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Seasonal fluctuation of *Chrysochromulina parva* (Prymnesiophyceae) in four ponds and lakes in the Kinki district, Japan

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Chrysochromulina parva Lackey (1939) was collected in spring from Sengari Reservoir, Karasuhara Reservoir and Yasuba-ike Pond in Hyogo Prefecture, while in winter and spring from Lake Biwa in Shiga Prefecture, Japan. It appeared at high density of 21,000 cells/m*l* on 13 April 1982 in Sengari Reservoir and 59,000 cells/m*l* on 14 March 1983 in Yasuba-ike Pond. The distinctive feature of this species is its rapid increase and subsequent decrease in a short time. *C. parva* seems to prefer eutrophic waters and is classified as eurythermal.

Key Index Words: Cell number—Chrysochromulina parva—*lake—pond—Prymnesiophyceae—reservoir—seasonal fluctuation.*

Chrysochromulina parva is a small organism with three appendages, two equal acronematic flagella and a haptonema. This species was first recorded from the Scioto River, U.S.A. (Lackey 1939). Thereafter the worldwide distribution of this species has been proved by many workers (Parke, Lund and Manton 1962, Heynig 1963, Thompson and Halicki 1965, Meyer and Brook 1969, Kristiansen 1971, Cronberg 1982, Bailey-Watts 1986, Duthie and Stout 1986, Munawer and Munawer 1986, Pollingher 1986, Reynolds 1986). In Japan it is distributed in three localities (Inouye and Chihara 1987), but its seasonal fluctuation has not been studied. The purpose of this paper is to make clear the seasonal fluctuation of *C. parva* and its character in four ponds and lakes in the Kinki district.

Materials and Methods

Study sites were: Sengari Reservoir situated over three cities, Kobe, Sanda and Takarazuka, Hyogo Prefecture; Karasuhara Reservoir, Kobe City; Yasuba-ike Pond, an irrigation pond in Takarazuka City; and Lake Biwa, Shiga Prefecture, the largest lake in Japan. Physicochemical characteristics of these ponds and lakes are summarized in Table 1. Total phosphorus and total nitrogen were determined according to procedures recommended by the Japanese Environmental Agency. Other chemical analyses were done by the methods of Japan Water Works Association (1985).

Investigations were made once or twice a week in Sengari Reservoir (March 1979-June 1987) and once a month in Yasuba-ike Pond (March 1980-June 1983), Karasuhara Reservoir (April 1978-March 1988) and the south basin of Lake Biwa (January 1981, May 1986-April 1987). Sampling stations in Sengari Reservoir are shown in Fig. 5. In Yasuba-ike Pond, water samples were taken at a station 1 m off the shore where the depth was 50 cm and in Karasuhara Reservoir at a station 3 m off the dam where the depth was about 17 m. In the south basin of Lake Biwa, water samples were taken at a station about 200 m off Yamada Habor and at a station about 2 km off the intake of the Lake Biwa Waterway No. 2 of Kyoto City.

Samples were collected in 1 *l* bottles from

Table 1. Physicochemical characteristics (mean values) of Sengari Reservoir, Karasuhara Reservoir, Yasuba-ike Pond and the south basin of Lake Biwa in the Kinki district, Japan.

Locality		Sengari Reservoir	Karasuhara Reservoir	Yasuba-ike Pond	South basin of Lake Biwa
Prefecture		Hyogo	Hyogo	Hyogo	Shiga
Area	(m^2)	1.12×10^6	1.15×10^5	2.50×10^3	5.68×10^7
Volume	(m^3)	1.16×10^7	1.32×10^6	4.00×10^3	2.00×10^8
Maximum depth	(m)	31.0	19.0	2.0	7.6
Period of investigation		Apr. 1979–Mar. 1987	Apr. 1979–Mar. 1987	Jan. 1979–Jan. 1988	May 1986–Apr. 1987
Chlorophyll *a*	($\mu g/l$)	8.7	18.4	24.5	10.1*
Total phosphorus	(mg/*l*)	0.019	0.037	0.086	0.017*
Total nitrogen	(mg/*l*)	0.54	0.81	0.99	
Total hardness	(mg/*l*)	22.8	64.7	29.7	
Alkalinity	(mg/*l*)	19.5	60.3	25.7	
COD	(mg/*l*)	2.7	4.3	9.2	
Conductivity	(μS/cm)	86.2	223	125	
pH		7.6	8.5	6.7	7.7

* Data from TEZUKA (1984).

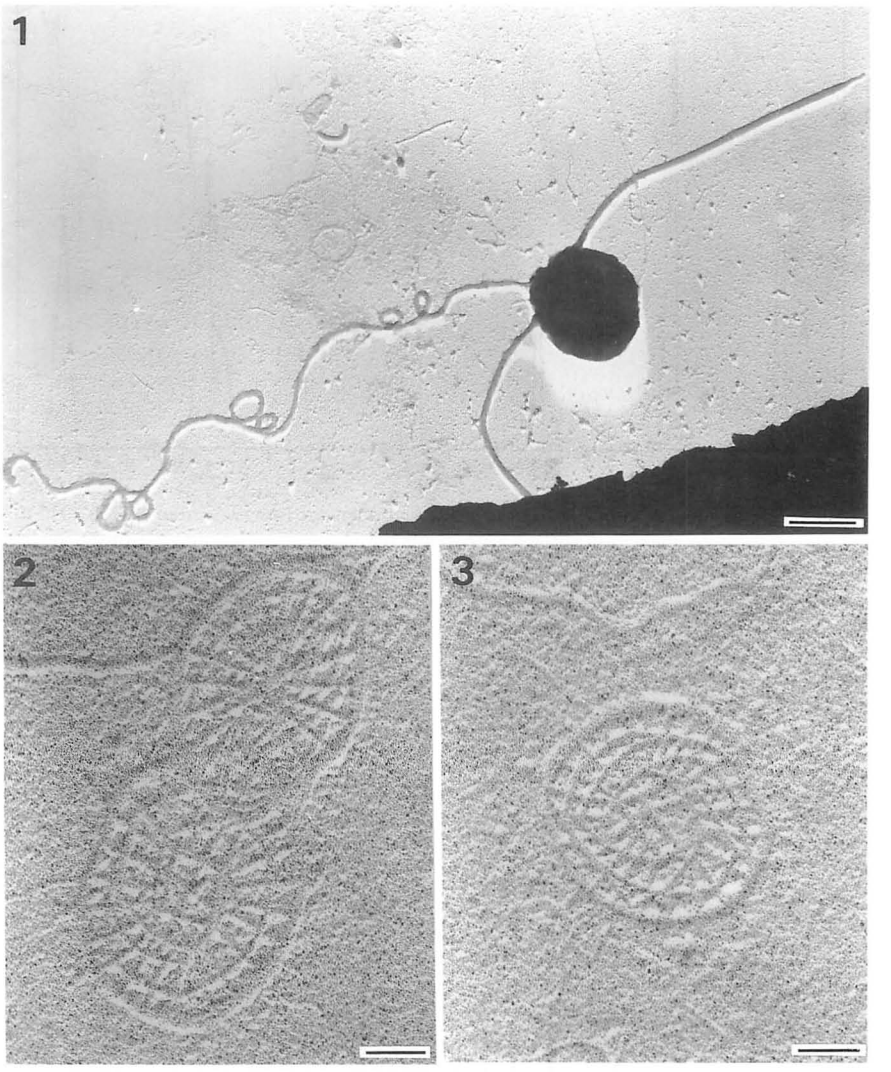
the surface at all stations. Water sample of 0.5 *l* each was fixed immediately with 0.5% Lugol's solution and subsequently with 2% formalin. The fixed sample was settled for a week and concentrated to 10 m*l*. Unfixed sample of 0.5 *l* each was centrifuged at 3,000 r.p.m. for 10 min. and concentrated to 1 m*l*. Both fixed and unfixed concentrated samples were used for examinations of *C. parva* with optical and electron microscopes. The cell number per m*l* of *C. parva* and other phytoplankton at each sampling time was estimated under an optical microscope by counting whole cells in 1/1000 m*l* of the fixed concentrated samples using a Fuchs Rosental hemacytometer. The method used to observe *C. parva* with a transmission electron microscope (JEM 100B) is described in a previous paper (ITO 1988).

Results

A very small organism with three appendages and two brown chloroplasts was collected from four ponds and lakes in the Kinki district, Japan. It was observed by electron microscopy and identified as *Chrysochromulina parva* by its very long haptonema and structure of scales lying above the cell surface. The haptonema is 7–15 times as long as the cell length. Scales are circular or oval with concentric striations and widely spaced radiating ridges (Figs. 1–3).

Sengari Reservoir

C. parva appeared from March to May (Fig. 4). The maximum peak in each year was observed on 27 April 1979, 13 April 1982, 2 May 1983, 7 May 1984, 7 May 1985, 21 April 1986 and 18 May 1987 at St. 5. The density of each peak was 6,800, 21,000, 3,700, 5,800, 2,800, 7,700 and 6,200 cells/m*l*, respectively, and their percentage to the total phytoplankton cell number was 57.1, 87.1, 45.4, 82.3, 42.4, 88.5 and 31.5%, respectively. *C. parva* was dominant at each time except for 1987 when it was subdominant next to *Uroglena americana*. It occurred at a temperature range from 7 to 23°C, and the densest population was encountered at 12–17°C. High density lasted for a short time. It appeared for a month or less except in 1983 and 1986. In 1982, for example, the maximum density observed on 13 April was reached in four days from a population of 840 cells/m*l* on 9 April. The high density



Figs. 1–3. *Chrysochromulina parva*. Fig. 1. A desiccated cell. Figs. 2 & 3. Scales detached from a desiccated cell. (Scale bars: 2 μm in Fig. 1; 0.1 μm in Figs. 2 & 3).

lasted for a very short time and the number fell to 150 cells/m*l* by 26 April.

The density of *C. parva* was different from station to station. In 1979, the density at St. 1 and St. 3 was 2,500 and 13,000 cells/m*l* respectively on 27 April, while on 4 May it was 13,000 and 1,500 cells/m*l* respectively. *C. parva* was not uniformly distributed in Sengari Reservoir (Fig. 5).

Yasuba-ike Pond

C. parva appeared also from March to May (Fig. 6). It was dominant on 23 April 1980, 9 April 1981, and 14 March and 13 April 1983. The density at each time was 19,000, 58,000, 59,000 and 25,000 cells/m*l* respectively, and their percentage to the total phytoplankton cell number was 56.1, 78.3, 63.9 and 31.2% respectively. The water temperature at the time when the maximum density in each year was recorded was 17.0°C in 1980, 14.7°C in 1981 and 7.8°C in 1983.

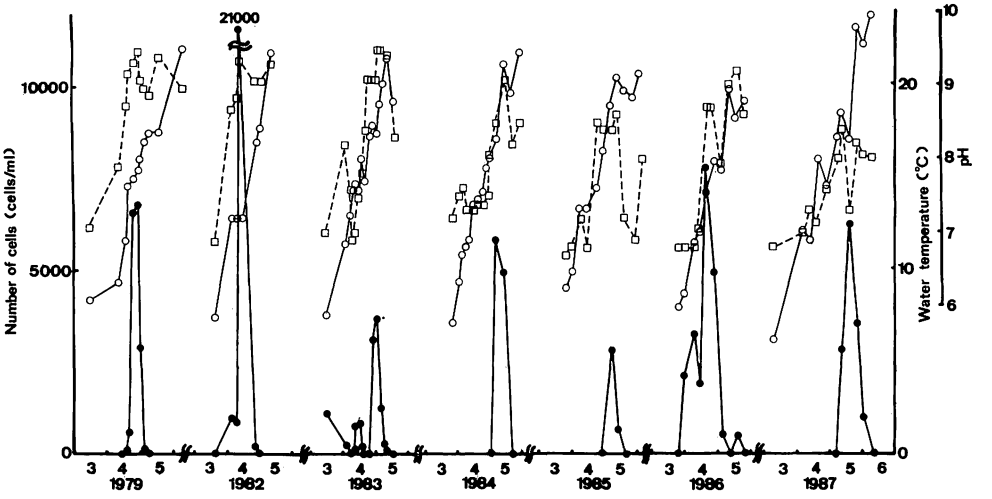


Fig. 4. Seasonal fluctuation of *Chrysochromulina parva* in Sengari Reservoir from March 1979 to June 1987 (solid circles) in relation to changes in surface water temperature (open circles) and pH (open squares).

Karasuhara Reservoir

C. parva was observed only once on 23 May 1979 during ten years from April 1978 to March 1988. The high density of this species was readily imagined because the water color changed from green to brown over the whole reservoir, although the quantitative study was not done. At that time the water temperature was 21.9°C, and pH 9.6.

The south basin of Lake Biwa

C. parva was subdominant next to *Fragilaria crotonensis* at a station about 200 m off Yamada Harbor on 23 January 1981. The density at

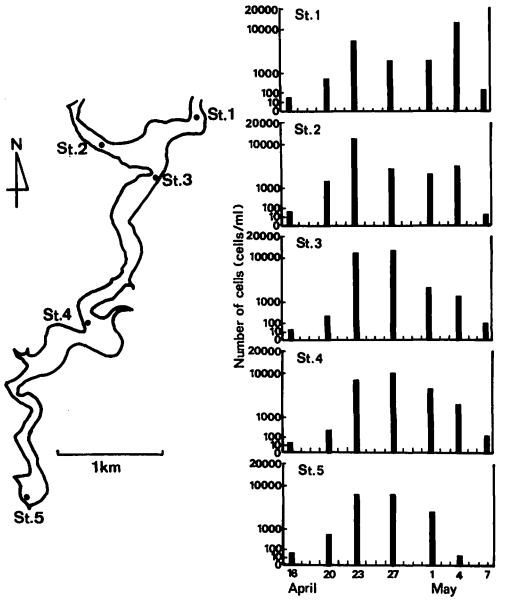


Fig. 5. Map showing five sampling stations and fluctuation in the cell number of *Chrysochromulina parva* in Sengari Reservoir from 16 April to 7 May in 1979.

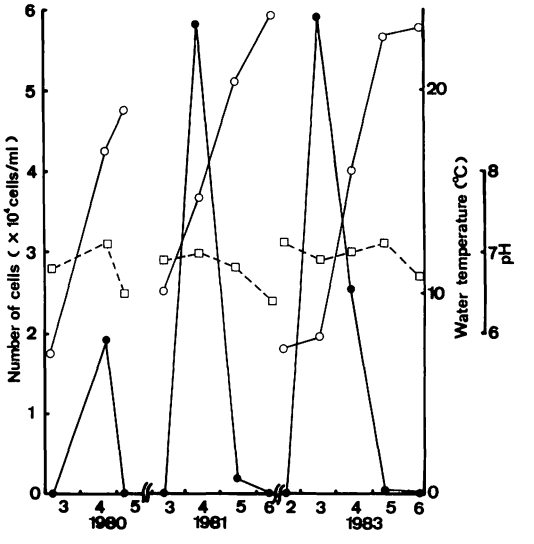


Fig. 6. Seasonal fluctuation of *Chrysochromulina parva* in Yasuba-ike Pond from March 1980 to June 1983 (solid circles) in relation to changes in surface water temperature (open circles) and pH (open squares).

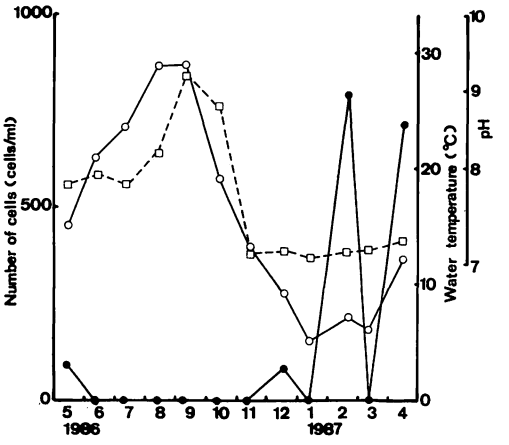


Fig. 7. Seasonal fluctuation of *Chrysochromulina parva* in the south basin of Lake Biwa from May 1986 to April 1987 (solid circles) in relation to changes in surface water temperature (open circles) and pH (open squares).

that time was 3,500 cells/m*l*, and the water temperature was 3.0°C. In the period from 13 May 1986 to 14 April 1987, *C. parva* appeared on 13 May and 17 December 1986 and on 17 February and 14 April 1987 at a station about 2 km off the intake of the Lake Biwa Waterway No. 2. The density at each time was very low, but on 17 February 1987 it was 790 cells/m*l* and *C. parva* became dominant, occupying 44.6% of the total phytoplankton cell number (Fig. 7).

Discussion

In Sengari Reservoir and Yasuba-ike Pond, *Chrysochromulina parva* rapidly increased and subsequently decreased in a short time. A similar phenomenon has been reported: The highest density of 32,000 cells/m*l* was observed in June 1960 in an English lake (Parke, Lund and Manton 1962). It was reached in two weeks from a population of 300 cells/m*l*, and two weeks later the density fell to 1,000 cells/m*l*. The high density of *C. parva* reaching 50,000 cells/m*l* was also observed in a small Danish lake in July 1969 (Kristiansen 1971). From these results it is apparent that *C. parva* rapidly increases and subsequently decreases in a short time, its characteristically high population density lasting for a very short time.

In the present study, *C. parva* occurred in a wide temperature range from 3 to 23°C and high densities above 10,000 cells/m*l* were reached at temperatures from 8 to 17°C. In two Japanese lakes, Kasumigaura and Hinuma, water blooms of this species occurred in December (Inouye and Chihara 1987). In a subtropical Israeli lake, *C. parva* appeared at high temperatures up to 30°C and maximum development was established at 14–18°C (Pollingher 1986). In a Danish lake, a high density of *C. parva* was observed at 15.8°C (Kristiansen 1971). Based on all available data, *C. parva* is classified as eurythermal with high abundance at low temperatures below 18°C. In Sengari Reservior and Yasuba-ike Pond, *C. parva* increased as water temperature became high and it decreased or disappeared at temperatures above 20°C. It is considered that water temperature is the major factor controlling seasonal fluctuation of *C. parva*.

Sengari Reservoir, Karasuhara Reservoir and Yasuba-ike Pond are eutrophic in terms of total phosphorus and total nitrogen concentrations (Sakamoto 1966), while Lake Biwa is intermediate between mesotrophic and eutrophic (Tezuka 1984). The maximum density of *C. parva* in Yasuba-ike Pond was 2.8 times higher than that in Sengari Reservoir, and 6 times higher than that in Lake Biwa. This implies that the *C. parva* biomass becomes larger as eutrophication progresses. *C. parva* has been reported from eutrophic ponds and lakes in England (Parke, Lund and Manton 1962, Reynold 1986), Scotland (Bailey-Watts 1986), Sweden (Cronberg 1982), Germany (Heynig 1963), Canada (Munawer and Munawer 1986) and Israel (Pollingher 1986) but not from oligotrophic lakes. It is inferred that *C. parva* prefers eutrophic waters.

In Japan *C. parva* has been recorded from Lake Kasumigaura, Lake Hinuma and Osaka Bay (Inouye and Chihara 1987). In this paper it is clearly shown that *C. parva* rapidly increases and subsequently decreases in a short time in four ponds and lakes having

different water quality. *C. parva* will be commonly collected from more localities in Japan by samplings at short intervals.

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伊藤裕之：近畿地方の4湖沼における *Chrysochromulina parva* LACKEY（プリムネシウム藻綱）の季節的消長

Chrysochromulina parva（プリムネシウム藻綱）が兵庫県の千苅貯水池，鳥原貯水池，安場池から春期に，滋賀県の琵琶湖から冬～春期に採集された。千苅貯水池では1982年4月13日に最大 1 m*l* 当たり，21,000細胞，安場池では1983年3月14日に59,000細胞といった高密度で出現した。本種は短期間に速く増減し，また富栄養の水界を好み広温性である。（652 神戸市兵庫区楠谷町37–1　神戸市水道局水質試験所）