

Diversity and Seasonal Succession of the Phytoplankton Community in Doi Tao Lake, Chiang Mai Province, Northern Thailand

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ABSTRACT.– The diversity and seasonal succession of phytoplankton were studied in Doi Tao lake, Chiang Mai, Thailand during September 2003 through to August 2004. The phytoplankton communities consisted of 162 species in 98 genera of 6 divisions. The number of species and density of phytoplankton showed high seasonal variation with high species number and density of phytoplankton in winter and summer, but low in the rainy season. Cyanophytes had the highest density during the winter and summer with three dominant species viz.: *Cylindrospermopsis philippinesis*, *Lyngbya limnetica* and *Oscillatoria* sp. Chrysophytes contributed the highest phytoplankton density in the rainy season with a dominant species, *Aulacosiera granulata*. Phytoplankton communities had the highest and lowest Shannon-Weaver diversity indices in the winter and summer, respectively. The highest Evenness index occurred in both the winter and rainy seasons, whereas the minimum was in winter. Sequential seasonal phytoplankton succession in Doi Tao lake was divisions Cyanophyta followed by Chrysophyta.

KEY WORDS: Doi Tao lake; phytoplankton diversity; seasonal succession

INTRODUCTION

Phytoplankton are defined as free-floating unicellular, filamentous and colonial organisms that grow photo-autotrophically in aquatic environments. They are the basis of food chains and food webs which directly provide food for zooplankton, fishes and some aquatic animals (Millman et al., 2005;

Shubert, 1984). Phytoplankton abundance and diversity are widely used as biological indicators of still-water quality in lakes and reservoirs. The density and species composition of phytoplankton in tropical lakes and reservoirs demonstrate particular annual biological characteristics (Palmer et al., 1977; Shubert, 1984; Washington, 1984; Pongswat et al., 2004).

Phytoplankton succession in open lakes depends on the availability of nutrients, hydraulic retention time, temperature, light intensity and transparency. Phytoplankton

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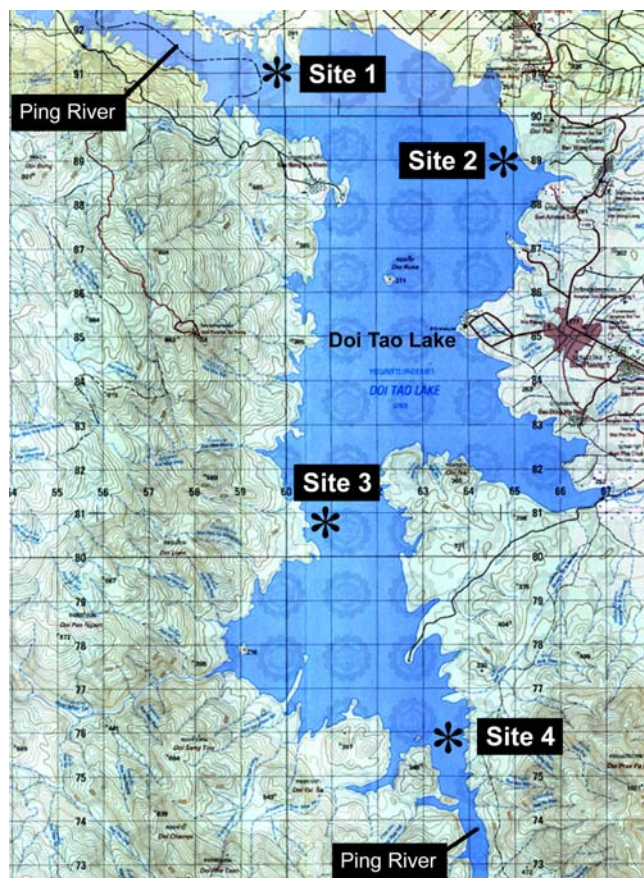


FIGURE 1. Map of Thailand showing the location of Doi Tao lake and the four sampling sites.

communities usually undergo a fairly predictable annual cycle, but some species may grow explosively and form blooms. (Toman, 1996; Hinder et al., 1999; Vaultot, 2001). Light limitation by high turbidity is another factor that frequently controls phytoplankton growth either during the whole year or seasonally (Ariyadej et al., 2004; Domingues et al., 2005).

Diversity indices are applied in water pollution research to evaluate the effects of pollution on species composition (Archibald, 1972). Species diversity responds to changes in particular to stresses and limiting factors, thus reflecting many interactions which may

characterize communities. Changes in any environmental factor will consequently change diversity (Washington, 1984), as long as adaptation is either rare or nonexistent, or gene flow from non-adaptive areas is great. The coexistence and avoidance of phytoplankton species fall into two categories: (i) the equilibrium theory of competition predicts that different species can coexist by being limited by different resources, whilst (ii) disequilibrium approaches predict that environmental variability permits the coexistence of species competing for the same resource. In application of these theories to biological

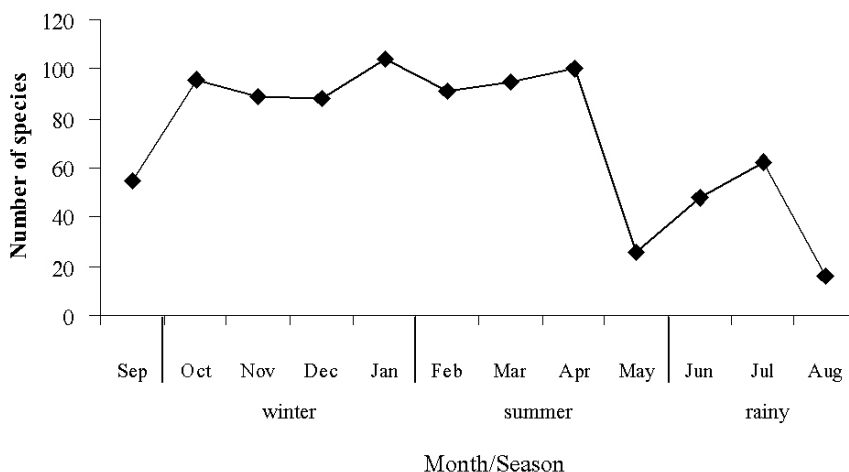


FIGURE 2. Total number of phytoplankton species recorded for each month in Doi Tao lake.

community descriptions, a high diversity value suggests a healthier ecosystem and a low diversity value a less healthy or degraded one. The reduction in numbers of species and the increase in number of individuals that characterize polluted areas results in significant decreases in values of diversity (Whitton, 1975; Sommer, 1993).

Doi Tao lake is an open lake located in the Doi Tao district of Chiang Mai province, northern Thailand. It has a capacity and surface area of 39,000,000 m³ and 6 km², respectively. The lake receives water from the Ping river before draining into the reservoir of Bhumibol dam. Fishing is the main activity of people who live in Doi Tao and nearby districts. The value of fishery products was several million baht per year (Doi Tao Fisheries Department, 2003). However, despite the economic and local importance of this lake, few researches have been done on limnology and biodiversity. The objective of this study was to investigate the diversity, species composition and seasonal succession of

phytoplankton in Doi Tao lake, in order to establish primary data that can be used for its sustainable fisheries management.

MATERIALS AND METHODS

Sample Collection and Processing

Samples of water at the surface (collected at the 30 cm depth from the surface) and the bottom samples (collected at the 30 cm above the bottom of the lake) were collected monthly from September 2003 until August 2004, from four sampling sites (the sampling sites were 10 m from the shore). The months were grouped together according to seasons as: winter was considered to be October to January; summer was February to May, rainy was June to September. The geographic coordinates of each site was determined by GPS. The location of the sampling sites were as follows: Site 1, Ban Huay Som at 18° 04' 09'' N, 98° 46' 56'' E (inlet of Doi Tao lake); Site 2, Tha Soon at 18° 04' 36'' N 98° 53' 05'' E (many raft-restaurants, travelling boats and fish cages at this site); Site 3, Ban Mae Lai

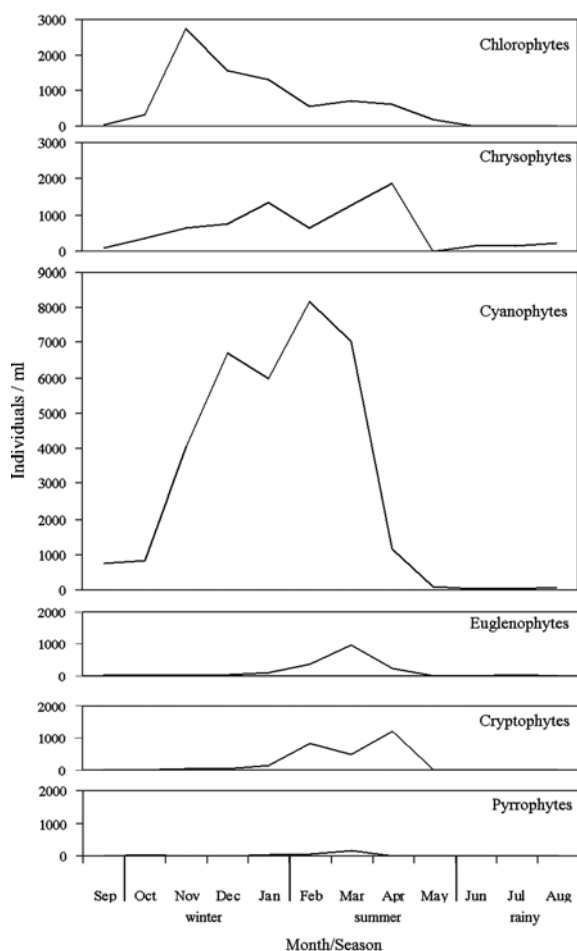


FIGURE 3. The density of each phytoplankton division observed in Doi Tao lake during the three annual seasons from September 2003 to August 2004.

at 17° 55' 8'' N 98° 50' 03'' (spillway of Mae Lai stream drain into the lake); and Site 4, Tha Bor Rae at 17° 55' 14'' N 98° 43' 55'' E (spillway of Doi Tao lake) (Fig. 1).

Phytoplankton Analysis

One thousand ml per each sample (8 samples per date) were concentrated by the

sedimentation method using 10 ml of Lugol's solution to a final volume of 10 ml and preserved with 1 ml Lugol's solution and stored in the dark, following the methods of Benson-Evan et al. (1985). Phytoplankton were identified and counted under a compound light microscope by the Drop microtransect method (Benson-Evans et al., 1985; Traichaiyaporn, 2000). The text books of Cox (1996), Desikachary (1959), Krammer and Lange-Bertalot (1991), Prescott (1978) and Smith (1950) were used to identify the phytoplankton. Phytoplankton species number and density were examined. Abundance of phytoplankton were ranked by the density of phytoplankton counted and recorded similarly to Benson-Evan et al. (1985) as dominant (>4,000 individuals/ml), abundant (1,000-4,000 individuals/ml), frequent (400-1,000 individuals/ml), occasional (80-400 individuals/ml), and rare (< 80 individuals/ml).

Diversity Analysis

Phytoplankton dynamics were examined using Shannon-Weaver index (Washington, 1984): $H' = -\sum (n_i / N) \ln (n_i / N)$

n_i is the abundance of species i , and N is the total number of individuals in the community.

The maximum diversity of a phytoplankton community occurs when all species are equally abundant in numbers or contribute equally to the total number of individuals. Maximum diversity is given

$$\text{by: } H_{\max} = \ln S$$

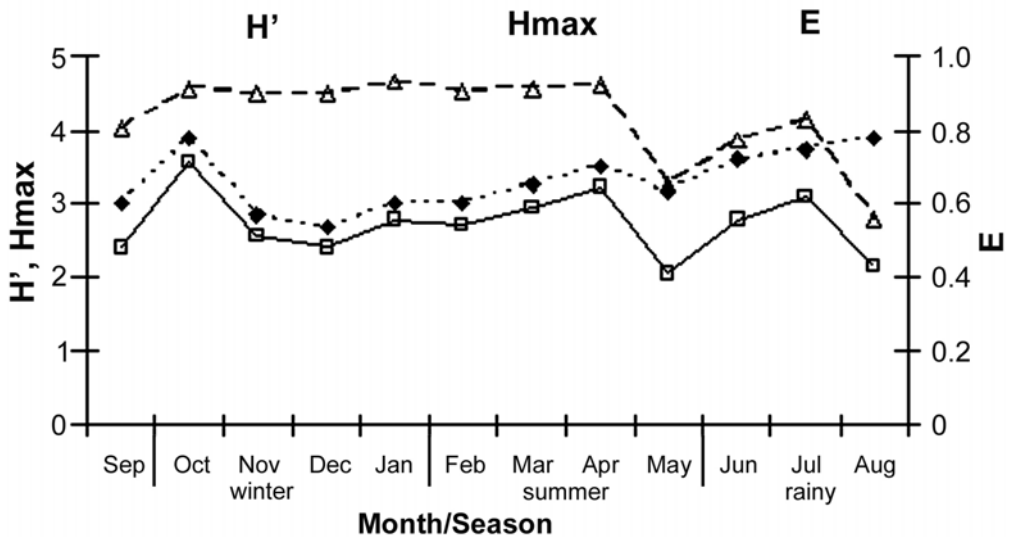


FIGURE 4. The Shannon-Weaver index (H'), Evenness index (E) and maximum diversity ($H_{\max}$) of phytoplankton communities in Doi Tao lake.

S is the total number of species of a community.

The Evenness-index (E) of the phytoplankton communities (Washington, 1984) was calculated by comparing the actual diversity to the maximum diversity.

$$E = H' / H_{\max}$$

RESULTS

Species Richness of Phytoplankton

The phytoplankton communities in Doi Tao lake in one year of sampling were composed of 162 species in 98 genera of 6 divisions. Division Chlorophyta had the highest number of species (64 species), followed by the division Chrysophyta (42 species), Cyanophyta (31 species), Euglenophyta (19 species), Cryptophyta (3 species) and Pyrrophyta (3 species). Species lists and abundance of phytoplankton are presented in Table 1.

The maximum species number of phytoplankton at anyone sampling time was 104 species, which was recorded in the winter (January), whereas only 16 different species were found in the rainy season (August) (Fig. 2, Table 2). In winter through to summer, Chlorophytes were the most specious division, whereas in the rainy season the maximum number of species belonged to the Chrysophyta division as the number of species decreased markedly in all other divisions. Photomicrographs of some phytoplankton are presented in Figures 3-6.

Density of Phytoplankton

The total number of phytoplankton ranged from a low density of 233 individuals/ml in July 2004 to 10,655 individuals/ml in March 2004. Low phytoplankton densities were observed in late summer and during the rainy season (233-690 individuals/ml) whilst high densities were seen in winter through to mid

TABLE 1. List of phytoplankton species in Doi Tao lake from September 2003 to August 2004.

Taxa / Seasons	Winter	Summer	Rainy	Taxa / Seasons	Winter	Summer	Rainy
Division Chlorophyta							
<i>Actinastrum</i> spp.	+	+	+	<i>Scenedesmus</i> spp.	+	+	+
<i>Ankistrodesmus</i> spp.	+	+	-	<i>Spermatozopsis erulians</i>	-	++	-
<i>Ankyra</i> sp.	++	++	+	Korsch			
<i>Botryococcus</i> sp.	+	-	-	<i>Staurastrum longbrachiatum</i> (Boreg) Gutwinski	+	+	+
<i>Chodatella</i> sp.	-	+	+	<i>Staurastrum</i> spp.	+	+	-
<i>Chlamydomonas</i> spp.	+++	++	+	<i>Stuarodesmus</i> sp.	-	+	+
<i>Chlorella</i> sp.	+	+	-	<i>Sphaerellopsis</i> sp.	-	-	-
<i>Chlorococcum</i> sp.	+	+	-	<i>Schroederia</i> sp.	+	+	-
<i>Chlorogonium</i> sp.	+	+	+	<i>Tetrachloridium</i> sp.	+	-	-
<i>Closteridium</i> sp.	+	+	-	<i>Tetrastrum</i> sp.	-	+	-
<i>Closterium</i> sp.	+	+	+	<i>Tetraedon minimum</i>	+	++	-
<i>Coelastrum</i> spp.	+	+	+	(A.Braun) Hansgirg			
<i>Collodictyon</i> sp.	+	-	-	<i>Treubaria</i> sp.	+	+	-
<i>Cosmarium</i> spp.	+	+	-	Division Chrysophyta			
<i>Crucigenia</i> spp.	+	+	+	<i>Achnanthes</i> sp.	+	+	+
<i>Dictyosphaerium</i> spp.	+++	++	+	<i>Amphora</i> sp.	+	+	+
<i>Dimorphococcus</i> sp.	++	+	-	<i>Attheya</i> sp.	+	+	-
<i>Dunaliella</i> sp.	+	-	-	<i>Aulacosiera granulata</i>	++	++	++
<i>Dysmorphococcus</i> sp.	+	-	-	(Ehrenberg) Ralfs			
<i>Gloeotila</i> sp.	+	+	-	<i>Chrysococcus</i> sp.	+	-	-
<i>Golenkinia</i> sp.	+	+	-	<i>Cyclotella</i> sp.	++	++	+
<i>Gonium pactorale</i> Müller	+	+	-	<i>Cymbella</i> spp.	+	+	+
<i>Gonium</i> sp.	+	-	-	<i>Cocconeis</i> sp.	-	+	-
<i>Eudorina</i> sp.	+	+	+	<i>Dinobryon sertularia</i>	+	+	-
<i>Lagerhimia</i> sp.	+	++	-	Ehrenberg			
<i>Micrastinium</i> sp.	+	+	+	<i>Centritractus</i> sp.	+	-	-
<i>Monoraphidium</i> sp.	+	+	+	<i>Fragilaria</i> spp.	+	++	+
<i>Pandorina</i> sp.	+	+	-	<i>Gomphonema</i> sp.	+	-	+
<i>Pediastrum</i> spp.	+	+	+	<i>Grammatophora</i> sp.	-	-	+
<i>Platymonas</i> sp.	+	-	-	<i>Gyrosigma</i> sp.	+	+	+
<i>Polyblepharides</i> sp.	+	-	-	<i>Merosila</i> sp.	+	+	+
<i>Polytomella</i> sp.	+	-	-	Note: +++++ = dominant, ++++ = abundant,			
<i>Radiococcus</i> sp.	+	+	+	+++ = frequent, ++ = occasional, + = not found			

summer (1,609-10,655 individuals/ml). The variation in phytoplankton numbers and diversity among seasons was high but not equal as across all divisions. For example,

Cyanophyta retained the highest density all through winter until mid summer whereas Chrysophyta was the most common division in late summer until the rainy season (Fig. 3, Table 2).

Table 1. Continues

Taxa / Seasons	Winter	Summer	Rainy	Taxa / Seasons	Winter	Summer	Rainy
Division Chrysophyta (cont.)				Division Cyanophyta			
<i>Raphidonema</i> sp.	+	-	-	<i>Oscillatoria</i> sp.	+++	++++	++
<i>Navicula</i> spp.	+	++	+	<i>Pseudanabaena</i> sp.	+++	++	+
<i>Nitzschia</i> spp.	+	++	+	<i>Raphidiopsis curvata</i> Fritsch & Rish	++	+++	+
<i>Oestrupia</i> sp.	-	-	+	<i>Raphidiopsis</i> sp.	+	-	+
<i>Pinnularia</i> spp.	+	++	+	<i>Romeria</i> sp.	-	+	+
<i>Rhizosolenia</i> sp.	+	+	-	<i>Spirulina</i> sp.	+	+	+
<i>Surirella</i> spp.	+	+	+	<i>Synechococcus</i> sp.	+	+	+
<i>Stauroneis</i> sp.	-	-	+				
<i>Synnedra</i> spp.	+	-	+	Division Euglenophyta			
Division Cyanophyta				<i>Astasia</i> sp.	+	-	-
<i>Anabaena</i> spp.	+	+	+	<i>Euglena acus</i> var. <i>gracilis</i> Prings	+	+	+
<i>Anabaenopsis philippinensis</i> (Taylor) Ka	+	+	-	<i>Euglena caudata</i> Hübner	+	+	-
<i>Aphanothece</i> sp.	+	-	-	<i>Euglena</i> spp.	+	+	+
<i>Botryococcus</i> sp.	+	-	-	<i>Phacus pyrum</i> Ehrenberg	+	+	-
<i>Barzia</i> sp.	+	-	+	<i>Phacus</i> spp.	+	+	+
				<i>Trachelomonas hispida</i> var. <i>crenulatocollis</i> (Mark) Lemmermann	-	+	+
<i>Chroococcus</i> sp.	+	+	+	<i>Trachelomonas</i> spp.	+	++	+
<i>Coelomolon</i> sp.	+	++	-	<i>Strombomonas</i> spp.	+	+	+
<i>Cylindrospermopsis</i> <i>raciborskii</i> (Wolosz) Seenayya & Subba	+++	+++	+				
<i>Cylindrospermopsis</i> <i>philippinensis</i> (Taylor) Ka.	++++	++++	+	Division Cryptophyta			
<i>Dactylococcopsis</i> sp.	+	+++	+	<i>Cryptomonas</i> sp.	+	+++	+
<i>Gomphosphaeria</i> sp.	+	+	-	<i>Chroomonas</i> sp.	+	++	+
<i>Gleotheca</i> sp.	+	-	-	<i>Monomasrix</i> sp.	-	+	-
<i>Gloeocystis</i> sp.	+	+	+				
<i>Lyngbya limnetica</i> Lemmermann	++++	++++	+	Division Pyrrophyta			
<i>Merismopedia</i> spp.	+	+	+	<i>Peridinium</i> spp.	+	+	+
<i>Microcystis aeruginosa</i> Kütz. Em. Elenkin	+	+	+	<i>Ceratium hirundinella</i> Schrack	+	+	+
<i>Oocystis</i> spp.	+	+	-				

Note: +++++ = dominant, ++++ = abundant, +++ = frequent, ++ = occasional, + = not found

Phytoplankton Species Diversity

Fluctuations in the Shannon-Weaver index (*H'*), maximum diversity (*H*_{max}) and

Evenness (*E*) indices were observed throughout the year but on the whole as little

variation among seasons excepting a late summer decline and early winter gain.

Thus the Shannon-Weaver index ranged between about 2.3 and 3.0 except for the late summer low of 2.05 in May and early winter high of 3.57 in October. The maximum diversity remained relatively constant at around 4.4 to 4.6 in winter and summer but at late summer declined to about 3 and again at late rainy season to the lowest value of 2.77 in August, with a peak

of 4.66 in January (Fig. 4, Table 2). The species richness varied from month to month but reached a maxima in January and in October the highest number of species with an equal number of individuals in each species was found.

The Evenness index (*E*) tended to track the Shannon-Weaver index in winter and summer within a range of 0.54 to 0.78. The lowest Evenness index was in December while the highest in October and August

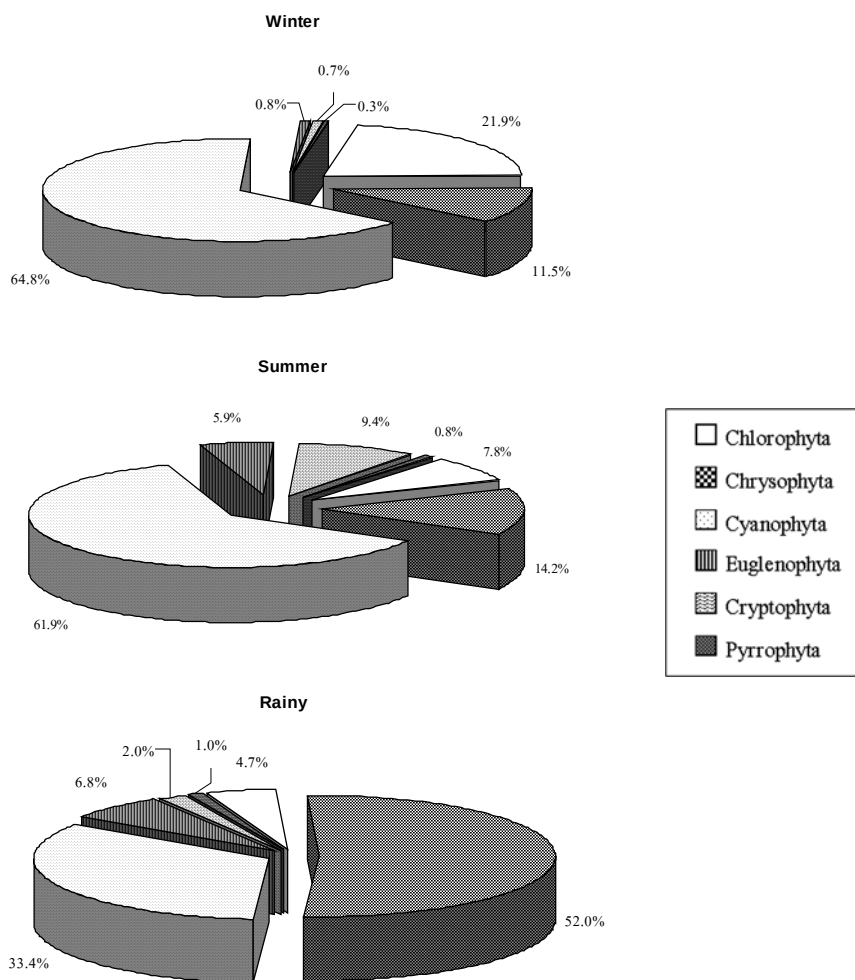


FIGURE 5. Phytoplankton compositions of each divisions in different seasons of Doi Tao lake.

TABLE 2. List of phytoplankton species in Doi Tao lake from September 2003 to August 2004.

Season/Month		Number of species	Density of phytoplankton (individuals/ml)							Indices		
			Total	Chloro phyta	Chryso phyta	Cyano phyta	Eugleno phyta	Crypto phyta	Pyrrophyta	H'	E	H _{max}
Winter	September	55	690	45	308	274	44	10	9	2.41	0.60	4.01
	October	96	1609	326	362	837	46	15	23	3.57	0.78	4.56
	November	89	7473	2730	654	4028	24	23	14	2.55	0.57	4.49
	December	88	9134	1571	775	6718	38	21	11	2.42	0.54	4.48
Summer	January	104	8908	1312	1329	5988	104	131	44	2.78	0.60	4.66
	February	91	10601	548	637	8172	360	824	60	2.71	0.60	4.51
	March	95	10655	713	1266	7063	980	472	161	2.95	0.65	4.55
	April	100	5089	618	1868	1165	222	1214	2	3.23	0.70	4.61
Rainy	May	26	335	11	205	113	4	1	1	2.05	0.63	3.26
	June	48	234	9	170	42	9	1	3	2.80	0.72	3.87
	July	62	233	5	152	43	18	14	1	3.10	0.75	4.13
	August	16	287	0	217	57	13	0	0	2.16	0.78	2.77

(Fig. 4, Table 2) suggested that the phytoplankton community in these two months were at their most diverse.

Phytoplankton Community and Seasonal Succession

Throughout the year, the mean phytoplankton composition in Doi Tao lake consisted of the divisions Cyanophyta 64.3%, Chrysophyta 14.2%, Chlorophyta 13.6%, Cryptophyta 4.4%, Euglenophyta 3.0%, and Pyrrophyta 0.5%. Seasonal succession of phytoplankton communities was observed in this study. The division Cyanophyta was the most abundant in winter and summer, at approximately 64.8% and 61.9% of the total, respectively (Table 2, Fig. 5), with *Cylindrospermopsis philippinesis*, *Oscillatoria* sp. and *Lyngbya limnetica* as the dominant species (Fig. 6). The replacement of Cyanophyta by Chrysophyta was apparent during the rainy season, accounting for approximately 52.0%, whereas Cyanophyta consisted of 33.4% of the total individuals' composition (Fig. 5) with

Aulacosiera granulata as the dominant species (Fig. 6).

DISCUSSION

For this one year study period, Doi Tao lake was found to have a high phytoplankton species diversity with a total of 162 species from 6 divisions recorded over the year. Seasonal succession was evident and the maximum number of species belonging to the Chlorophyta division occurred in winter whereas the minimum occurred in the rainy season when most species present belonged to the Chrysophyta. Phytoplankton species in Doi Tao lake recorded in this study are in broad agreement with those reported in 2002 (158 species) (Seekao et al., 2005). Further study for a couples of year are needed to monitor in Doi Tao lake to get data for formulation the species diversity and seasonal succession of phytoplankton.

Reports of species diversity in different reservoirs across northern Thailand showed high variation in species diversity; e.g. 122 species were reported in Mae Kuang Udomtara reservoir (Peerapornpisal et al.,

1999), 68 species in Mae Ngat Somboonchol reservoir (Tularak et al.,

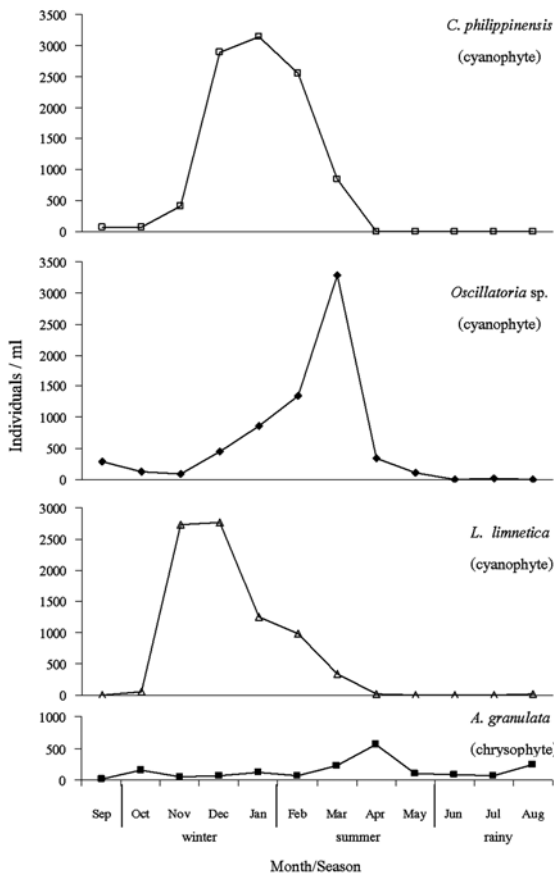


FIGURE 6. The seasonal abundance (individuals/ml) of the four most common phytoplankton species in Doi Tao Lake during September 2003 to August 2004.

2001), 75 and 89 species were reported for Mae Kham and Mae Moh reservoirs around Mae Moh Power Plant, respectively (Pinkate and Traichaiyaporn, 2004), and 57 species in the Hui Lan reservoir (Chompusri and Peerapornpisal, 2005). In addition, one hundred and thirty five phytoplankton species were recorded in the Banglang reservoir in southern Thailand (Ariyadej et al., 2004, 2005).

Differences in phytoplankton diversity among different lakes and reservoirs will in part depend on the physico-chemical water quality in each location (Millman et al., 2005). The recorded number of species in Doi Tao lake and the northern reservoirs was highest in the winter perhaps due to the clear water in this season which allows high light penetrance and thus photosynthesis for phytoplankton growth in all divisions (Pieterse and van Zyl, 1988; Guenther and Bozelli, 2004).

The Shannon-Weaver and Evenness index values of phytoplankton in Doi Tao lake showed little variation among seasons, suggesting that overall phytoplankton species richness and diversity were quite stable all year round. The maximum values of both Shannon-Weaver diversity and Evenness indices were observed in October 2003, suggesting the strongest ecological health status of the lake for the year (Washington, 1984). The sharp decline in both indices in November to December is likely due to the Cyanophytes bloom (Fig. 3).

Shannon-Weaver index values of phytoplankton communities can be used to indicate water pollution status. Values of less than 1 are interpreted as heavily polluted, 1-3 as moderately polluted and more than 3 as clean water (Whitton, 1975). The Shannon-Weaver index of Doi Tao lake varied from 2.05 to 3.57, suggesting that the water quality should be classified as moderately polluted to clean.

Doi Tao lake is an open lake, receiving and giving water from and to the Ping river, at the same time supplying water to the Bhumibol dam in Tak province. During 2003 to 2004, water quality in Doi Tao lake highly fluctuated in different seasons, probably caused by élninyo conditions.

These conditions significantly affected water quality parameters including especially the water level, nutrient loading, levels of suspended solids and hydraulic retention time of the lake (Khuantraikong and Traichaiyaporn, 2004) and, therefore, likely accounts for a major part of the fluctuating phytoplankton composition observed in the lake.

The high density of phytoplankton present in winter through to mid summer, and low density in late summer until the rainy season correlates well with the low total suspended solids in the first period and high suspended solids in the second period (Khuantraikong and Traichaiyaporn, 2004), and photosynthesis levels and growth of phytoplankton (Pieterse and van Zyl, 1988). In the rainy season, loading of suspended solids by high influx from the Ping river led to a high turbidity, low water transparency and a short hydraulic retention time of the lake (Khuantraikong and Traichaiyaporn, 2004). These factors are therefore likely to have also controlled the phytoplankton growth (Toman, 1996; Pugnetti and Bettinetti, 1999) leading to the reduced phytoplankton density in the rainy season.

Seasonal succession of phytoplankton was found in Doi Tao lake. Phytoplankton succession is also reliant upon environmental factors such as nutrients level, N:P ratio, trophic status and water residence time (Sze, 1998; Olding et al., 2000; Vaulot, 2001). In the winter and summer, when Cyanophytes bloomed, the water in Doi Tao lake was clear with low nutrient concentrations and long water residence time (Khuantraikong and Traichaiyaporn, 2004). The dominant species (Cyanophyta division) relate to long water residence time (Olding et al., 2000) because it provides the stable water column

conditions necessary for cyanobacterial dominance. Also low nutrient levels, especially nitrogen and phosphorus as limiting factors, allows dominance of those species of Cyanophytes that can fix nitrogen and use stored phosphorus from within their cells (Sze, 1998). The succession of the Cyanophytes by Chrysophytes was found in the rainy season when the lake had high nutrient concentrations (or eutrophic status) and low N:P ratios (nitrogen was the limiting factor) (Khuantraikong and Traichaiyaporn, 2004). Species within Chrysophyta have good nutrient storage (Alam et al., 2001), and also a higher tolerance level to in unsuitable aquatic environments relative to Cyanophyta (Primakov and Nikolaenko, 2001), accelerating the replacement of Chrysophyta in this season aided by that with lower N:P supply ratios, the diatoms (Chrysophytes) can divide rapidly when phosphorus is not limited (Casas et al., 1999). In another study of a mesotrophic lake in Japan (Ada Hayden), cryptophytes were abundant in winter, Chlorophytes and Chrysophytes dominated in summer, whereas the Cyanophytes dominated in the rainy season (Millman et al., 2005). The differences in the annual phytoplankton composition of this lake compared to Doi Tao may simply reflect their location in different climatic zones. The most familiar pattern of succession in tropical lakes and reservoirs are: the Cyanophytes dominated in winter, thereafter followed by Chlorophytes bloom in summer. As the nutrient concentrations in the water decrease, Chlorophytes decline and are replaced by Cyanophytes which in turn are replaced by Chlorophytes with decreasing water temperatures and mixing of the water in the rainy season. The pattern

described for Doi Tao lake was also Cyanophytes dominating in winter and summer but then followed by Chrysophytes in the rainy season, and was, therefore, different to the above pattern and of other reservoirs in Thailand (Peerapornpisal et al., 1999; Tularak et al., 2001; Alam et al., 2001; Ariyadej et al., 2004, 2005; Pongswat et al., 2004; Junshum and Traichaiyaporn, 2005). One major difference lies in that Doi Tao lake is an open lake with influx and loading of nutrients from the Ping river, while the others are closed reservoirs and lakes. Water velocity in an open lake is a main factor affecting the variation of loading nutrients and suspended solids in different seasons, therefore controlling phytoplankton communities (Toman, 1996; Hinder et al., 1999).

The authors would like to conclude that the phytoplankton communities in Doi Tao lake showed seasonal variation with high species number and density in winter and summer. In the rainy season, the observed number of species and density values dropped. The species diversity and Evenness indices showed only a slight variation from month to month. The pattern of seasonal succession of phytoplankton in this lake was Cyanophytes dominated the winter and summer and replaced by Chrysophytes in the rainy season And is likely to be related to the water qualities and especially velocity, turbidity and nutrient concentration. The data showed that the winter and summer seasons were appropriate for caged fish culture when enough natural food for the fish was available, but was probably not-appropriate in the rainy season.

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LITERATURE CITED

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