ScienceAsia 30 (2004): **261-267**

Diversity of Phytoplankton in the Rama IX Lake, A Man-Made Lake, Pathumthani Province, Thailand

Sirikhae Pongswat,[a*] Sompong Thammathaworn,[a] Yuwadee Peerapornpisal,[b] Nathawut Thanee[a] and Charuwan Somsiri[c]

[a] School of Biology, Institute of Science, Suranaree University of Technology, Muang District Nakhon Ratchasima 30000, Thailand.
[b] Department of Biology, Faculty of Science, Chiang Mai University, Muang District Chiang Mai 50200, Thailand.
[c] Natural Inland Fishery Institute, Ministry of Agriculture and Cooperatives, Kasetsart University, Chatuchak, Bangkok 10900, Thailand.

[*] Corresponding author, E-mail: pongswat1_s@hotmail.com

Received 17 July 2003
Accepted 28 May 2004

ABSTRACT: The study on the diversity of phytoplankton in the Rama IX lake, a man-made lake, Pathumthani province was conducted from February 2000 to January 2001. The lake is divided into two sections, identified by the North Rangsit District Irrigation as the first and the second sections. Phytoplankton found in the first section showed a total number of 86 different taxa, which were divided into 9 taxonomic groups. The taxonomic groups, starting from the most rich in species, were Chlorophyceae with 30, Euglenophyceae with 21, Cyanophyceae with 17, Diatomophyceae with 9, Dinophyceae and Cryptophyceae with 4, Zygnemaphyceae with 3 and Chrysophyceae and Xanthophyceae with1 taxa. In the second section, phytoplankton found were of 59 different taxa. They were divided into 8 taxanomic groups. Chlorophyceae was the group with the most species with 21 species, followed by Cyanophyceae with 12, Euglenophyceae with 11, Diatomophyceae with 9, Cryptophyceae and Dinophyceae with 4, Zygnemaphyceae with 2 and Chrysophyceae with 1. *Cylindrospermopsis raciborskii* was found to be the dominant species with the highest phytoplankton biovolume throughout the investigation in both sections.

KEYWORDS: plankton diversity, Rama IX lake, man – made lake, Thailand, tropical area

INTRODUCTION

An investigation of diversity of phytoplankton was conducted in Rama IX lake, Pathumthani, Thailand. The objectives of the study were to investigate the diversity and the species composition of phytoplankton. Studies of biodiversity of phytoplankton have been conducted for over 100 years. The first publication of a phytoplankton study in Thailand was written by Schmidt (1900-1916)[1]. He published "Flora of Koh Chang" based on materials collected by the Danish Expedition to Siam 1899-1900, in which 161 genera, 1001 species, 287 varieties and 63 forms of Cyanophyta, Chlorophyta and Chromophyta were reported.

Thailand is in the tropical zone with a high diversity of living organisms. There are several reports on species of phytoplankton existing in Thailand, but the report of Wongrat[2] showed that there were very few detailed studies on taxonomy. The problem is the lack of proper taxonomic publications on specific groups of organisms.

Phytoplankton can be found all over the world. It can exist in temperate regions and tropical regions; however the effects of different latitudes on the distribution of phytoplankton are not clear. Some species of phytoplankton e.g. *Cylindrospermopsis raciborskii* and *C. philippinensis* can be found in tropical regions[3], but some species of phytoplankton, such as *Asteroinella formosa*[4] are only found in temperate lakes. In temperate latitudes, the growth of phytoplankton depends on the seasonal cycle. The driving force and mechanisms of seasonal changes are related to variations in the physical, chemical and biotic environment, e.g. changes in solar irradiance and nutrient levels[5]. However, in tropical latitudes, the seasonal succession of phytoplankton species is not as obvious as in temperate latitudes[5]. It might be supposed that the growth of phytoplankton in tropical latitudes depends on ambient nutrient levels more than on other environmental factors [6]. Minimal seasonal variation in day length and heat income does not prevent remarkable phytoplankton seasonal cycles in the tropics, where the fluctations in phytoplankton biomass and composition are often related mainly to changes in hydrological and hydrographical conditions, including variations in water level in lakes [7,8].

Study Area

The Rama IX lake is located at 14° 02' N latitude and 100° 44' longitude in Khlongluang and Thanyaburi districts, Pathumthani province, Thailand. It is one of His Majesty's Royal Projects to provide a water supply for the public in Pathumthani province. It supplies water for growing rice and vegetables during the dry season. It also serves to store excess water during floods, which reduces the damage caused by floods. During the dry seasons, the water from this lake is irrigated to different canals in Bangkok's suburbs in order to decrease water contamination in those canals[9]. The entrance of the lake can be approached from 2 directions. First, from Rangsit - Nakorn Nayok road on highway number 305 along North Khlong 5 about 2 kilometers from the highway. Secondly along North Khlong 6 about 2.3 kilometers from the highway. The Rama IX lake is a big lake and it consists of 2 sections (Fig 1.).

The first section receives water from Khlong 6, and covers an area of about 1,264 km^2, with the capacity of 6,000,000 cubic meters.

The second section receives water from Khlong 5, and covers an area of approximately 2,864 km^2, and the capacity of 11,100,000 cubic meters[9]. The climate of the area of Rama IX lake consists of 3 seasons over the year. The rainy season (May-October) is influenced by the southwest monsoons. The cold season (end of October-February) is influenced by northeast monsoons and the summer season (March-May).

Materials and Methods

The water samples were collected biweekly from February 2000 to January 2001 from the 2 deepest points of the 2 sections. The water of both sections was

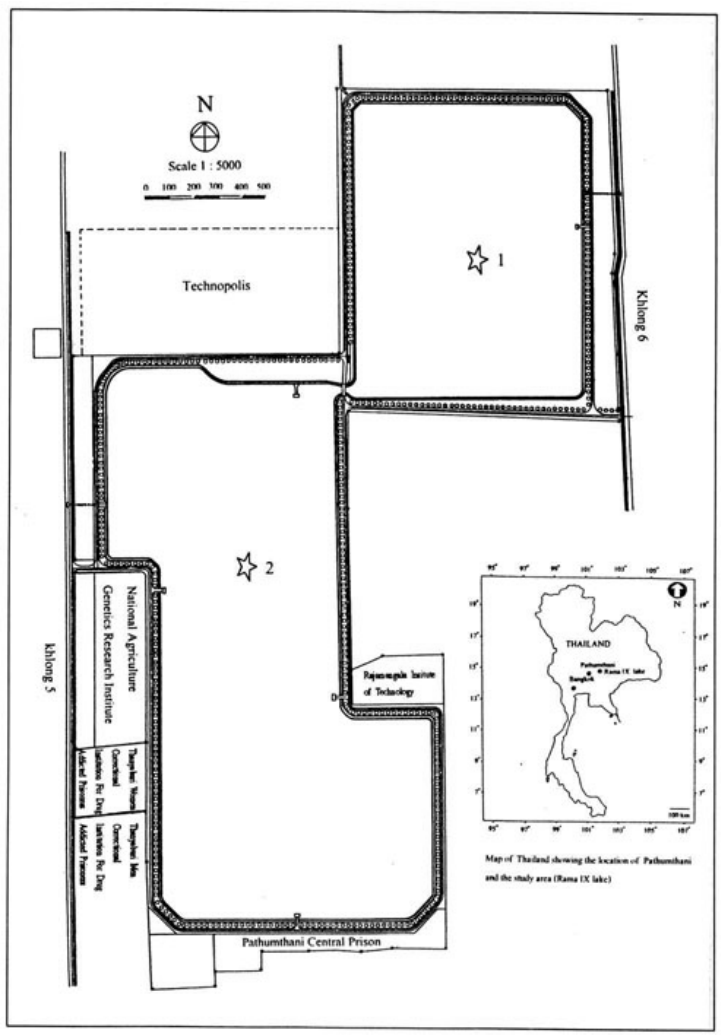

Fig 1. The Rama IX lake showing sampling sites.

collected only from the annual rainfall and neither section had true inflows or outflows.

Phytoplankton were collected using two techniques. Firstly, phytoplankton were collected for identification with a plankton net (mesh size 10 μm) which was pulled up vertically to the surface. The water sample from the plankton net was placed into an approximately 100 ml bottle; this process required 2-3 samples to fill the bottle. Secondly, phytoplankton were collected to assess the number of phytoplankton by using a water sampler. The water samples at the deepest point of both sections were collected from the surface water and every meter for the first three meters depth and every 5 meters from then on to the bottom of the lake. The water samples were poured into dark glass bottles and preserved with 2 ml of Lugol's solution per 100 ml of sample. For counting and biovolume estimation the samples were sedimented and studied with an inverted microscope using the Utermöhl method [10]. Calculation of the individual number (per liter) was based on the cell counts from subsamples. The biovolume of total phytoplankton was calculated from the abundance and volume approximations for each species[11].

Identification of phytoplankton from the net samples was based on relevant texts (i.e. the floras of Huber-Pestalozzi) [12,13,14,15,16,17,18,19,20]. For detailed identification of the genera and species, several special publications from tropical environments were used[3,21,22].

Results

A total of 86 species (9 classes) and 59 species (8 classes) of phytoplankton were identified from the first section, and the second section, respectively of Rama IX lake (Table 1).

Following Rott's 1981 classifications[11], we found that the total phytoplankton consisted of 9 classes in the first section. The Chlorophyceae was the most abundant class with 30 species, approximately 34% of the total species number. There were 17 species of Cyanophyceae, about 19% of the total species. There were 21 species of Euglenophyceae, 24% of the total species number. Nine Diatomophyceae species were found, adding up to around 10% of the total species number. Four species of Dinophyceae and

Table 1. Diversity of phytoplankton in the Rama IX lake (February, 2000 - January, 2001) (+ = found, - = not found)

Class / Scientific Name	Section 1	Section 2	Class / Scientific Name	Section 1	Section 2
Cyanophyceae			**Dinophyceae**		
Anabaena sp.	+	+	*Ceratium furcoides* (Levander) Langhans	+	+
A. aphanizomenoides Forti	+	+	*Peridiniopsis cunningtonii* Lemmermann	+	+
Aphanizomenon sp.	+	+	*Peridinium* sp. 1	+	+
Aphanothece nidulans Richter	+	+	*P.* sp. 2	+	+
Aphanothece smithii Komárková-Legnerová et Cronberg	+	+	**Diatomophyceae**		
Aphanocapsa elaschista West et G.S. West	+	-	*Achnanthes minutissima* Kützing var. *minutissima*	+	+
A. nubilum Komárek et Kling	+	+	*Amphora* sp.	-	+
Coelomoron pusillum (Van Goor) Komárek	+	-	*Anomoeoneis vitrea* (Grunow) Ross	+	+
Cylindrospermopsis raciborskii (Wolosz) Seenayya & Subba	+	+	*Aulacoseira granulata* (Ehrenberg) Ralfs	+	+
C. philippinensis (Taylor) Ka	+	+	*Cocconeis placentula* Ehrenberg	+	+
Gomphosphaeria natans Komárek et Hindák	+	-	*Cyclotella* sp.	+	-
Merismopedia punctata Meyen	+	+	*Cymbella* sp.	-	+
Microcystis aeruginosa Kützing	+	-	*Eunotia* sp.	+	-
Oscillatoria limosa (C. Agardh) Gomont	+	+	*Fragilaria ulna* var. *acus* (Kützing) Lange-Bertalot	+	+
Planktolyngbya limnetica Lemmermann	+	+	*Gyrosigma macrum* (W.Smith) Griffith & Henfrey	-	+
P. sp.	+	+	*G.* sp.	+	-
Spirulina platensis (Nordstedt) Geitler	+	+	*Nitzschia* sp.	+	+
Cryptophyceae			**Chrysophyceae**		
Chroomonas sp.	+	+	*Uroglenopsis americana* (Calkins) Lemmermann	+	+
Cryptomonas sp.	+	+	**Chlorophyceae**		
Rhodomonas sp.1	+	+	*Acanthosphera* sp.	+	+
R. sp.2	+	+	*Actinastrum gracillimum* G.M.Smith	+	+
			Ankistrodesmus falcatus (Corda) Ralfs	+	-

Table 1. Cont'd.

Class / Scientific Name	Section 1	Section 2	Class / Scientific Name	Section 1	Section 2
Botryococcus braunii Kützing	+	+	*Tetrastrum staurogeniaeforme* (Schroder) Lemmermann	+	+
Carteria sp.	+	+	**Zygnemaphyceae**		
Chlamydomonas sp.1	+	+	*Cosmarium bioculatum* Brébisson ex Ralfs	+	+
C. sp.2	+	+	*Staurodesmus phimus* var. *semlunaris* (Schmidle) Teiling	+	-
Chlorogonium sp.	+	+	*Staurastrum perundulatum* Gionlel	+	+
Chlorella vulgaris Beijerinck	+	+	**Xanthophyceae**		
Coelastrum microporum Naegeli	+	-	*Isthmochloron gracile* (Reinsch) Hansgirg	+	-
C. pseudomicroporum Korshikov	+	-	**Euglenophyceae**		
Coelastrum sphaericum Naegeli	+	+	*Euglena chakoweinsis* Swirenko	+	+
Crucigeniella crucifera (Wolle) Komárek	+	+	*E. proxima* Dangeard	+	+
Dictyosphaerium tetrachotonum Printz	+	+	*E. minima* France	+	-
D. pulchellum Wood	+	-	*Lepocinclis* sp.	+	+
Eudorina elegans Ehrenberg	+	-	*Phacus longicauda* (Ehrenberg) Dujardin	+	-
Eutetramorus globosus Walton	+	-	*P. pyrum* (Ehrenberg) F. Stein	+	-
Monoraphidium arcuatum (Korshikov) Hindák	+	+	*P. ranula* Pochmanin (Ehrenberg) Dujardin	+	-
M. contortum (Thuret) Komárková-Legnerová	+	+	*Trachelomonas bernardinensis* W. Vischer	+	+
M. griffithii (Berkeley) Komárková-Legnerová	+	+	*T. curta* Da Cunha	+	-
M. irregulare (G.M. Smith) Komárková-Legnerová	+	+	*T. dubia* (Swirenko) Deflandre	+	-
Oocystis sp.	-	+	*T. dybowskii* Drezepolski	+	+
Pandorina morum (O.F.Müller) Bory	+	-	*T. hispida* (Perty) Stein	+	-
Pediastrum simplex Meyen	+	+	*T. intermedia* Dangeard	+	+
Planktonema lauterborni Schmidle	+	+	*T. minima* Drezepolski	+	-
Radiococcus planktonicus J.W.G. Lund	+	-	*T. mucosa* Swirenko	+	+
Scenedesmus acuminatus (Lagerh) Chodat var. *acuminatus*	+	-	*T. oblonga* Lemmermann	+	+
S. armatus (Chodat) G. M.Smith	+	-	*T. similis* Stokes	+	-
S. opoliensis P. Richter	+	-	*T. volvocina* Ehrenberg	+	+
Spirogyra sp.	-	+	*T. volvocinopsis* Swirenko	+	+
Tetraedron minimum (A. Braun) Hansgirg	+	+	*Strombomonas fluviatilis* (Lemmermann) Deflandre	+	+
			S. verrucosa var. *borystheniensis* (Roll) Deflandre	+	-

Cryptophyceae were present, 4% of the total species number. Zygnemaphyceae had 3 species, 3% of the total species number and Chrysophyceae and Xanthophyceae had 1 species each calculated 1% of the total species number (Fig 2.). In the second section, the total species number could be divided into 8 classes. The Chlorophyceae was the most rich in species with 21 species found, 33% of the total. Euglenophyceae had 11 species present, estimated at 17%. Twelve species of Cyanophyceae were found, constituting around 19% of the total. Nine Diatomophyceae were found adding up to around 14% of the total species number. Cryptophyceae and Dinophyceae had 4 species each, 6% of the total. Zygnemaphyceae had 2 species present, 3% of the total, and Chrysophyceae had 1 species, or 2% of the total (Fig 3.). In the first section, phytoplankton comprised 86 species. The most abundant classes in decreasing order were Cyanophyceae, Euglenophyceae and Dinophyceae, respectively. The dominant species were *Cylindrospermopsis raciborskii*, *Peridinopsis cunningtonii* and *Trachelomonas volvocina* respectively. In the second section, phytoplankton comprised 59 species. The most abundant classes in decreasing number were Cyanophyceae, Euglenophyceae and Dinophyceae, respectively. The dominant species were *Cylindrospermopsis raciborskii*, *Trachelomonas volvocina* and *Peridinium* sp1.

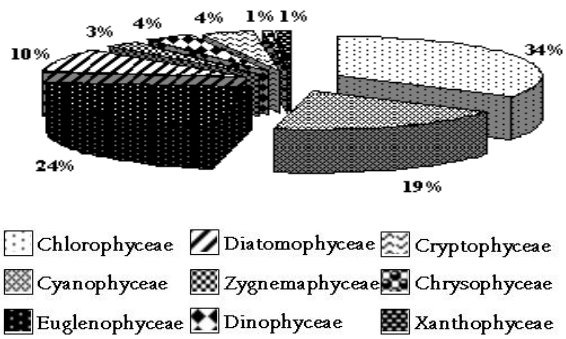

Fig 2. The percentage of the species number in each class in the first section of Rama IX lake (February 2000 – January 2001)

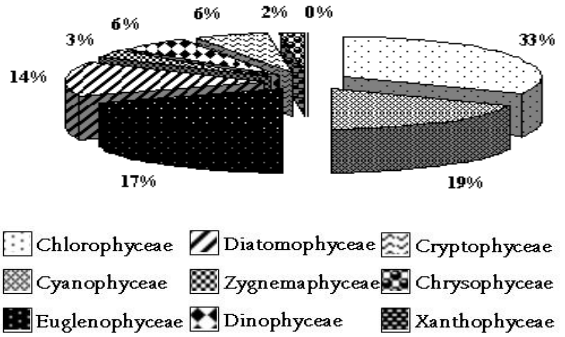

Fig 3. The percentage of the species number in each class in the second section of Rama IX lake (February 2000 – January 2001)

TAXONOMIC NOTES OF SOME SPECIES

Dinophyceae

***Ceratium furcoides* (Levander) Langhans**

Cells are narrowly spindle-shaped in outline and strongly flattened dorsiventrally. The epivalve is narrowly conical; a long horn forms from just above the cingulum. The cingulum is slightly narrow. The body of hypovalve is broad and short. It is divided into a varying number of posterior horns, usually 2 or 3, rarely 1. The central or median horn is the longest. It is formed by the antapical plates. On epivalve here four apical plates are present of which the fourth does not reach the apex. The plates are coarsely reticulate with fine spicules. Chloroplasts are numerous and oval shape.

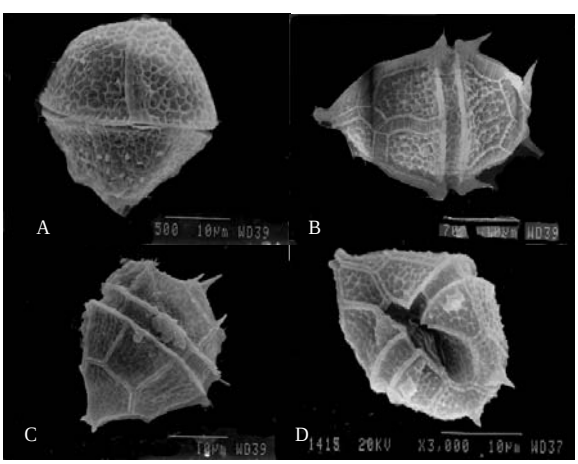

Fig 4. Micrographs of phytoplankton found in Rama IX lake (A-D) Dinophyceae: (A) *Peridinium* sp.1, (B) *Peridinium* sp.2, (C) *Peridiniopsis cunningtonii* Lemmermann, dorsal view (D) ventral view
SEM-micrographs.
Scale bar (A-D) = 10 mm

***Peridiniopsis cunningtonii* Lemmermann**

(Fig 4C,4D,5E,5F and 5G)

Cells are oval and extremely flattened dorsiventrally. The epitheca is conical. The hypotheca is rounded with 2-6 spines. The epicone has only six preequatorial plates. The cingulum spirals slightly to the left. The sulcus barely extends into the epitheca, it widens along the hypotheca, where it does not reach the antapex. Hypothecal plates bear spicules. The plates are delicately reticulated. Plate formula: Po, 42 , 1a, 63 , 6c, 5s, 52 3†, 23 3†. Chloroplasts are present, resting stages oval and thick-walled. Cells are 17.5-22.5 μm

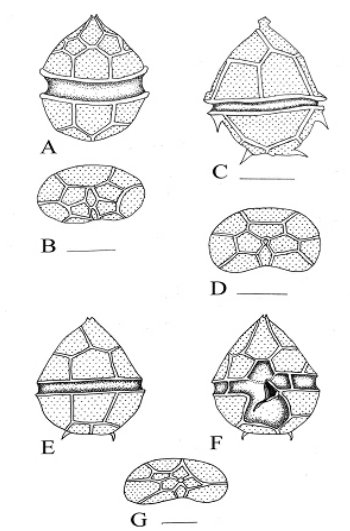

Fig 5. Illustration of phytoplankton found in Rama IX lake (A-G) Dinophyceae: (A) *Peridinium* sp.1, dorsal view (B) projection of epitheca (C) *Peridinium* sp.2, dorsal view (D) projection of epitheca (E) *Peridiniopsis cunningtonii* Lemmermann, dorsal view (F) ventral view (G) projection of epitheca
Scale bar (A-G) = 10 μm

broad, 25-30 μm long and 17.5-20 μm thick.

***Peridinium* sp.1** (Fig 4A,5A and 5B)

Cells are spherical and slightly flattened dorsiventrally. The cingulum is wide, relatively deep and spirales to the left. The sulcus extends slightly into the epicone, it widens slightly along the hypocone where it reaches the antapex. The apical pore is shifted to the left, cell wall of the porate plate with a wide range of ornamentation; plate formula: Po, 42 , 2-3a, 73 , 5c, 5s, 52 3†, 23 3†. Cells are 17.50-20 μm broad 20-25 μm long and 12.5-15 μm thick.

***Peridinium* sp.2** (Fig 4B,5C and 5D)

Cells are ellipsoidal. The hypotheca is smaller than the epitheca. The theca is ornamented with spines. Plate formula: Po, 42 , 2-3a, 73 , 52 3 , 23 3 . Chloroplasts are numberous, yellow-brown to dark brown. Cells are 20-23 μm broad, 27.5-34 μm long and 17.5-20 μm thick.

Diatomophyceae

***Achnanthes minutissima* Kützing**

Cells are elliptic to linear elliptic or linear-lanceolate in valve view, with true raphes and one pseudoraphe; apices are bluntly rounded or slightly tapering, not protracted; girdle view markedly bent. Cells are narrow in both views, often with reflexed apices when seen in girdle view, between central raphe endings small and knob-like. Cells are rarely moving, sometimes the cells are attached by mucilage stalks secreted from one end of the raphid valve, 2.5-4 μm broad, 5-25 μm long. Striae are visible on valves at 500 x magnification (30-32 in 10 μm).

***Anomoeoneis vitrea* (Grunow) Ross**

Cells are solitary, usually lying in valve view. Valves lanceolate are often with rostrate or capitate poles. Cells have a single, highly lobed plastid with its centre close to one side of the girdle, deeply invaginated beneath the raphes slits and centrally along the mid-line of the girdle. Striae are visible on valves at 500 x magnification 37 in 10 μm.

***Aulacoseira granulata* (Ehrenberg) Ralfs**

Frustules without intercalary bands, cells are arranged in chains of cylindrical cells in girdle view. The valves are either flat or convex, in which instance there are teeth at the poles which aid in adjoining the cells. In some there is a sulcus or ringlike incision around the midregion, the girdle being smooth. The wall is punctate, coarse or faint. In this species the spines have two "roots" that straddle a row of pores on the mantles. Valves are 5-7.5 μm broad and 16-18 μm long. Chloroplasts are discoid.

***Cocconeis placentula* Ehrenberg**

Cells are elliptic to linear elliptic in valve view. The epivalve shows an axial pseudoraphe and is convex, whereas the hypovalve is concave or flat and shows a raphe with central and polar nodules. The valves have prominent transverse striae, but the pattern differs on the 2 valves. In many, there is a clear marginal band formed by a interruption of the striae on the valve which has the raphe. Chloroplasts are flat and c-shaped. Cells are solitary, 10.2 μm, broad, 16.2 μm long. Striae are visible on valves at 500 x magnification (15 in 10 μm).

Zygnemaphyceae

***Cosmarium bioculatum* Brébisson ex Ralfs**

Cells are small, sinus deep, narrow towards inside, widening outwards, semicells transverse oblong-elliptical with a somewhat flatly rounded base and apex. The wall is smooth with punctae; cells are 7.5-8 μm broad, 10-15 μm long, 2.5-3.75 μm thick.

***Staurodesmus phimus* var. *semulunaris* (Schmidle) Teiling**

Semicells are crescent shaped (often lunate), sinus open, acute typically isthmus with a rather broad, apex concave. Terminal spines are divergent, the spines of moderate length and end views are conspicuously narrow. Cells are 7.5-10 μm broad, 5-7.5 μm long without process; 17.5-20 μm broad, 15-17.5 μm long with process, isthmus 6 μm.

***Staurastrum perundulatum* Gionlel**

Semicells are with a median protuberance, apical margin slightly concave, and apical angles produced to form a long nodulated diverging process tipped with four spines. From a ventral view the cells look oblong-elliptic with a protuberance in the middle of each side. Cells are 5-7.5 μm broad, 7.5-10 μm long without processes and 20-22.5 μm broad. 22.5-25 μm was the complete length with processes.

Discussion

A checklist of the freshwater algae in Thailand was compiled from 53 publications. The total number of 161 genera, 1,001 species, 287 varieties, and 63 forms consists of 39 genera, 209 species, and 2 varieties of the Division Cyanophyta (blue-green algae); 75 genera, 406 species, 141 varieties, and 19 forms of the Division Chlorophyta (green algae and euglenoids); 46 genera, 385 species, 144 varieties, and 44 forms of the Division Chromophyta; and 1genus, 1 specie, and 1 variety of the Division Rhodophyta[23]. Since 1974, Thai scientists have increasingly studied biodiversity, including studies of the environment and environmental impact assessments[24]. At present, the status of phytoplankton diversity in Thailand deserves serious attention. The comparison between the number of phytoplankton species known in the world and in Thailand implies that there are many more species awaiting discovery. There are 1,700 species of blue green algae known worldwide; however, in Thailand only 700 species have been identified, and it has been estimated that 1,000 species

have still not been categorized. Another example is green algae, of which over 7,000 species are well-known in the world, whereas in Thailand only 1,500 species have been identified and over 1,000 are presumed to still be undiscovered[25].

Acknowledgements

We sincerely thank Dr. Barbara Meyer, Institut für Limnologie Plön, Germany, for her kind assistance in confirming and identifying some species of Dinophyceae. We would also like to thank Assoc. Prof. Dr. Eugen Rott from the Institut für Botanik. Innsbruck, Universitat Innsbruck and Prof. Rupert Lenzenweger from Ried in Innkreis, Austria for their confirmation of some species of dominant phytoplankton. This work was supported by TRF/BIOTEC Special Program of Biodiversity Research and Training grant BRT543027.

References

1. Wongrat L (1998) *The status of phytoplankton diversity in Thailand.* Advance in Microalgal and Protozoal Studies in Asia Global Environmental Forum, Tsukuba.
2. Wongrat L (1999) *Phytoplankton.* Kasetsart University Press, Bangkok.
3. Peerapornpisal Y (1996) *Phytoplankton seasonality and limnology of three reservoirs in the Huai Hong Khrai Royal Development Study Cent Chiang Mai Thailand.* Ph.D. Dissertation Institut der Botanik, University of Innsbruck.
4. Talling J F (1987) The phytoplankton of Lake Victoria (East Africa) *Arch Hydrobiol Ergeb Limnol.* 25,229-56.
5. Harris G P(1986) *Phytoplankton ecology structure function and fluctuation*. Chapman and Hall, London.
6. Morris J (1980) *Physiological ecology of phytoplankton*. Blackwell Scientific, Oxford.
7. Ibanez M S R (1998) Phytoplankton composition and abundance of a central Amazonian floodplain lake *Hydrobiol.* 362, 79-83.
8. Train S and Rodrigues L (1998) Temporal fluctuations of the phytoplankton community of the Bafa river in the upper Paraná river floodplain Mato Grosso do Sul Brazil. *Hydrobiol* 361, 125-34.
9. Irrigation North Rungsit (1998) *A summary of Rama IX lake and of His Majesty's Royal Projects Amphur Khlongluang and Amphur Thanyaburi Pathumthani province*. Irrigation Department Ministry of Agriculture and Cooperatives Pathumtani, Thailand.
10. Utermöhl H (1958) Zur Vervollkommnung der quantitative Phytoplankton methodic. *Verh int Ver Limnol* 9,1-38.
11. Rott E (1981) A contribution to the algal flora from highland lakes in the Ecuadorian Andes. *Ber Nat-med Ver* 68, 13-29.
12. Huber-Pestalozzi G (1938) *Das Phyto-plankton des Süss-wassers:Blaualgen Bakterien Pilze* 1. Teil E Schweizerbart' sche Verlagsbuchhandlung, Stuttgart.
13. Huber-Pestalozzi G (1941) *Das Phytoplankton des Süss-wassers Chrysophyceen Farblose Flagellaten Heterokonten* 2. Teil E Schweizerbart' sche Verlagsbuchhandlung, Stuttgart.
14. Huber-Pestalozzi G (1942) *Das Phytoplankton des Süss-wassers: Diatomeen*, 2. Teil E.Schweizerbart' sche Verlagsbuchhandlung, Stuttgart.
15. Huber-Pestalozzi G (1955) *Das Phytoplankton des Süss-wassers: Euglenophyceen* 4. Teil E Schweizerbart' sche Verlagsbuchhandlung, Stuttgart.
16. Huber-Pestalozzi G (1961) *Das Phytoplankton des Süss-wassers: Chlorophyceae (Grünalgen) Ordnung: Volvocales* 5. Teil E Schweizerbart' sche Verlagsbuchhandlung, Stuttgart.
17. Huber-Pestalozzi G (1968) *Das Phytoplankton des Süss-wassers: Cryptophycea, Chloromonadaphycea Dinophyceae* 3. Teil E Schweizerbart' sche Verlagsbuch-handlung, Stuttgart.
18. Huber-Pestalozzi G (1982) *Das Phytoplankton des Süss-wassers: Conjugatophyceae Zygnematales and Desmidiales (excl Zygnemataceae)* 8. Teil E Schweizerbart' sche Verlagsbuchhandlung, Stuttgart.
19. Huber-Pestalozzi G (1983) *Das Phytoplankton des Süss-wassers: Chlorophyceae (Grunalgen) Ordnung Chlorococcales* 7. Teil E Schweizerbart' sche Verlagsbuch-handlung, Stuttgart.
20. Prescott G W (1970) *How to know the freshwater algae*. Brown Company, Iowa.
21. Hirano M (1975) *Phytoplankton from lake Boraphet in the Central Plain of Thailand.* Centr Biol Lab Kyoto University 24(4) , 187-203.
22. Yamagishi T and Hirano M (1973) *Some freshwater algae from Cambodia.* Kyoto University, Kyoto.
23. Wongrat L (1995) Freshwater algae in Thailand. In : *Algae in Thailand.* (Edited by Lewmanomont, K Wongrat L and Supanwanid C.) pp 98-99. Office of Environmental Policy and Planning Ministry of Science Technology and Environment, Bangkok.
24. Powtonasoak S (2000) *Research and development at algae for potential benefits in Thailand.* Marine Biotechnology Research Unit National Center for Genetic Engineering and Botechnology, Chulalongkorn University Press, Bangkok.
25. Thailand Country Study on Biodiversity (1992) *Ministry of science.* Technology and Environment and UNEP.