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A Critical Inventory Of Freshwater Phytoplankton In Sicilian Lakes

Abstract

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This report provides a summary of the current knowledge about the species composition of freshwater phytoplankton assemblages in the major man made and natural lakes of Sicily. The development of freshwater phytoplankton studies in Sicily starts in 1979 and is carried out on 33 water bodies. The distribution of the major taxonomic groups (*Cyanophyceae*, *Chlorophyceae*, *Trebouxiophyceae*, *Ulvophyceae*, *Charophyceae*, *Chrysophyceae*, *Synurophyceae*, *Tribophyceae*, *Bacillariophyceae*, *Dinophyceae*, *Euglenophyceae*, *Cryptophyceae*) and the frequency of the most important *taxa* are reported. Blooming and uncommon species are highlighted. Moreover, the chlorophyte *Botryococcus terribilis*, the cyanophyte *Microcystis panniformis*, and the tribophyte *Pseudostaurastrum limneticum* are recorded for the first time in Italy.

Introduction

Both specific composition and structural dynamics of freshwater phytoplankton assemblages in 33 Sicilian lakes (Fig. 1) were examined through a series of limnological investigations carried out since 1979 (Calvo & al. 1984). These studies were realized in 5 natural and 28 artificial lakes. In 8 water bodies more detailed researches were carried out (Barone & al. 1982; Barone 1983; Barone 1985; Barone & al. 1989; Barone & al., 1990; Calvo & al. 1993; Barone & Naselli Flores 1994; Barone & Naselli Flores 1998; Naselli Flores & Barone 2002). Among the examined water bodies, only 1 is oligotrophic, 7 are hypertrophic, 12 eutrophic and 13 mesotrophic.

The ecological approach (Naselli Flores & Barone 1994; Barone & Naselli Flores 1995; Naselli Flores 1996; Naselli Flores 1998; Naselli Flores 2000) suggested that in Sicilian reservoirs physical factors - along with the specific morphology and hydrology of the water body - are more important in selecting species than chemical and biological components. Especially, the variations of the z_{mix}/z_{eu} ratio, due to the operational procedure to which reservoirs are generally subject, were recognised as switch allowing the assemblage shift. A comparative analysis in natural and man-made Sicilian water bodies with different trophic state (Naselli Flores & Barone 2000) showed that, under the same climatic condi-

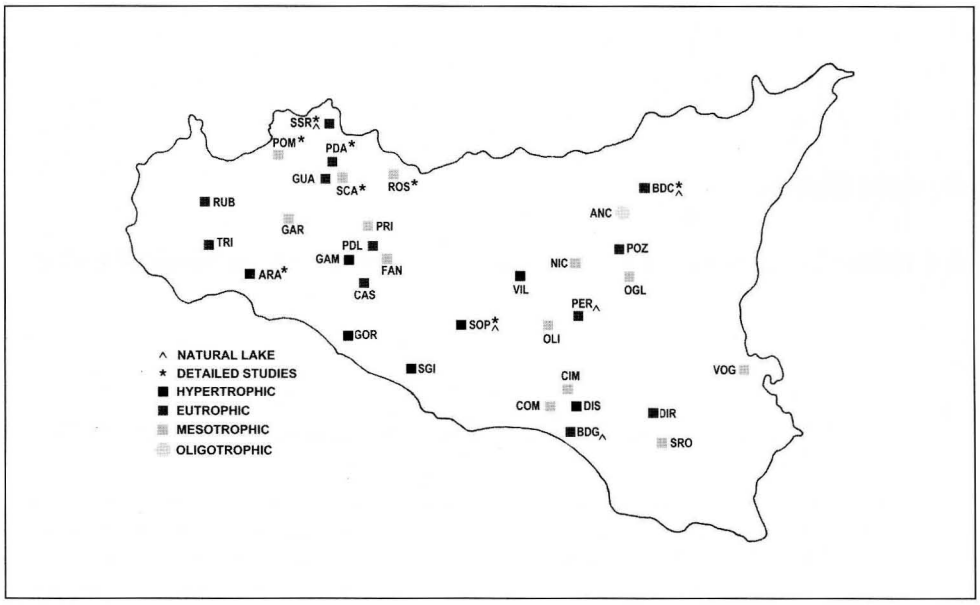

Fig. 1 Distribution of the examined lakes. ANC=Ancipa, ARA=Arancio, BDC=Biviere di Cesaro, CAS=Castello, CIM=Cimia, COM=Comunell, DIR=Dirillo, DIS=Disueri, FAN=Fanaco, GAM=Gammauta, GAR=Garcia, GOR=Gorgo, GUA=Guadalami, NIC=Nicoletti, OGL=Ogliastro, OLI=Olivo, PDA=Piana degli Albanesi, PER=Pergusa, POM=Poma, POZ=Pozzillo, PRI=Prizzi, ROS=Rosamarina, RUB=Rubino, SCA=Scanzano, SGI=San givanni, SOP=Soprano, SSR=Stagno di Santa Rosalia, TRI=Trinità, VIL=Villarosa, VOG=Vasca Ogliastro.

tions, autogenic (increase of biomass, decrease in light penetration and euphotic depth) and allogenic (use of the stored waters, anticipated breaking of the thermocline, increase of the mixing depth) processes may address the structure of phytoplankton assemblage in the same direction even though the quantity of biomass remains linked to nutrient.

The taxonomical approach allowed compiling, for the first time, a preliminary list of the freshwater phytoplanktic species occurring in Sicily. In this paper an inventory of the *taxa* identified up to now is reported, with regard to their frequency in the water bodies, also pointing up some significant species.

Discussion

In Table 1 both the list of the identified *taxa*, adopting the taxonomic classification proposed by Graham & Wilcox (2000), and the frequency of each *taxon*, calculated from its presence in the lakes, are reported. Altogether the identified taxa are 206. The distribution of the major taxonomic groups in the lakes, assessed from the frequency of the *taxa* identified, is described in Figure 2. As a whole organisms belonging to *Chlorophyceae*, *Bacillariophyceae* and *Cryptophyceae* occur in all the lakes, whereas algae included in

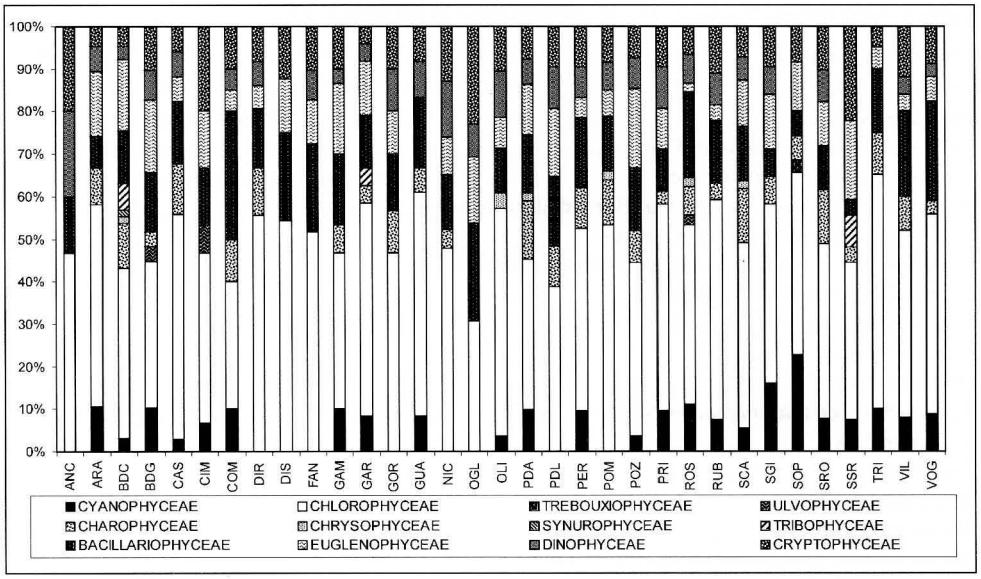

Fig. 2 Distribution of the major taxonomic groups in the lakes.

Trebouxiophyceae, *Ulvophyceae*, *Chrysophyceae*, *Synurophyceae*, *Tribophyceae* are uncommon.

Cyanobacteria were detected in 25 lakes. Among the 28 identified *taxa*, *Anabaena*, *Microcystis*, *Phormidium* and *Planktothrix* represent the most common genera. Water-blooms due to *Microcystis* spp., *M.* cf. *aeruginosa*, *M. wesenbergii*, *Anabaena* spp., *A. solitaria* f. *smithii* (Barone & Naselli Flores 1994; 2000), *A. solitaria* f. *planctonica*, *A. spiroides* f. *crassa* (Barone 1985), *Anabaenopsis elenkinii* and *Planktothrix agardhii* (Naselli Flores & Barone 2000) were observed, more frequently in the summer season and in the more eutrophic lakes. The uncommon *Anabaenopsis elenkinii* f. *circularis* was recorded in 3 lakes (Barone & Naselli Flores 1989). *Microcystis panniformis*, a water-bloom forming species, toxic and pantropical, common in reservoirs of tropical America (Komárek & al. 2000) was recently (2001) detected, for the first time in Italy, in the hypertrophic Lake Arancio (unpublished data).

Among chlorophytes, the Chlorophyceae are the most diversified taxonomic group with 84 taxa identified. The uncommon *Actinastrum aciculare* f. *africanum* (Naselli Flores & Barone 2000), *Paradoxia multiseta* (Barone 1979; Barone & Naselli Flores 1994) and *Spermatozopsis exsultans* (Barone & Naselli Flores 2002) were recorded. The small flagellate *Chlamydomonas* cf. *ehrenbergii*, blooming (279×10^6 cells l^{-1}) in winter and forming very thick surface scums, was observed in the hypertrophic Lake Soprano (Naselli Flores & Barone 2000). Moreover, the colonial *Botryococcus terribilis*, noted only from Brasil, Chad, Cuba and Czechoslovakia (Komárek & Marvan 1992), was recently (2001) identified in Lake Arancio (unpublished data).

Trebouxiophyceae (*Golenkinia radiata*) and *Ulvophyceae* (*Planctonema lauterbornii*) are very rare, whereas *Charophyceae*, represented by *Desmidiales* and *Zygnematales*

Table 1. *Taxa* list and frequency (F) of planktic algae in the sicilian lakes.

CYANOPHYCEAE	**F (%)**
Anabaena spp.	27
Anabaena aphanizomenoides Forti	3
Anabaena nodularioides Geitler	6
Anabaena solitaria f. *planctonica* (Brunnthaler) Komárek	6
Anabaena solitaria f. *smithii* Komárek	6
Anabaena spiroides f. *crassa* (Lemmermann) Elenkin	18
Anabaenopsis elenkinii V. Miller	6
Anabaenopsis elenkinii V. Miller f. *circularis* (G. S. West) Jeeji-Bai	9
Aphanizomenon spp.	6
Aphanotece sp.	3
Coelosphaerium kuetzingianum Nägeli	3
Limnothrix sp.	6
Lyngbya sp.	6
Merismopedia spp.	6
Microcystis spp.	30
Microcystis cf. *aeruginosa* (Kützing) Kützing	3
Microcystis cf. *flos-aquae* (Wittrock) Kirchner	30
Microcystis panniformis Komárek, Komárková-Legnerová, Sant'Anna, Azevedo & Senna	3
Microcystis viridis (A. Braun in Rabenhorst) Lemmermann	3
Microcystis wesenbergii (Komárek) Komárek in Kondrateva	3
Oscillatoria spp.	6
Phormidium spp.	12
Phormidium tenue (Agardh ex Gomont) Anagnostidis et Komárek	6
Planktothrix spp.	12
Planktothrix agardhii (Gomont) Anagnostidis et Komárek	3
Pseudanabaena spp.	3
Spirulina sp.	3
Woronichinia naegeliana (Unger) Elenkin	3
CHLOROPHYCEAE	
Actinastrum aciculare f. *africanum* (Huber-Pestalozzi) Compère	3
Actinastrum aciculare Playfair	3
Ankira sp.	3
Ankira judayi (G. M. Smith) Fott	12
Ankira lanceolata (Koršikov) Fott	6
Ankistrodesmus bibraianus (Reinsch) Koršikov	3
Ankistrodesmus fusiformis Corda	3
Botryococcus braunii Kützing	39
Botryococcus protuberans W. et G. S. West	3
Botryococcus terribilis Komárek & Marvan	3
Carteria spp.	36
Characium sp.	3
Chlamydomonas spp.	15
Chlamydomonas cf. *ehrenbergii* Golenkin	3

Table1. Continued

Chlamydomonas monadina Stein	3
Chlorococcum sp.	3
Coelastrum astroideum De Notaris	6
Coelastrum microporum Nägeli in A. Braun	39
Coelastrum reticulatum (Dangeard) Senn	15
Coenococcus sp.	3
Crucigenia quadrata Morren	12
Crucigenia tetrapedia (Kirchner) W. & G. S. West	55
Crucigeniella sp.	3
Crucigeniella rectangularis (Nägeli) Komárek	12
Dictyosphaerium pulchellum Wood	45
Dictyosphaerium tetrachotomum Printz	3
Didymocystis spp.	88
Dimorphococcus lunatus A. Braun	3
Elakatothrix gelatinosa Wille	45
Eudorina elegans Ehrenberg	6
Eutetramorus sp.	3
Gonium sp.	3
Kirchneriella irregularis (G. M. Smith) Koršikov	3
Korshikoviella sp.	3
Lagerheimia cf. *genevensis* (Chodat) Chodat	3
Lagerheimia subsalsa Lemmermann	24
Micractinium pusillum Fresenius	21
Monoraphidium spp.	24
Monoraphidium arcuatum (Koršikov) Hindák	30
Monoraphidium circinale (Nygaard) Nygaard	58
Monoraphidium contortum (Thuret) Komárková-Legnerová	70
Monoraphidium komarkovae Nygaard	24
Monoraphidium minutum (Nägeli) Komárkova-Legnerová	64
Monoraphidium tortile (W. & G. S. West) Komarková-Legnerová	64
Oocystis spp.	97
Oocystis lacustris Chodat	3
Pandorina morum (O. F. Müller) Bory	12
Paradoxia multiseta Swirenko	6
Pediastrum boryanum (Turpin) Meneghini	30
Pediastrum sp.	3
Pediastrum duplex Meyen	33
Pediastrum simplex Meyen	33
Pediastrum simplex Meyen var. *echinulatum* Wittrock	3
Pediastrum tetras (Ehrenberg) Ralfs	6
Phacotus lenticularis Stein	3
Planktosphaeria gelatinosa G. M. Smith	21
Pteromonas angulosa (Carter) Lemmermann	3
Quadrigula sp.	3
Radiococcus sp.	3
Scenedesmus spp.	64
Scenedesmus abundans (Kirchner) Chodat	3
Scenedesmus acuminatus (Lagerheim) Chodat	52

Table1. Continued

Scenedesmus acuminatus Chodat	9
Scenedesmus arcuatus Lemmermann var. *platydisca* G. M. Smith	3
Scenedesmus cf. *bijuga* (Turpin) Lagerheim	3
Scenedesmus dimorphus (Turpin) Kützing	3
Scenedesmus linearis Komárek	3
Scenedesmus cf. *magnus* Meyen	3
Scenedesmus obtusus Meyen	3
Scenedesmus opoliensis P. Richter	3
Scenedesmus opoliensis P. Richter var. *carinatus* Lemmermann	3
Scenedesmus quadricauda (Turpin) Brébisson *sensu* Chodat	79
Scenedesmus sempervirens Chodat	3
Schroederia setigera (Schröder) Lemmermann	9
Spermatozopsis exsultans Korschikoff	3
Sphaerocystis schroeteri Chodat	24
Syderocystopsis fusca (Koršikov) Swale	3
Tetrachlorella alternans (G. M. Smith) Koršikov	24
Tetraedron sp.	9
Tetraedron caudatum (Corda) Hansgirg	3
Tetraedron minimum (A. Braun) Hansgirg	73
Tetrastrum sp.	9
Treubaria setigera (Archer) G. M. Smith	3
Westella botryoides (W. West) De Wildeman	3
TREBOUXIOPHYCEAE	
Golenkinia radiata Chodat	3
ULVOPHYCEAE	
Planctonema lauterbornii Schmidle	9
CHAROPHYCEAE	
Closterium spp.	9
Closterium aciculare T. West	6
Closterium acutum Brébisson	27
Closterium acutum Brébisson var. *variabile* (Lemmermann) W. Krieger	45
Closterium limneticum Lemmermann	21
Closterium limneticum Lemmermann var. *fallax* R?□i?ka	9
Cosmarium spp.	45
Cosmarium bioculatum (Brébisson) Ralfs var. *depressum* (Schaarschmidt) Schmidle	3
Cosmarium humile (Gay) Nordstedt	3
Mougeotia cf. *gracillima* (Hassall) Wittrock	3
Mougeotia spp.	12
Staurastrum spp.	27
Staurastrum chaetoceras (Schröder) G. M. Smith	6
Staurastrum hexacerum (Ehrenberg) Wittrock	3
Staurastrum tetracerum (Kützing) Ralfs	18

Table1. Continued

Staurodesmus dejectum (Brébisson) ex Ralfs	3
Staurodesmus isthmosus (Heimerl) Croasdale	3
Teilingia granulata (Roy et Bisset) Bourrelly	3
CHRYSOPHYCEAE	
Dinobryon sp.	3
Dinobryon divergens Imhof	3
Dinobryon sociale Ehrenberg	9
Ochromonas sp.	3
SYNUROPHYCEAE	
Syncrypta cf. *volvox* Ehrenberg	3
TRIBOPHYCEAE	
Goniochloris spp.	9
Isthmochloron sp.	3
Ophiocytium capitatum Wolle	3
Pseudostaurastrum limneticum (Borge) Chodat	3
Tetraplektron sp.	3
BACILLARIOPHYCEAE	
Asterionella sp.	3
Aulacoseira ambigua (Grunow) Simonsen	27
Aulacoseira granulata (Ehrenberg) Simonsen	6
Chaetoceros muelleri Lemmermann	6
Cyclotella spp.	48
Cyclotella cf. *bodanica* Grunow	3
Cyclotella glomerata Bachmann	9
Cyclotella cf. *glomerata* Bachmann	3
Cyclotella meneghiniana Kützing	3
Cyclotella ocellata Pantocsek	24
Cyclotella stelligera Cleve et Grunow	3
Cymatopleura sp.	3
Cymbella spp.	6
Diatoma sp.	3
Diatoma tenuis Agardh	3
Fragilaria spp.	52
Fragilaria ulna (Nitzsch) Lange-Bertalot	12
Fragilaria ulna (Nitzsch) Lange-Bertalot var. *acus* (Nitzsch) Lange-Bertalot	36
Gyrosigma sp.	6
Mastogloia sp.	3
Navicula spp.	85
Nitzschia spp.	9
Nitzschia acicularis (Kützing) W. Smith	9
Nitzschia sigma (Kützing) W. Smith	3

Table1 Continued

Stephanodiscus spp.	97
Surirella sp.	3
Tabellaria fenestrata (Lyngbye) Kützing	3
EUGLENOPHYCEAE	
Colacium simplex Huber-Pestalozzi	12
Euglena spp.	82
Euglena acus Ehrenberg	9
Euglena cf. *allorgei* Deflandre	3
Euglena cf. *pisciformis* Klebs	3
Euglena cf. *subehrenbergii* Skuja	3
Euglena cf. *variabilis* Klebs	3
Euglena sanguinea Ehrenberg	3
Euglena tripteris (Dujardin) Klebs	21
Lepocinclis texta (Dujardin) Lemmermann	3
Phacus spp.	39
Phacus curvicauda Swirenko	9
Phacus longicauda (Ehrenberg) Dujardin var. *major* Swirenko	3
Phacus pyrum (Ehrenberg) Stein	3
Phacus tortus (Lemmermann) Skvortzov	33
Strombomonas spp.	24
Strombomonas verrucosa (Daday) Deflandre	3
Trachelomonas spp.	30
Trachelomonas caudata (Ehrenberg) Stein	3
Trachelomonas hispida (Perty) Stein	3
Trachelomonas hispida (Perty) Stein var. *coronata* Lemmermann	3
Trachelomonas ovata Roll	3
Trachelomonas volvocina Ehrenberg	48
DINOPHYCEAE	
Ceratium furcoides (Levander) Langhans	3
Ceratium hirundinella (O. F. Müller) Dujardin	58
Diplopsalis sp.	3
Gymnodinium spp.	67
Peridiniopsis spp.	3
Peridiniopsis cf. *elpatiewskyi* (Lemmermann) Bourrelly	3
Peridinium spp.	64
Peridinium palatinum Lauterborn	3
CRYPTOPHYCEAE	
Campylomonas reflexa (Skuja) Hill	88
Cryptomonas spp.	9
Cryptomonas cf. *erosa* Ehrenberg	88
Cryptomonas cf. *pyrenoidifera* Skuja	3
Cryptomonas cf. *rostrata* Troitzkaja	21
Plagioselmis nannoplanctica (Skuja) Novarino, Lucas et Morrall	100

orders, show more importance with 19 *taxa* identified. Desmids exhibit the highest diversity in a small natural lake (Barone & al. 1989), characterized by low pH values (< 7), but manifested a persistent and significant autumnal bloom with *Closterium limneticum* var. *fallax* in the hypertrophic Lake Arancio (Barone & Naselli Flores 1994). In this reservoir also the filamentous *Mougeotia* cf. *gracillima* showed a noteworthy autumnal bloom (Naselli Flores & Barone 1998).

Chrysophyceae and *Synurophyceae* (*Syncrypta* cf. *volvox*) are uncommon, but the colonial chrysophycean *Dinobryon divergens* was rising to an autumnal bloom in a small natural lake (Barone & al. 1989).

Organisms belonging to the *Tribophyceae* class are not very important members of the phytoplankton assemblages. Only 3 tribophycean *taxa* with low density were detected. *Pseudostaurastrum limneticum* (Mischococcales), cosmopolite species usually found in acid water (Bourrelly 1981) but seldom signaled, is recorded here for the first time in Italy from Lake Biviere di Cesarò, a small natural lake studied in detail (Barone & al. 1989).

The *Bacillariophyceae* class was represented by 27 *taxa*, but many small centric diatoms were not identified. In many lakes *Cyclotella* spp. spring bloom were observed (Calvo & al. 1993), whereas the colonial *Aulacoseira granulata* was showed a summer bloom in Arancio (Barone & Naselli Flores 1994). It is interesting to note that *Tabellaria fenestrata* and *Asterionella* sp. - very common *taxa* in the temperate lakes – were recorded only in Biviere di Cesarò.

The *Euglenophyceae*, exhibiting 23 *taxa*, are very common, especially in autumn. *Euglena*, *Phacus* and *Trachelomonas* are the main genera recorde. The species *Euglena sanguinea* causes a cyclic summer neustonic bloom in Biviere di Cesarò (Barone & al. 1989).

The *Dinophyceae* class was represented by 8 taxa. The more common are *Ceratium hirundinella*, *Gymnodinium* spp. and *Peridinium* spp. The rare *Ceratium furcoides* was found (2001) forming a bloom in Lake Arancio (unpublished data).

Among the *Cryptophyceae Campylomonas*, *Cryptomonas* and *Plagioselmis* are the more frequent genera. In particular, *Plagioselmis nannoplanctica* is the only species detected in all the lakes. *Cryptomonas* sp. and *Plagioselmis nannoplanctica* in early summer showed a significant bloom in Santa Rosalia pond (Barone & Naselli Flores, in press), a small temporary water body.

Concluding remarks

This review, showing the fragmentary knowledge about species composition of the freshwater phytoplankton assemblages in Sicily, must be considered as a preliminary information useful to advance the taxonomic studies, prerequisite for the development of a right water strategy management. To this end the achievement of a database with identification keys is in progress.

However, the data up to now collected enable to recognise the more common phytoplanktic functional groups (Reynolds & al. 2002). These groups (J, M, X1, X2, Y, W1, W2) are characteristic of small enriched lakes according to the hydrological and trophic features of most water bodies in Sicily.

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