcus turgidus (Kützing) Nageli
Chroococcus varius A.Braun in Rabenhorst
Cylindrospermum stagnale (Kützing) Bornet et Flauhault
Desmococcus olivaceum (Persoon ex Acherson)
Microcystis aeruginosa (Kützing) Kützing
Microcystis incerta (Lemmermann) Lemmermann
Merismopedia elegans A.Braun
Merismopedia glauca (Ehrenberg) Nägeli
Merismopedia punctata Meyen
Hormogonales
Oscillatoria curviceps C.Agardh ex Gomont
Oscillatoria guttulata Van Goor
Pseudanabaena limnetica Lemmermann
Spirulina laxa G.M.Smith
BACILLARIOPHYTA
Centrales
Cyclotella ocellata Pantocsek
Melosira varians C.Agardh
Pennales
Amphora coffeaeformis (C.Agardh) Kützing
Amphora ovalis Kützing
Caloneis silicula (Ehrenberg) Cleve
Cocconeis pediculus Ehrenberg
Cocconeis placentula Ehrenberg
Cymbella affinis Kützing
Cymbella cistula (Ehrenberg) Kirchner
Cymbella minuta Hilse ex Rabenhorst
Cymbella prostrata (Berkeley) Cleve
Cymbella ventricosa C.Agardh
Diatoma vulgaris Bory
Encyonema perpusillum (A.Cleve) D.G.Mann
Entomoneis alata (Ehrenberg) Ehrenberg
Entomoneis paludosa (W.Smith) Reimer
Epithemia smithii Carruthers
Epithemia sorex Kützing
Fragilaria ulna (Nitzschia) Lange-Bertalot
Gomphonema olivaceum (Hornemann) Brėbisson var. *Olivaceum*
Gyrosigma attenuatum (Kützing) Rabenhorst
Meridion circulare (Greville) C.Agardh
Navicula cincta (Ehrenberg) Ralfs
Navicula cryptocephala Kützing
Navicula digitoradiata Gregory Ralfs in Pritchard
Navicula elginensis Gregory Ralfs in Pritchard var. *Elginensis*
Navicula platystoma Ehrenberg
Navicula pupula Kützing
Navicula radiosa Kützing
Navicula rhyncocephala Kützing
Navicula veneta Kützing
Nitzschia acicularis (Kützing) W.Smith
Nitzschia closterium (Ehrenberg) W.Smith
Nitzschia constricta (Kützing) Ralfs
Nitzschia palea (Kützing) W.Smith
Pinnularia appendiculata (C.Agardh) Cleve
Rhoicosphaneia abbreviata (C.Agardh) Lange-Bertalot
Surirella brebissonii Krammer Lange-Bertalot
Surirella ovalis Brėbisson
CHLOROPHYTA
Chlorococcales
Ankistrodesmus falcatus (Corda) Ralfs
Botryococcus braunii Kützing
Eudorina elegans Ehrenberg
Kirchneriella elegans Playfair
Kirchneriella lunaris (Kirchner) K.Möbius
Kirchneriella irregularis (G.M.Smith) Korshikov
Kirchneriella obesa (West) Schmidle
Monoraphidium griffithii (Berkeley) Komárková-Legnerová
Monoraphidium minutum (Nägeli) Komárková-Legnerová
Monoraphidium mirabile (West et G. West) Pankow
Oocystis pusilla Hansgirg
Pediastrum dublex Meyen
Raphidocelis contorta (Schmidle) Marvan et al.
Scenedesmus abundans (Kirchner) Chodat
Scenedesmus arcuatus (Lemmermann) Lemmermann
Scenedesmus communis E.H.Hegewald
Scenedesmus magnus Meyen
Scenedesmus obtusus Meyen
Tetraedron minimum (A.Braun) Hansgirg
Tetrastrum triangulare (Chodat) Komárek
Desmidiales
Closterium kuetzingii Brébisson
Closterium praelongum Brébisson
Cosmarium venustum (Brébisson) W. Archer
Staurastrum gracile Ralfs
Selenastrum gracile Reinsch
Oedogoniales
Oedogoniom cleveanum Wittrock
CHRYSOPHYTA
Chrysomonadales
Dinobyron sertularia Ehrenberg
CRYPTOPHYTA
Cryptomonadales
Cryptomonas ovata Ehrenberg
DINOPHYTA
Peridiniales
Peridinium cinctum (O. F. Müller) Ehrenberg
Preperidinium meunieri (Pavillard) Elbrächter
Protoperidinium brevipes (Paulsen) Balech
EUGLENOPHYTA
Euglenales
Euglena clavata Skuja
Euglena elastica Prescott
Euglena elongata Schewiakoff
Euglena gracilis G. A. Klebs
Euglena minuta Prescott
Euglena oxyuris Schmarda
Euglena polymorpha P. A. Dangeard
Euglena proxima P. A. Dangeard
Phacus acuminatus A. Stokes
Phacus chloroplastes Prescott
Phacus stokesii Lemmermann
Trachelomonas hispida (Perty) F. Stein
Trachelomonas hispida var. *punctata* Lemmermann
Trachelomonas lacustris Drezepolski
Trachelomonas pulcherrima Playfair
Trachelomonas rotunda Svirenko
Trachelomonas scabra Playfair
Trachelomonas scabra var. *ovata* Playfair
Trachelomonas similis A. Stokes
Trachelomonas volvocina Ehrenberg
XANTOPHYTA
Goniochloris fallax Fott
Goniochloris mutica (A. Braun) Fott
Goniochloris smithii (Baurrelly) Fott

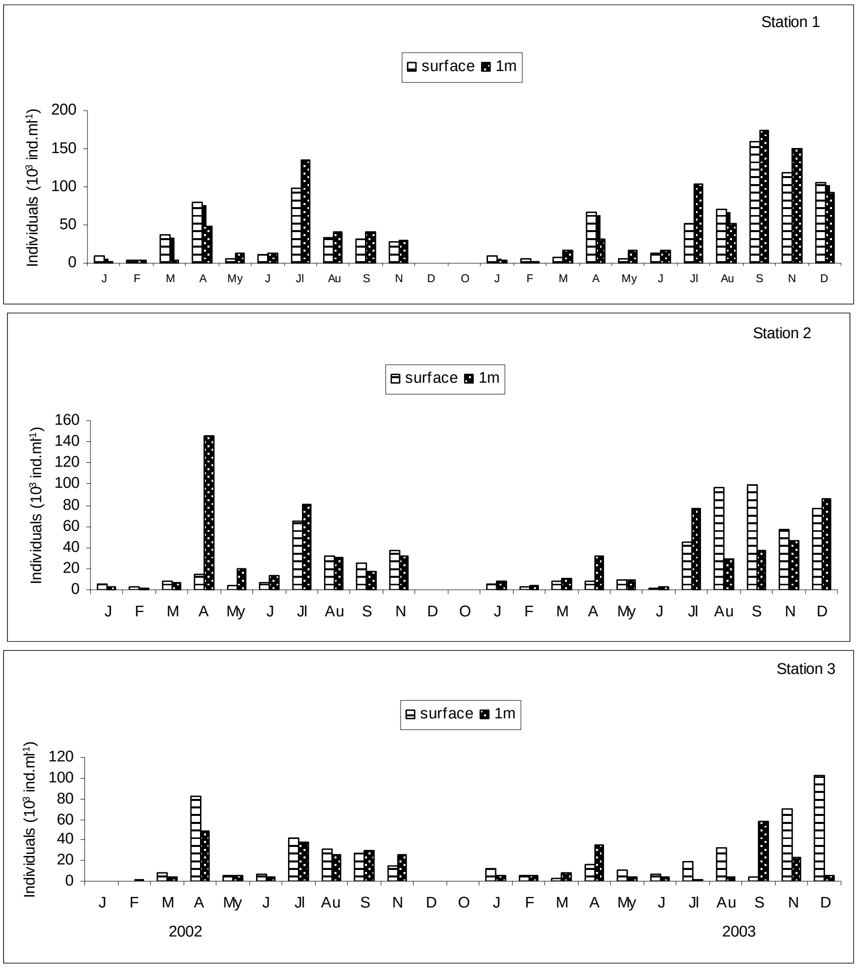

Figure 2. Seasonal variation of phytoplankton density (ind. ml^{-1}) at surface and 1 m depth sampled between January 2002 and December 2003.

Lake. Peaks of phytoplankton were recorded in April and July 2002, July and September 2003. The contributions of *Pseudanabena limnetica* was the highest in these months. Additionally, *Merismopedia punctata* was important contributing high to total organism numbers in September 2003. Total number of organisms reached the highest level with 173,343 ind/ml at St. 1 in September 2003 during the study period. *Pseudanabena limnetica* were found to be dominant, *Merismopedia punctata* were subdominant at all stations in this month (Figure 3).

The functional groups represented by the algae encountered in Liman Lake were B, D, N, P, S1, S2, X1, Y, F, G, J, L_0, M, W1 and W2. In the classification of trait-separated phytoplankton groups, some characteristics of the S1, F and L_0 Reynolds associations describe the Liman Lake assemblages, but they do not strictly match with them. The S1 assemblage (*Pseudanabaena limnetica*), which constituted a great part of the phytoplankton, was mostly found in turbid mixed layers and tolerant to highly light deficient conditions. The members of F group function best in clear water and are otherwise tolerant of deep mixing, have a strong representation among mesotrophic lakes. F assemblage, which can develop in clear epilimnia, is tolerant to low nutrients, high turbidity includes *Kirchneriella* spp. This species is frequently recorded in the Liman Lake. L_0 assemblage is tolerant to segregated nutrients, sensitive to prolonged or deep mixing and includes *Merismopedia* spp.

Discussion

Although Bacillariophyta were dominant in respect to species numbers, Cyanophyta and Chlorophyta type phytoplankton were registered in terms of population density in Liman Lake. *Pseudanabena limnetica*, *Merismopedia punctata*, *Ankistrodesmus falcatus* and *Kirchneriella lunaris* were found to be dominant and subdominant organisms in certain months alternately.

Cyanophyta were found to be prominent in Bulgaria (Stoyneva, 2003) and in Hungary (Padisak and Reynolds, 1998), which are in the same climatic zone with Turkey. Cyanophytes were also the most numerous in Sanabria Lake (Spain) (Hoyos and

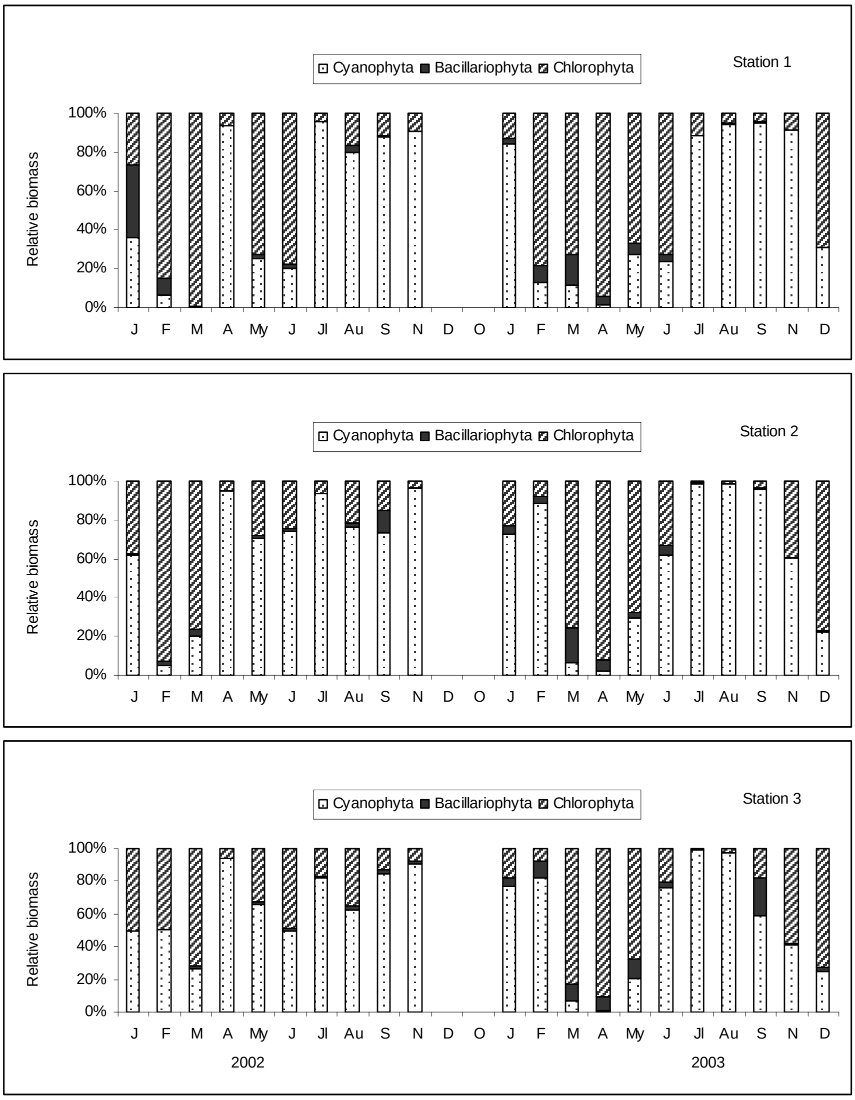

Figure 3. Seasonal variation of the density of the main algal groups during the sampling period.

Comin, 1999). During summer and winter the assemblages were characterised by a high development of *Pseudanabaena limnetica* in Donghu Lake of China (Lei *et al*., 2005). The permanent dominance of Oscillatoriales during summer and autumn has often been reported for eutrophic lakes in Central Europe (Berger and Sweers, 1988). Cyanophyta dominance, and sometimes bloom formation are among the most visible symptoms of accelerated eutrophication of lakes and reservoirs (Moss *et al*., 1997). The dominance of Oscillatoriales in the lakes of Kızılırmak Delta region is a result of the anthropogenic induced eutrophication process.

The succession during 2002 began with R-Strategists (*Pseudanabaena limnetica*). This group was followed by C-Strategists (small green algae). This group was again followed by R-Strategists and at last C-Strategists became dominant in Liman Lake. The same succession type was also seen in Tatlı Lake (Soylu *et al.*, 2007). In the phytoplankton of Gıcı Lake, the succession began with R-Strategists (Cryptophytes, tolerant to disturbance). This group was followed by C-Strategists (Chlorophytes) and S-Strategists (Euglenophytes and Cyanophytes) (Soylu and Gönülol, 2006).

Nowadays, the phytoplankton functional groups approach comprises more than 45 assemblages that are identified by alphanumerical codes according to their sensitivities and tolerances (Reynolds, 2006; Padisak *et al*., 2009). In Liman Lake 16 functional groups (B, D, N, P, S1, S2, X1, Y, F, G, J, L_0, M, W1 and W2) were identified. In the classification of trait-separated phytoplankton groups (Reynolds *et al*., 2002) some charactersitics of the S1, F and L_0 Reynolds associations describe the Liman Lake assemblages, but they don't strictly match with them. S1 group was also seen in Hungarian rivers (Borics *et al*., 2007) and Hungarian shallow lakes (Padisak *et* *al*., 2003). M and P associations are the common groups of Liman Lake and Ömerli Reservoir (İstanbul) (Albay and Akçaalan, 2003). In the classification of trait-separated phytoplankton groups (Reynolds *et al*., 2002) some characteristics of D (*Nitzschia palea*), P (*Ulnaria ulna*) and N (*Cosmarium denticulatum*) Reynolds associations describe the Gıcı Lake assemblages (Soylu and Gönülol, 2006). The species found are placed separately in groups S_N, H1 and L_M in Bulgarian wetlands (Stoyneva, 2003). As in Bulgarian wetlands, S_N and H1 functional groups, which are tolerant to mixing and poor light conditions, were found dominant in Kastoria Lake, Greece. Additionally, M and S1 groups were identified in the same lake (Moustaka-Gouni *et al*., 2007).

Phytoplankton functional groups approach applied to aquatic systems provides important information for understanding the dynamic of species selection in the pelagic communities in different regions. This approach assumes that characteristics of a community can be better understood and managed if species are grouped into classes that possess similar characteristics or behave similarly (Solbrig, 1993). Finally, the functional group approach constitutes a useful tool for understanding the phytoplankton community in every system; but it is necessary to check whether the grouping of species reflected the autoecological features of organisms (Padisak *et al*., 2009).

References

Albay, M. and Akçaalan, R. 2003. Factors influencing the phytoplankton steady-state assemblages in a drinking-water reservoir (Ömerli Reservoir, İstanbul). Hydrobiologia, 502: 85-95.

Berger, C. and Sweers, H.E. 1988. The IJsselmeer and its phytoplankton with special attention to the suitability of the lake as a habitat for *Oscillatoria agardhii* Gom. Journal of Plankton Research, 10: 579–599.

Borics, G., Varbiro, G., Grigorszky, I., Krasznai, E., Szabo, S. and Kiss, K.T. 2007. A new evaluation technique of potamoplankton fort he assessment of the ecological status of rivers. 17. Archiv für Hydrobiologie supplement, 161: 465-486.

Grime, J.P. 1979. Plant strategies and vegetation processes. John Wiley & Sons, New York, New York, 222 pp.

John, D.M., Whitton, B.A. and Brook, A.J. 2003. The Freshwater Algal Flora of the British Isles: An identification guide to freshwater and terrestrial algae. The Natural History Museum and The British Phycological Society, Cambridge University Press, Cambridge, 702 pp.

Hoyos, C. and Comin, F.A. 1999. The importance of inter-annual variability for management. Hydrobiologia, 395/396: 281-291.

Krammer, K. and Lange-Bertalot, H. 1991a. Süßwasserflora von Mitteleuropa. Bacillariophyceae, Band 2/3, 3. Teil: Centrales, Fragillariaceae, Eunoticeae, Stuttgart: Gustav Fischer Verlag. 1-576.

Krammer, K. and Lange-Bertalot, H. 1991b. Süßwasserflora von Mitteleuropa. Bacillariophyceae, Band 2/4, 4. Teil: Achnanthaceae, Kritische Ergänzungen zu Navicula (Lineolatae) und Gomphonema Gesamtliteraturverzeichnis. Stuttgart: Gustav Fischer Verlag. 1-436.

Krammer, K. and Lange-Bertalot, H. 1999a. Süßwasserflora von Mitteleuropa. Bacillariophyceae, Band 2/1, 1. Teil: Naviculaceae, Berlin: Spectrum Academicher Verlag. 1-876.

Krammer, K. and Lange-Bertalot, H. 1999b. Süßwasserflora von Mitteleuropa. Bacillariophyceae, Band 2/2, 2. Teil: Bacillariaceae, Epithemiaceae, Surirellaceae, Berlin: Spectrum Academicher Verlag. 1-610.

Kruk, C., Mazzeo, N., Lacerot, G. and Reynolds, C.S. 2002. Classification schemes for phytoplankton: a local validation of a functional approach to the analysis of species temporal replacement. J. Plankton Res., 24: 901-912.

Lei, A., Hu, Z., Wang, J., Shi, Z. and Tam, F. 2005. Structure of the Phytoplankton Community and Its Relationship to water Quality in Donghu Lake, Wuhan, China. J. Integr. Plant Biol., 47(1): 27-37.

Lund, J.W.G., Kipling, C.D. and Le Cren, E. 1958. The Inverted microscope method of estimating algal numbers and statistical basis of estimations by counting. Hydrobiologia, 11: 143-170.

Moustaka-Gouni, M., Vardaka, E. and Tryfon, E. 2007. Phytoplankton succession in a shallow Mediterranean Lake (L. Kastoria, Greece): Steady-state dominance of *Limnothrix redekei*, *Microcystis aeruginosa* and *Cylindrospermopsis raciborskii*. Hydrobiologia, 575: 129–140.

Moss, B., Madgwick, J. and Philips, G. 1997. A Guide to the Restoration of Nutrient-Enriched Shallow Lakes. W.W. Hawes, UK.

Naselli-Flores, L., Padisák, J., Dokulil, M. and Chorus, I. 2003. Equilibrium/steady-state concept in phytoplankton ecology. Hydrobiologia 502: (Dev. Hydrobiol. 172), 395-403.

Olrik, K. 1994. Phytoplankton-Ecology. Determining Factors for Distribution of Phytoplankton in Freshwater and the Sea, Ministry of the Environment, Denmark, Danish Environmental Protection Agency, Nofo Print, Elsinore, 183 pp.

Padisak, J. and Reynolds, C.S. 1998. Selection of phytoplankton associations in Lake Balaton, Hungary, in response to eutrophication and restoration measures, with special reference to the Cyanoprokaryotes. Hydrobiologia, 384: 41-53.

Padisak, J., Barbosa, F.A.R, Koschel, R. and Krienitz, L. 2003. Deep layer Cyanoprokaryota maxima are constitutional features of lakes: Examples from temperate and tropical regions. Archiv für Hydrobiologie, Special issues, Advances in Limnology, 58: 175-199.

Padisak, J., Crossetti, L. O. and Naselli-Flores, L. 2009. Use and misuse in the application of the phytoplankton functional classification: a critical review with updates. Hydrobiologia, 621: 1-19.

Reynolds, C.S. 1984. Phytoplankton periodicity: the interactions of form, function and environment variability. Freshwater Biol., 14: 111-142.

Reynolds, C.S. 1988. Functional morphology and the adaptive strategies of freshwater phytoplankton. In: C.D. Sandgren (Ed.), Growth and reproductive strategies of freshwater phytoplankton. Cambridge University Press, Cambridge: 388-433.

Reynolds, C.S., Huszar, V.L., Naselli-Flores, L. and Melo,

S. 2002. Towards a functional classification of the freshwater phytoplankton. J. Phytopl. Res., 24: 417-428.

Reynolds, C.S. 2006. The ecology of phytoplankton. Cambridge University Pres, Cambridge, 535 pp.

Round, F.E. 1953. An investigation of two bentic algal communities in Malharm Tarn, Yorkshire. J. Ecol., 41: 97-174.

Salmaso, N. and Padisak, J. 2007. Morpho-functional groups and phytoplankton development in two deep lakes (Lake Garda, Italy and Lake Stechlin, Germany). Hydrobiologia, 578: 97-112.

Solbrig, O.T. 1993. Plant traits and adaptive strategies: their role in ecosystem function. In: E.D. Schulze and H.A. Money (Eds), Biodiversity and Ecosystem Function Ecological Studies. Springer-Verlag, Berlin: 97-116.

Soylu, E.N. and Gönülol, A. 2006. Seasonal variation in the diversity, species richness and composition of the phytoplankton assemblages in a shallow lake. Cryptogamie Algologie, 27(1): 85-101.

Soylu, E.N., Maraşlıoğlu, F. and Gönülol, A. 2007. Phytoplankton seasonality of a shallow turbid lake. Algological Studies, 123: 95-110.

Stoyneva, M.P. 2003. Steady-state phytoplankton assemblage in shallow Bulgarian wetlands. Hydrobiologia, 502: 169-176.

Weithoff, G., Walz, N. and Gaedke, U. 2001. The intermediate disturbance hypothesis-species diversity or functional diversity? User's manual. US Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia, GA, EPA/600/3-87-039, 1993. J. Plankton Res., 23: 1147-1155.