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Some Remarkable Changes in the Plankton of Lake Biwa in Recent Years

By

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1.

The plankton community of any great lake in a prime or an old age is said to have kept an equilibrium in its constitution as well as its seasonal periodicity, but it seldom loses its balance.

That no great change has occurred in the plankton of Lake Biwa for the past times, at least during the last several thousands years, was demonstrated by my microfossil analyses of the core samples of bottom deposits which were taken from the profundal zone of this lake (K. NEGORO, 1954b, '58). It seems, however, probable that the changes of secondary importance in the plankton of Lake Biwa took place occasionally in the past, even if they happened very rarely.

So far as I have known, these changes of the so-called secondary importance in the plankton of Lake Biwa have been observed in the following three occasions, one of which was only experienced by me:

1) Prof. Em. Tamiji KAWAMURA, who was the director of our Station, noticed in about 1925 a considerable multiplication of *Ceratium hirundinella*, by which the lake water showed a brown colour.

2) Mr. Yasuji KONDO, a former member of our Station, observed a remarkable phenomenon in about 1932, at which the lake water showed a strongly alkaline reaction due to the enormous occurrence of *Nodularia* sp. in the southern shallower part (the so-called auxiliary basin) of Lake Biwa.

3) Early in October of 1958 an enormous multiplication of a single species, *Botryococcus Braunii*, was found by me in the main basin of Lake Biwa, the whole water of which had become deeply muddy colour due to the attacking of the typhoon on August 25th of the same year.

2.

In the recent years the remarkable changes of plankton components were

twice observed in the whole basin of Lake Biwa. I should like to report here those changes.

1. *An explosive multiplication of Closterium aciculare* T. WEST var. *subpronum* W. et G. S. WEST.

Closterium aciculare Tuffen WEST var. *subpronum* W. et G. S. WEST (W. and G. S. WEST, 1902, '04) is ever a member of the plankton in the main basin of Lake Biwa (K. NEGORO, 1954a, '56). It is a slender, straight form, curving slightly only near the ends; breadth $4.5-7\mu$, breadth of apices $1-1.5\mu$; length $450-650\mu$, about one hundred times longer than diameter. Cell-wall smooth and colourless, chloroplasts with 5 to 14 pyrenoids, each of terminal vacuoles containing one moving granule. In Lake Biwa this planktonic desmid appears usually in spring (Feb.-May) and autumn (Sept.-Nov.), being the most abundant from April to May.

From February of 1958 this desmid showed a tendency to increase slightly, and from the end of January of the next year it began active multiplication. During the two months or so of the spring, from the end of March to the end of May of 1959, it reached a maximum multiplication; the individual number per litre of water was ten or more times as that of a normal year. Then toward the summer of the same year the alga decreased gradually and from the middle of October began to increase again. Even at the end of December it occurred in a considerable quantity, continuing to the end of April of 1960. Thereafter the alga diminished rapidly its number.

During the highest multiplication period of this desmid, it was striking that a white plankton-net was soon coloured green by filtration of lake water and the decayed algal cells fell like dust over the leaves of submerged plants. The fibre or textile manufactories by the lake had some trouble in using the lake water; moreover, the water-works of Kyoto city met with a difficulty to filter the water conducted from Lake Biwa.

Mr. Mitsugi OISHI, an university student under my leadership, made in 1959 a study on the plankton of the Seta-gawa River, the only natural outlet of Lake Biwa (M. OISHI, MS.). According to his calculation, the individual number of *Closterium aciculare* var. *subpronum* per litre of water at the starting point of the outlet has been changed with the progress of months, as shown in the following table (Table 1).

From the results of my study on a great number of plankton material collected in 1950 from the whole littoral regions of the main basin of Lake Biwa, I have come to a conclusion that the centre of the occurrence of *Closterium aciculare* var. *subpronum* may be located in the northernmost region of the lake (K. NEGORO, 1954a). At the beginning of July of 1959, I had fortunately an opportunity to make a limnological survey of this region (off the Tsuzurao Peninsula) and was able to ascertain my supposition. I have observed there an astonishing multiplication of the desmid, which I have never met with elsewhere. The result of this observation is as follows (Table 2).

Table 1. The individual number of *Closterium aciculare* var. *subpronum* contained in 1 litre water of the Seta-gawa River, the only natural outlet of Lake Biwa.

Date	Station A (The right bank = Otsu city side)	Station B (The left bank = Seta town side)	Date	Station A (The right bank = Otsu city side)	Station B (The left bank = Seta town side)
1958. XII. 13	2.2	2.0	1959. V. 25	1319.0	846.5
" XII. 20	7.8	1.9	" VI. 1	462.5	—
" XII. 27	30.6	32.0	" VI. 8	334.0	371.0
1959. I. 3	34.1	47.6	" VI. 15	55.5	121.0
" I. 10	12.1	80.2	" VI. 29	15.0	2.0
" I. 17	65.7	—	" VII. 13	19.0	32.0
" I. 24	203.7	113.5	" VII. 27	1.0	1.0
" I. 30	186.3	106.8	" VIII. 10	0.0	1.5
" II. 7	222.0	119.6	" VIII. 24	35.0	13.0
" II. 21	190.4	10.6	" IX. 28	8.0	—
" III. 7	322.1	130.2	" X. 14	37.0	48.5
" III. 21	446.0	4814.0	" XI. 10	48.0	46.0
" IV. 4	221.0	487.5	" XI. 18	156.0	178.0
" IV. 18	676.5	670.5	" XI. 26	663.0	518.0
" IV. 25	960.0	1434.0	" XII. 3	280.5	226.0
" V. 2	2869.0	804.0	" XII. 10	835.5	275.5
" V. 18	1121.5	307.0	" XII. 26	1431.5	776.5

Table 2. The result of a limnological observation in the northernmost region of Lake Biwa at a depth of 65 m off Tsuzurao Peninsula and the vertical distribution of *Closterium aciculare* var. *subpronum* (number per litre of lake water).

July 7th, 1959; 13^h. Cloudy weather.
Atmospheric temperature 28.0°C.

Depth (m)	Temperature of water (°C)	pH	O ₂ (cc/l)	O ₂ (%)	The individual number of <i>Closterium aciculare</i> var. <i>subpronum</i>
0	26.0	7.8	5.97	103.8	}130584
5	23.9	7.9	5.77	96.5	
10	20.8	7.6	6.74	106.6	} 42087
15	17.5	7.3	6.64	98.4	
20	16.1	7.1	6.27	90.2	} 16835
30	11.5	6.9	6.37	83.1	
40	10.1	6.9	6.43	81.2	} 6839
50	9.8	6.9	6.59	82.7	
60	9.5	6.95	6.51	81.2	} 1964
63	9.0	6.9	6.53	80.5	

The zone of 0-5 m deep contained as many as 130 thousands individuals of the desmid in 1 litre water, but 40-60 m zone only ca. 2 thousands. The materials from the zone below 5 m comprised a great number of feded cells of this alga.

2. *A sudden occurrence of Daphnia galeata G. O. Sars.*

On October 4th, 1958, Mr. Hisanao YAMAGUCHI, a member of the staff of our Station, discovered a daphnid with a pointed head about 2.5 mm long, which had never been found in this lake, in the plankton material collected at a station of 3 m deep in the main basin of Lake Biwa off Hikone city. This crustacean was identified by Prof. M. UÉNO as a peculiar race of *Daphnia galeata* G. O. Sars. Afterwards this daphnid was also seen in the southern or auxiliary basin until the middle of December. In the next year, too, this planktonic animal appeared in the auxiliary basin on September 26th and disappeared entirely on December 10th.

According to OISHI's study (M. OISHI, MS.), *Daphnia galeata* was found at the starting point of the outlet Seta-gawa in the following number (Table 3):

Table 3. The individual number of *Daphnia galeata* contained in 1 litre water of the Seta-gawa River, the only natural outlet of Lake Biwa.

Date			Station A (The right bank = Otsu city side)	Station B (The left bank = Seta town side)
1958.	XII.	13	0.0	1.0
"	XII.	20	0.0	0.0
1959.	XI.	10	0.0	2.0
"	XI.	18	2.0	24.0
"	XI.	26	0.0	2.0
"	XII.	3	2.0	11.0
"	XII.	10	0.0	53.5
"	XII.	26	0.0	0.0

This planktonic animal is not so abundant even during the period of its maximum occurrence, but it is impressible with its peculiar shape and the rare occurrence in such a warm-water as Lake Biwa.

3.

By what these changes of the so-called secondary importance have been caused in the plankton of Lake Biwa? The causes of the first and second changes stated above are unknown. It is, however, evident that the third-mentioned change experienced by me was caused by the turbidity of lake water due to the disturbance by typhoon. Just after that time the physical and

Table 4. The result of a limnological observation in the main basin of Lake Biwa at a depth of 70 m off Omatsu.

October 4th, 1953; 10^h. Fine weather.
Atmospheric temperature 21.0°C.

Depth (m)	Temperature of water (°C)	pH	O ₂ (cc/l)	O ₂ (%)
0	22.0	7.1	6.20	100.3
5	21.6	7.0	6.07	97.4
10	21.5	7.0	6.08	97.4
11	21.5	6.9	5.84	93.6
12	20.3	6.7	5.57	87.3
15	18.2	7.0	5.76	86.6
20	15.2	6.8	6.36	89.8
25	12.8	6.9	6.55	87.9
30	10.6	6.6	6.46	82.5
40	8.9	6.7	6.77	83.5
50	8.2	6.6	6.65	80.4
60	7.9	6.6	6.56	78.8
65	7.7	6.5	—	—

chemical conditions measured in the main basin off Omatsu at the western coast were as follows (Table 4).

The transparency of water measured with SÉCCHI'S white disc was only 90 cm, while it was several metres at the same season of a normal year. The lake water was strongly turbid and was a yellowish brown in colour due to suspended muddy particles. This turbidity of lake water spread in the whole basin did not disappear for three months after the disturbance by the violent wind (the typhoon No. 13 of this year). I have never seen such thick turbidities in Lake Biwa over the last ten years, with the exception of this occasion. The two plankton changes in recent years, i.e., an explosive multiplication of *Closterium aciculare* var. *subpronum* and a sudden occurrence of *Daphnia galeata*, seem to agree in time. What changes of natural conditions in Lake Biwa have caused such remarkable phenomena? According to the investigations by the Fishery Experimental Station of Shiga Prefecture and by the Water-works Bureau of Kyoto City, no conspicuous changes are found in the temperature of water as well as in the quantity of nutrients dissolved in water (Fish. Exp. Stat. Shiga Pref., 1958, '59, '60; Water-works Bureau of Kyoto City, 1957, '58, '59). However, so far as the radioactivity measurements of lake water are concerned, there is found a marked change of radioactivity in recent years (Water-works Bureau of Kyoto City, 1957, '58, '59). It has become extraordinarily higher for about ten months, from July of 1958 to May of the next year; it

(in average) was 8.6 ± 1.7 c.p.m./l^{*)} in February, 1959, 9.7 ± 1.6 c.p.m./l in April, while it was 2.0 ± 1.4 and 1.7 ± 1.6 c.p.m./l respectively in the corresponding months of 1958.

I suppose that the two remarkable changes in the plankton of Lake Biwa in recent years would have any relation with the change in radioactivity of the lake water. It may be safe to say that the unusual development of plankton, in particular of the algal plankton under consideration here, was caused by the minute change in quantity of any rare but indispensable minor constituent, which might possibly have arisen from the alteration of radioactivity in the water.

I wish to express my hearty thanks to Prof. Dr. M. UENO for his kindness in reading the manuscript and to Prof. Dr. M. ICHIKAWA, director of the Otsu Hydrobiological Station, for his encouragement.

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Explanation of Plate I

- Figs. 1 and 2. The plankton of *Closterium aciculare* T. WEST var. *subprorum* W. et G. S. WEST at a period of its enormous multiplication, accompanied with few individuals of *Ceratium hirundinella* and *Staurastrum paradoxum*.
- Fig. 3. *Daphnia galeata* G. O. SARS.
- Fig. 4. A pointed head of *Daphnia galeata* G. O. SARS.

*) 23 c.p.m./l are equivalent to 10^{-7} μ Curie per ml.

