Journal of Environmental Sciences Vol.17,No.3,pp.389—394,2005

ISSN 1001—0742
CN11—2629/X

Article ID: 1001-0742(2005)03-0389-06 **CLC number**: X524 **Document code**: A

Present status and changes of the phytoplankton community after invasion of *Neosalanx taihuensis* since 1982 in a deep oligotrophic plateau lake, Lake Fuxian in the subtropical China

ZHANG Xia, XIE Ping*, CHEN Fei-zhou, LI Yan-ling, LI Si-xin, GUO Ni-chun, QIN Jian-hui

(Donghu Experimental Station of Lake Ecosystems, State Key Laboratory for Freshwater Ecology and Biotechnology of China, Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan 430072, China. E-mail: xieping@inb.ac.cn)

Abstract: Phytoplankton assemblages in the subtrophical oligotrophic Lake Fuxian, the second deepest lake in China, were investigated monthly from September 2002 to August 2003. A total of 113 species belonging to seven phyla were identified, among them, a filamentous green alga, *Mougeotia* sp., dominated almost throughout the study period and comprised most of the total phytoplankton biomass. *Mougeotia* sp. has made a substantial development during the past decades: it was absent in 1957, only occasionally present in 1983, increased substantially in 1993, and became predominant in 2002—2003. It is likely that natural invasion of the Taihu Lake noodlefish (*Neosalanx taihuensis*) has led to a change of dominant herbivorous zooplankton from small to large calanoid, which has increased grazing pressure on small edible algae, and thus has indirectly favored the development of the inedible filamentous *Mougeotia* sp.

Keywords: phytoplankton community; *Neosalanx taihuensis*; oligotrophic plateau lake

Introduction

Introduction of exotic fish from the Yangtze River to lakes of Yunnan-Guizhou Plateau has led to significant ecological consequences of the lake ecosystem. So far, most concerns have been on the extinction of endemic fish species (Yang, 1994; Xie, 1997; 2001), but little is known about the changes of other components (i.e., phytoplankton assemblages) of the ecosystem after the invasion of exotic fish.

Lake Fuxian (212 km^2 in surface area) located in the central Yunnan Province, is a subtropical oligotrophic freshwater lake. It is the second deepest lake in China, with a maximum depth of 155 m. This plateau lake contains 25 relict native fish (12 are endemic to this lake) (Yang, 1995). There is a small shallow eutrophic lake, Xingyun Lake, adjacent to Lake Fuxian. Both lakes are connected by a natural hollow waterway (Gehe River), and water from Xingyun Lake naturally flows into Lake Fuxian. In 1982—1984, 0.21 million fingerlings of the Taihu Lake noodlefish (*Neosalanx taihuensis*) from the Yangtze River were introduced into Xingyun Lake. The noodlefish of Xingyun Lake invaded naturally into Lake Fuxian through Gehe River, and soon built natural population there. Before the invasion of *N. taihuensis*, an endemic species, *Anabarilius grahami* (Regan), dominated with an annual production of 300—400 t (Yang, 1995). The production of *N. taihuensis* was only 8 t in 1987 but increased sharply to over 1000 t/a since 1990, while the production *A. grahami* declined dramatically to only 1—2 t/a at present.

However there have been only very limited information on phytoplankton assemblage in this lake so far. The purposes of this research were to describe the present status of phytoplankton assemblage through an annual sampling program at 12 sites in 2002—2003, and to describe the long-term changes of dominant phytoplankton during 1957—2003 with emphasis on the possible role of the invasion of exotic fish in triggering the changes after mid-1980s.

1 Materials and methods

Lake Fuxian (24°17′—37′N, 102°49′—57′E, altitude 1721 m) is a subtropical deep lake with a volume of 189 × 10^8 m^3. Its maximum and average depth are 155 m and 89.7 m, respectively. The northern basin of the lake is wider and deeper than the southern basin (Fig. 1). The average annual rainfall is about 951.4 mm. In general, rainy season occurs from May to October, and dry season from November to April. The lake shows a long water retention time of about 180 year. Generally thermoline initially occurs in late March, and stable stratification is observed in July. Then the thermoline gradually deepens and disappears completely after December. Theoretically, the thickness of thermoline of Lake Fuxian is 22.4 m (NIGLAS, 1990).

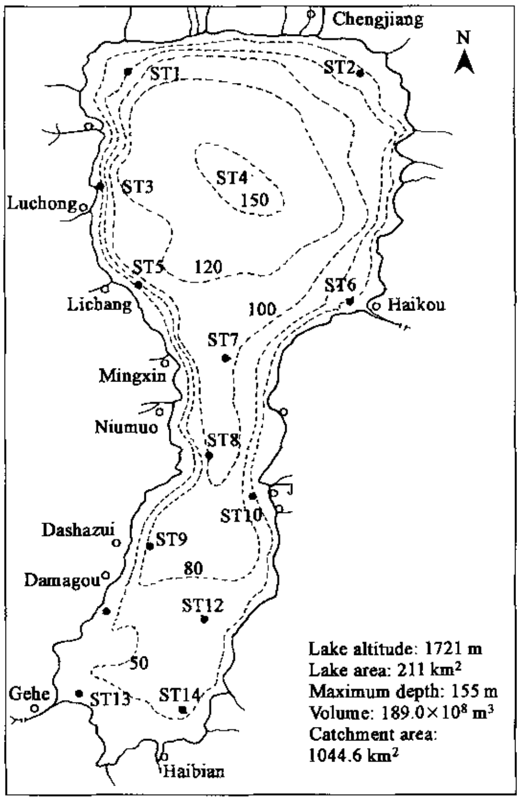

Fig. 1 Map of Lake Fuxian

The main inflow is Gehe watergate through which high nutrient water flows from the eutrophic Xingyun Lake. The river inflow in mid-summer is 0.4—0.5 m^3/s with a discharge rate of 20 m^3/s (Kenji, 2002). Haikou River, the

---

Foundation item: The Key Project of Chinese Academy of Sciences (No. KSCX1-SW-13). * Corresponding author

only outflow, is situated in the east edge of the lake with an average discharge of 3.59 m^3/s. With the increase of resident population, the development of tourism, and more noticeably, discharge of eutrophic waters from Xingyun Lake to Lake Fuxian, nutrient contents showed a steady increase during the past decades. Nevertheless, Lake Fuxian is still at an oligotrophic status according to the standard of OECD (OECD, 1982).

Water samples at 14 stations were collected monthly from September in 2002 to August in 2003. The depth of the stations was between 19—150 m with an average of 81.2 m. Because the deepest point of the lake located in ST13 and ST4 near to the Gehe River, at ST 4 and ST 13, samples were collected at a series of discrete depths from the surface to the bottom(ST4: 0, 5, 10, 15, 20, 30, 40, 50, 100 m; ST13: 0, 5, 10, 15, 20, 30 m). For the rest 12 regular stations, each sample was a mixture of 5—8 sub-samples collected from different depths(0, 5, 10, 15, 20, 30, 40, 50). Data of nutrients, phytoplankton and zooplankton on each sampling date are mean of the 12 regular sampling stations.

In the laboratory, total phosphorus (TP) concentration was measured by colorimetry after digestion of the total samples with $K_2S_2O_8$ + NaOH to orthophosphate (Ebina, 1983). Total Nitrogen was digested simultaneously with TP. After digestion, TN was measured as nitrate and absorbance was measured at 220 nm. Nitrate (NO_3^--N) was analyzed using the automated Korolev/cadmium reduction method.

The values of temperature, pH, conductivity and water transparency were obtained *in situ*. Temperature was measured by a WMY-01 digital thermometer. pH and conductivity were determined with PHB-4 pH meter and DDB-303A, respectively. Dissolved oxygen (DO) was measured by a JPB-607 DO meter. Transparency was measured by a Secchi disk.

Chlorophyll *a* was determined by a spectrophotometer (Lorenzen, 1967) after filtration on Whatman GF-C glass filters and 24 h extraction in 90% acetone. Phytoplankton determinations were carried out on samples preserved in acetic Lugol's solution and formaldehyte (Saraceni, 1974) and sedimented for 48 h. Then the supernatant was removed and the residue was collected. After completely mixing, 0.1 ml concentrated samples were counted directly through a 0.1 ml counting chamber using a Nikon microscope at a magnification of 400 ×. Phytoplankton species were identified according to Hu (Hu, 1979). The count (including the colonial forms) was conductal by enumerating single cells. Algal biomass (expressed as mg fresh weight L^{-1}) was estimated from the closest geometric volume of each taxa, assuming a mean density of 1 g/mm^3. If the size of species in a taxa differ distinctly, the individuals of that species were divided into several cell size classes in order to determine the volume accurately.

Crustacean zooplankton was sampled using a 5 L modified Patalas bottle sampler. Samples were obtained by straining 50—80 L lake water collected from different depths through a 64 μm mesh plankton net and were preserved by the methods of Haney (Haney, 1973). Crustacean plankton was identified according to Chiang (Chiang, 1979) and Sheng (Sheng, 1979) and counted under a magnification of 6.3 × 10.

2 Results

Annual means and ranges of the main physical, chemical and biological parameters in Lake Fuxian are listed in Table 1. Pronounced stratification was observed from April to November and a complete homogenization took place from January to March. Water temperature was the highest in July (24.6℃) and the lowest in February (14℃). The relative low Secchi depth (Sd) occurred in March, July and November. In general, Sd was higher in the north basin than in the south basin.

Table 1 Annual means and ranges of physical, chemical and biological parameters in Lake Fuxian

	Mean	Range
Secchi disc depth, m	7.01	5.19—7.91
Conductivity, μS/cm	287.0	237.8—345.6
pH	8.73	8.25—9.32
Dissolved oxygen content, mg/L	9.63	7.32—13.83
TP, μg/L	20.7	18.9—21.8
TN, μg/L	198.1	168.5—213.0
NO_3-N, μg/L	40.2	10.0—106.0
Chlorophyll *a*, μg/L	2.65	1.27—5.68
Density, × 10^4 ind./L	14.3	3.8—27.6
Biomass, mg/L	0.419	0.064—0.853

The maximum pH was in April. The maximum conductivity was in August. Mean DO concentration had a maximum in October and a minimum in September. The minimum concentrations (about 10 μg/L) of NO_3-N were recorded in November and March (Fig.2).

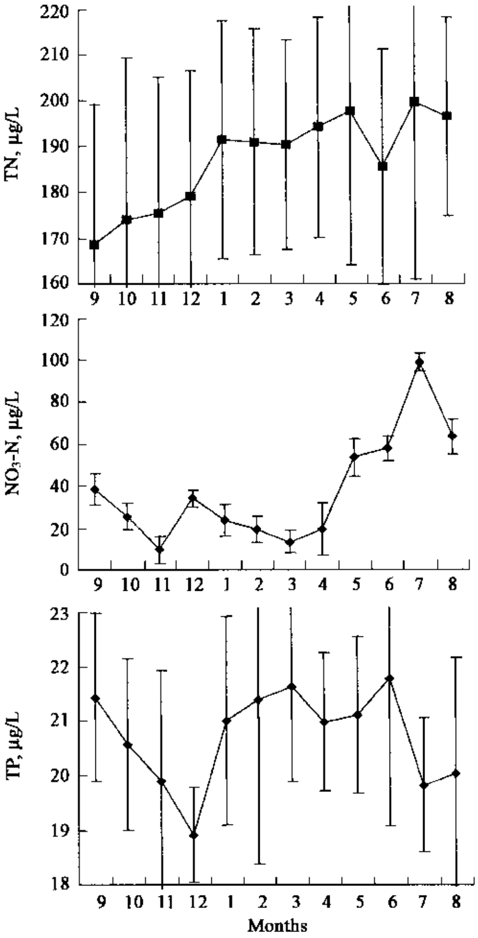

Fig.2 Temporal variations of TN, NO_3-N and TP at 12 regular stations

The cladoceran *Bosmina longirostris*, and the calanoid *Phyllodiaptomus tunguidus* dominated the crustacean plankton community during the study period (Fig. 3). The highest density peak of total planktonic crustaceans was present in April (24.8 ind./L) when *Daphnia* sp. contributed to 99% of total cladocerans. The density of cyclopoids was below 0.3 ind./L throughout the study period.

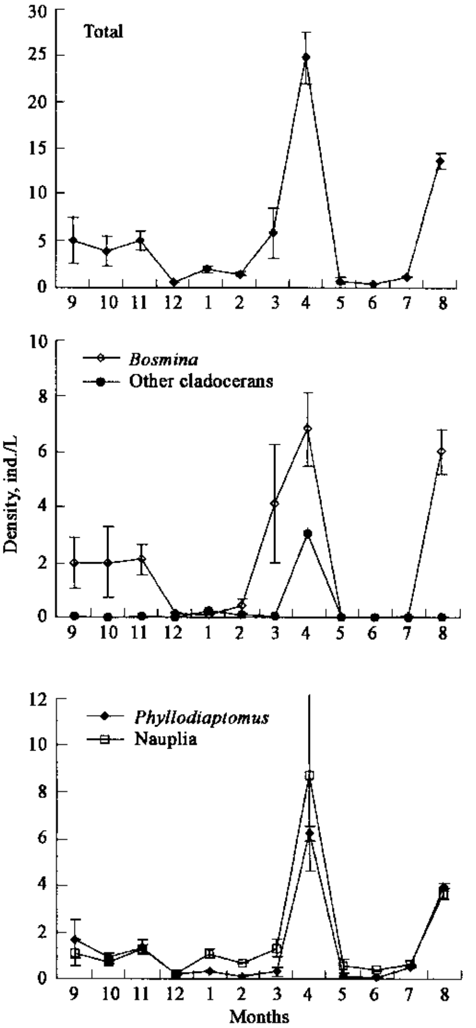

Fig.3 Temporal variations in the density (ind./L) of crustacean plankton in regular samples

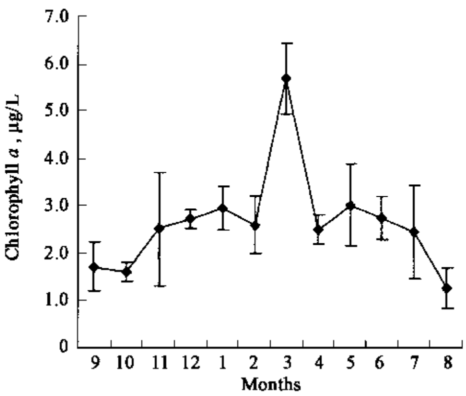

Fig.4 Temporal variations of total algal biomass(μg/L)

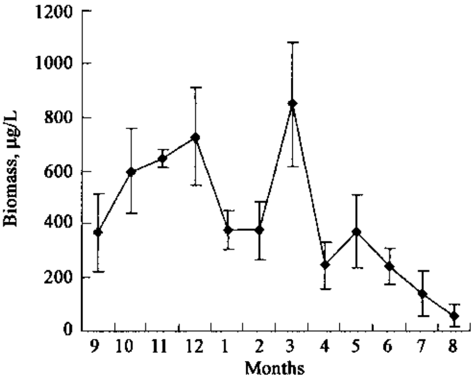

Fig.5 Temporal variations of chlorophyll *a*(μg/L)

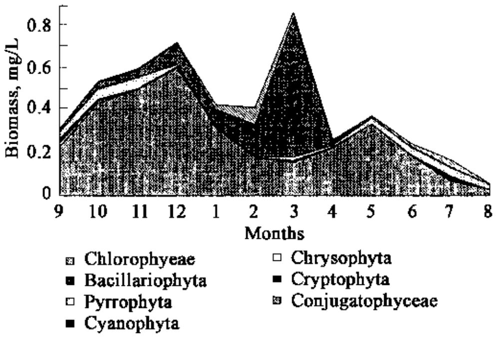

Fig. 6 Temporal variations of biomass (μg/L) values subdivided by algal classes in regular samples

Both chlorophyll *a* concentration and total algal biomass showed a high peak in March, and a minimum value in August. They showed a quite similar seasonal dynamics(Fig. 4). Dense populations of centric diatoms contributed greatly to the maxima of chlorophyll a and algal biomass(Fig.5).

During the study period, 113 species belonging to seven phyla (Chlorophyta, Cyanophyta, Bacillariophyta, Pyrrophyta, Cryptophyta, Chrysophyta, Euglenophyta) were identified. Among the phytoplankton assemblages, *Mougeotia* sp. were dominant throughout the study period (Figs.6—9).

During the complete thermal homogenization of the water column (from December to January), *Mougeotia* sp. and *Fragilaria crotonensis* were dominant, and *Mougeotia* sp. reached a maximum biomass of 0.59 mg/L in December. When water temperature reached the lowest in February, the filamentous green alga *Ulothrix subtilissima* showed a high peak value (Fig. 10). In the early spring (March), the unicellular centric diatom *Cyclotella rhomboideo-elliptia* contributed greatly to the phytoplankton assemblages. With the appearance of thermal stratification at the end of March, dominance of diatoms was quickly replaced by *Mougeotia* sp.

In the summer (July—August), when thermal stratification was intensified, *Mougeotia* sp. declined greatly and the phytoplankton community was more diverse, and *Coelastrum reticulatum*, *Microcystis aeruginosa*, and *Tetraedron minimum* had also made substantial development. It should be noted, however, that *Microcystis aeruginosa* colonies were present mostly at the station 13 near to the Gehe River where *Microcystis* colonies were transported from the eutrophic Xingyun Lake.

At the beginning of the autumn, *Microcystis aeruginosa* and *Tetraedron minimum* disappeared soon, and *Cryptomonas*, *Dinobryon* and *Pyrrophyta* showed substantial increases, and *Mougeotia* became dominant again in the

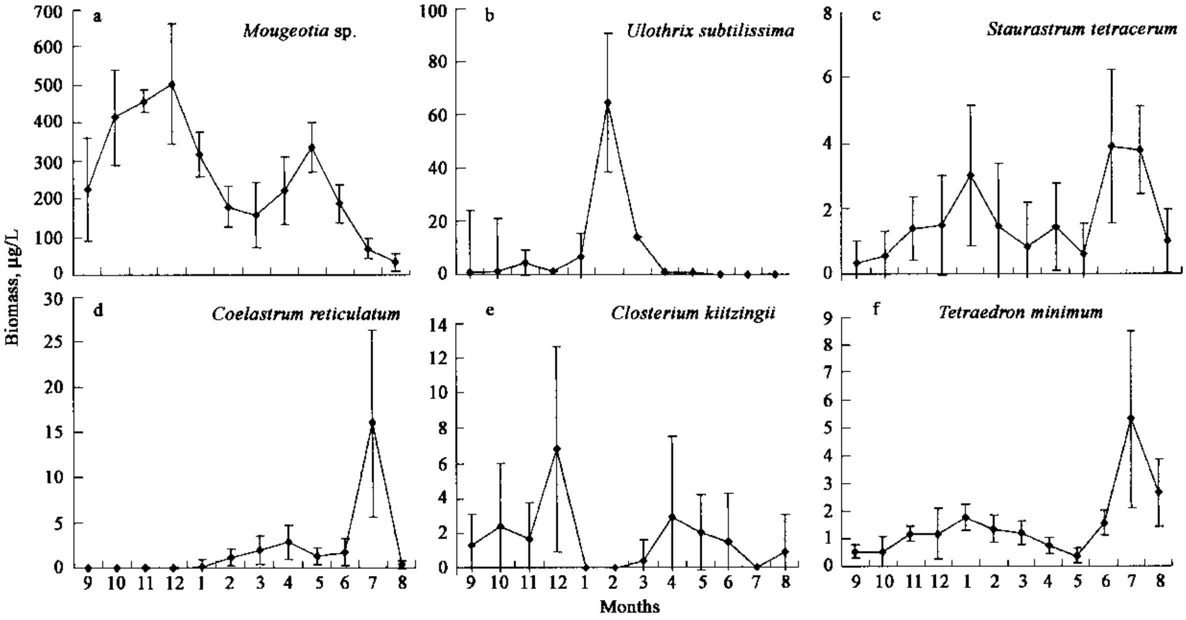

Fig.7 Temporal variations of biomass(μg/L) for the most abundant Chlorophyta species: Conjugatophyceae(a.c.e) and Chlorophyceae(b.d.f)

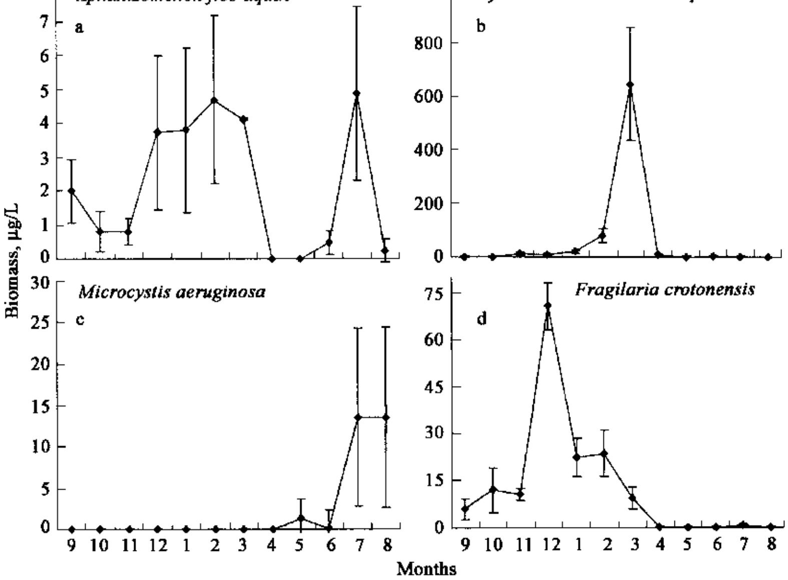

Fig.8 Temporal variations of biomass(μg/L) for the most abundant Cyanophyta(a, c) and Bacillariophyta(b, d) species

phytoplankton community.

3 Discussion

There have been obvious changes in dominant species in Lake Fuxian during the past decades(Table 2). A colony-forming green alga, *Eudorina elegans* Erh. was the most dominant alga species(Li, 1963) in 1957. A filamentous green alga, *Ulothrix* sp., and a filamentous cynaobacterium *Aphanizomenon flos-aquae* became the most important two species(Xing, 1984) in 1989. The most important dominant changed from a desmid *Staurastrum indentatum* in 1989, to a dinoflagellate *Ceratinm hirundinella* in 1993, and to a filamentous green alga *Mougeotia* sp. in 2002—2003. During 1957—2003, although nitrogen and phosphorus showed substantial increases, phytoplankton abundance did not show obvious tendency, but great changes took place in algal the dominant species. The most significant change of phytoplankton assemblage since 1983 was the steady development of the filamentous *Mougeotia* sp.

In 1983, *Mougeotia* appeared at all sampling sites only in May and was occasionally detected in another three months (Xing, 1984). In 1993, this species appeared in the two survey months over the whole lake with a density of 16232 ind./L in May(Deng, 1996). In 2002—2003, it dominated phytoplankton community all the year in all sampling sites. Reynolds (Reynolds, 1997) classified *Mougeotia* as Association T which show preferential adaptation in more persistently mixed layers. *Mougeotia* sp. have their optimum conditions for growth beginning from oligo-mesotrophy (Nico, 2002). It can exist in a variety of habitats with a wide range of nutrient levels and pH(Table 3). Hillebrand(Hillebrand, 1983) observed its floating mats on several small ponds in the

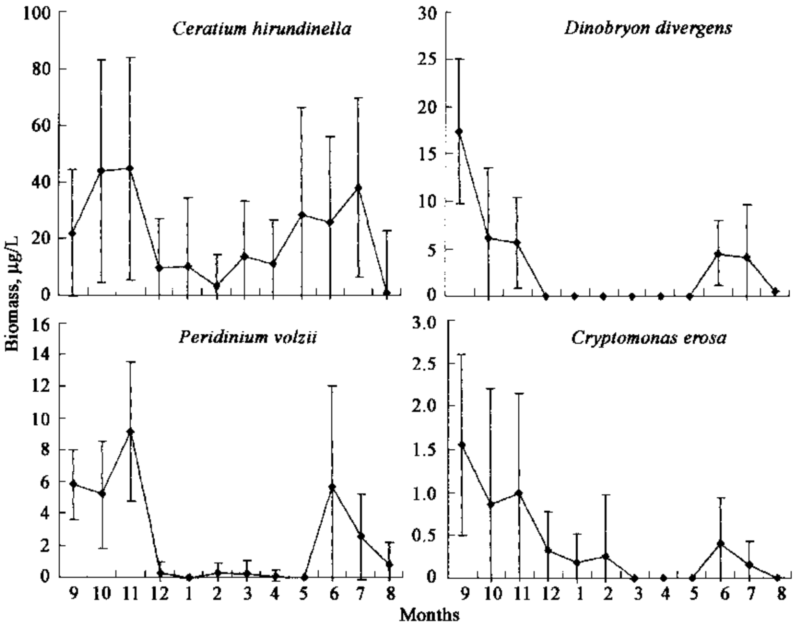

Fig.9 Temporal variations of biomass(μg/L) for the most abundant Pyrrophyta(left), Chrysophyta and Cryptophyta species(right)

Table 2 Comparison of dominant algal species, algal abundance and species number in Lake Fuxian in different study periods

Study period	1957(Jul.—Sep.)	1983 (Feb., May, Aug., Dec.)		1989(Apr., May)		1993(May, Aug.)		2002—2003	
	Dominant species	Dominant species	Species number	Dominant species	Species number	Dominant species	Species number	Dominant species	Species number
Chlorophyta	*Eudorina elegans* Erh.* *Staurastrum paradoxom*	*Ulothrix* sp.* *Ankistrodesmus* sp. *Crueigenia tetrapedia* *Staurastrum* sp.	20	*Staurastrum indentatum*.* *Mougeotia* sp. *S. manfeldtii var. annulatum* *S. tetracerum var. tortum*	16	*Staurastrum* sp. *Mougeotia parvala* *Coelastrum reticulatum*	31	*Mougeotia* sp.* *S. tetracerum* *S. indentatum*	62
Cyanophyta	*Aphanizomenon flos-aquae*	*A. flos-aquae**	13	*A. flos-aquae*	2	*A. flos-aquae*	16	*A. flos-aquae*	24
Bacillariophyta	*Cyclotella rhamboideo-elliptica*	*C. rhomboideo-elliptica* *C. bodanica Eul.*	4	*C. rhomboideo-elliptica* *Stephanodiscus minutulus*	49	*Cyclotella* sp.	13	*C. bodanica Eul.* *C. rhomboideo-elliptia* *Fragilaria crotonensis* Kitton.	20
Chrysophyta					1	*Dinobryon divergens*	2	*Dinobryon divergens*	1
Pyrrophyta	*Ceratium hirundinella*	*C. irundinella*	1		2	*C. hirundinella**	2	*C. hirundinella*	2
Euglenophyta			1				1		2
Charophyta							1		
Cryptophyta	*Chroomonas* sp.								2
Total algal (mg/L)		0.46		0.921				0.419	
Reference	Li *et al*. (1963)	Xing (1984)		Wei *et al*. (1994)		Deng *et al*. (1996)		Present study	

Note: * Indicates the most important dominance

Table 3 Occurrence or abundance of *Mougeotia* and concentrations of nutrient(μg/L) in various freshwater systems

	Location	pH	TP, μg/L	NO_3-N, μg/L	TN, μg/L	Sources
Lake Fuxian	Yunnan Province, China	8.3—9.3	18.9—21.8	10—106	169—213	Present study
Tundra ponds	Smoking Hills, Cape Bathurst, NWT	8.1—8.2				James, 1996
East Twin Lake	Portage Co., Ohio	4.5				James, 1996
Little Rock Lake	North-central, Wisconsin	4.7—5.1				James, 1996
Lake Garda	South of Alps, Italy	8.0—8.9	12—20	50—320		Nico, 2002
Caohai Lake	Guizhou Province, China	8.0		25		Wang, 1998
Yilong Lake	Yunnan Province, China	8.4—10		92—165		Wang, 1998

Netherlands. The ponds were all eutrophic and bicarbonate-rich, with pH ranging from 7.5 to 9.9. Fairchild and Sherman (Fairchild, 1993) found that the proportion of *Mougeotia* was highest in the acidic lakes (pH 5.2—5.3). However, the experimental results of James (James, 1996), revealed that *Mougeotia* reached the maximum growth and highest gross photosynthesis at pH 8.

In a subtropical oligotrophic lake, Lake Garda, a progressive increase of *Mougeotia* and *Closterium* followed the beginning of eutrophication, and *Mougeotia* sp. showed

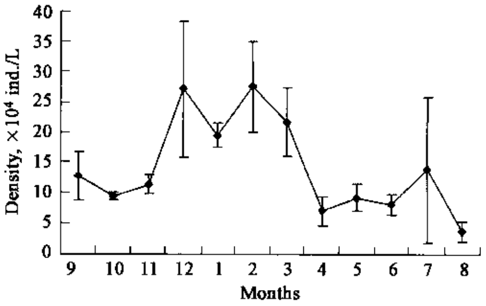

Fig.10 Temporal variations of density($\times 10^4$ ind./L) for regular samples

an optimum growth in a mesotrophic level(Nico, 2002). In Lake Fuxian, both TP and TN showed substantial increases from 1983 to 2002: from below or around 10 μg/L to 20.7 μg/L for TP, and from 0.12 mg/L to 0.198 mg/L for TN. It may be difficult to conclude that such increases in TP and TN concentrations have triggered the massive growth of *Mougeotia* in our study lake, considering their presence in wide ranges of nutrient levels.

The structure of a phytoplankton community is not only determined by nutrient condition (the so called bottom-up forces), but also dependent on grazing pressure by herbivorous animals(the so called top-down forces)(Shapiro, 1980). Since the invasion of the exotic fish, *Neosalanx taihuensis*, in about 1982, the endemic fish, *Anabarilius grahami*, gradually lost its dominance. Both *A. grahami* and *N. taihuensis* primarily prey on zooplankton; diet of these two species is similar(Yang, 1995). In Dianchi Lake, *N. taihuensis* mainly preyed on *Neutrodiaptomus mariadvigae mariadvigae*, since their frequency of occurrence in the food items of this fish reached 67%—100% (Liu, 1994). A high grazing pressure by this fish led to an obvious reduction in abundance of this copepod(Liu, 2001), but an obvious increase in abundance of a large-bodied calanoid *Neodiaptomus schmacheri* (Wang Z. R. private communication). In Lake Fuxian, *N. taihuensis* mainly feed on *Bosmina longirostris* and *Phyllodiaptomus tunguidus*, the average frequency of occurrence ratio in the food of the fish was 74% and 55%, respectively(Qin, unpublished data). Quite similar to Lake Dianchi, invasion of *Neosalanx taihuensis* led to a change of dominant crustacean zooplankton from a small calanoid, *N. mariadvigae* (1.13—1.35 mm for adult female) to a large calanoid *Phyllodiaptomus tunguidus* (1.7—1.96 mm for adult female). In oligotrophic Lake Inari, the invasion of a zooplanktivore fish, Vendace, has led to a shift in both zooplankton size and species composition: the smallest zooplankton species in the community (*Bosmina longirostris*) has replaced larger cladocerans and the three most numerous cladoceran species were all significantly smaller (Thomas, 2001). These two invasive species (*N. taihuensis* and Vendace) select different size of prey which leads to different changes of the zooplankton community. In Lake Fuxian, the large calanoid may be more efficient in feeding on small-sized algae, according to Brooks and Dodson (Brooks, 1965). The filamentous *Mougeotia* are inedible by zooplankton due to its large size. It is likely that invasion of *N. taihuensis* has led to a change of dominant herbivorous zooplankton from small-sized calanoid to large-sized one, which has increased grazing pressure on small edible algae (e.g. *Chroomonas* sp.) and thus has indirectly favored the development of the inedible filamentous Mougeotia.

References:

Brooks J L, Dodson S I, 1965. Predation, body size and composition of plankton [J]. Science, 150: 28—35.

Chiang S C, Du N S, 1979. Fauna sinica, crustacea, freshwater cladocera[M]. Beijing: Science Press.

Deng X Y, Xu J H, 1996. Studies on algae of Lake Fuxian in Chengjiang County of Yunnan[J]. Journal Yunnan University, 18 (2): 139—145.

Ebina J, Tsutsui T, Shirai T, 1983. Simultaneous determination of total nitrogen and total phosphorus in water using peroxodisulfate oxidation [J]. Water Research, 17: 1721—1726.

Fairchild G W M, Sherman J W, 1993. Algal periphyton response to acidity and nutrients in softwater lakes: Lake comparison vs. nutrient enrichment approaches[J]. Journal of North American Benthological Society, 12: 157—167.

Haney J F, Hall D J, 1973. Sugar-coated *Daphnia*: a preservation technique for Cladoera[J]. Limnology and Oceanography, 18: 331—333.

Hillebrand H, 1983. Development and dynamics of floating clusters of filamentous algae[M]. In: Periphyton of freshwater ecosystems(R. G. Wetzel ed.). Junk. 31—39.

Hu H, Li R, Wei Y *et al*., 1979. Freshwater algae in China[M]. Shanghai: Science Press.

James M G, Arancibia-Avila P, Graham L E, 1996. Physiological ecology of a species of the filamentous green alga *Mougeotia* under acidic conditions: Light and temperature effects on photosynthesis and respiration[J]. Limnology and Oceanography, 41(2): 253—262.

Kenji O, Michio K, Mitsuru S *et al*., 2002. On the micro ecosystem in the connected lakes-study on the Yunnan plateau lakes, shallow Xingyun Lake and deep Lake Fuxian[J]. Yunnan Geography and Environment Research, 14 (2): 10—19.

Li S H, Yu M J, Li G Z *et al*., 1963. Limnological survey of the lakes of Yunnan Plateau[J]. Oceanologia et Limnologia Sinica, 5(2): 87—114.

Liu Z W, Zhu S Q, 1994. Food and feeding behaviour of ice-fish(*Neosalanx taihuensis*) in Dianchi Lake[J]. Acta Zoologica Sinica, 40(3): 253—261.

Liu Z W, 2001. The introduction of icefish, *Neosalanx taihuensis* Chen, in China with several reference to the subtropical lakes of the Yunnan Plateau (southwest China) [J]. Verhandlungen Internationale Vereinigung fur Theoretische und Angewandte Limnologie, 27: 3877—3880.

Lorenzen C J, 1967. Determination of chlorophyll and pheo-pigments: spectrophotometric equations[J]. Limnology and Oceanography, 12: 343—346.

Nico S, 2002. Ecological patterns of phytoplankton assemblages in Lake Garda: seasonal, spatial and historical features[J]. Journal of Limnology, 61(1): 95—115.

Nanjing Institute of Geography and Limnology of Chinese Academy of Science (NIGLAS), 1990. Lake Fuxian[M]. Beijing: Ocean Press.

OECD, 1982. Eutrophication waters. Monitoring, assessment and control[M]. Paris: OECD.

Reynolds C S, 1997. Vegetation processes in the pelagic: a model for ecosystem theory[M]. Oldendorf: Ecology Institute.

Saraceni C, Ruggin D, 1974. Techniques for sampling water and phytoplankton [M]. In: A manual on methods for measuring primary production in aquatic environments (R. A. Vollemoveider ed.). IBP Handbook 12. Oxford: Blackwell. 5—7.

Shapiro J, 1980. The importance of trophic-level interactions to the abundance and species composition of algae in lakes[M]. In: Hypertrophic ecosystems (J. Barica and L. R. Moore ed.). Junk Publisher, The Hague. 105—116.

Sheath R G, Cole K M, 1992. Biogeography of stream macroalgae in North America[J]. Journal of Phycology, 28: 448—460.

Sheng J R, 1979. Fauna sinica, crustacea, freshwater copepoda[M]. Beijing: Science Press.

Thomas B, Amundsen P, 2001. The competitive edge of an invading specialist [J]. Ecology, 82(8): 2150—2163.

Wang S M, Dou H S, 1998. China lakes[M]. Beijing: Science Press.

Wei Y X, Li R H, Shi Z X *et al*, 1994. A survey of the phytoplankton and assessment of the water quality and trophic characteristics of three big lakes from Yunnan plateau[M]. In: Compilation of reports on the survey of algal resources in south-western China (Shi Z. X, Wei Y. X. *et al*. ed.). Beijing: Science Press.

Xie P, Chen Y, 1997. Threats to biodiversity in Chinese inland waters[J]. Ambio, 28: 674—681.

Xie P, Chen Y. 2001. Invasive carp in China's plateau lakes[J]. Science, 294: 999—1000.

Xing Z M, 1984. Phytoplankton in Lake Fuxian[R]. In: Investigation report on fishery resource in water system of Nanpanjiang River(Institute of Aquatic Product in Yunnan Province(IAP)ed.).

Yang J X, Chen Y R, 1995. The biology and resource utilization of the fishes of Lake Fuxian, Yunnan[M]. Kuming: Yunnan Science and Technology Press.

Yang J X, Chen Y R, He Y, 1994. Studies on fish diversity in plateau lakes of the central Yunnan. China[J]. Biodiversity, 2(4): 204—209.

(Received for review July 16, 2004. Accepted September 19, 2004)