

First Report of the Regular Limnological Survey of Lake Biwa (Oct.1965 – Dec.1966)

II. Plankton in General and Phytoplankton*

By

Ken-ichiro NEGORO

Ôtsu Hydrobiological Station, Kyoto University

I. The Collecting Stations

By the constriction-like, narrowest portion of the lake between Katada fishing village and the delta of River Yasu-gawa, Biwa-ko may be divided into two parts, namely the main basin or the northern part and the accessory basin or the southern part. The former is far larger as well as deeper than the latter. The water of the accessory basin is seemed to be mesotrophic, while that of the main basin is typically oligotrophic and streams down from north to south, longitudinally across the accessory basin, toward the endmost, sole effluent Seta-gawa.

As already mentioned in the foregoing article "General Remark", one station, Ie-1, in the main basin and three stations, Nb-2, Nb-5, and Na-3, in the accessory basin were selected for the survey of the present report, viz. the collection of the plankton. Station Nb-2 (an eastern littoral point), Station Nb-5 (a point in the middle portion, formerly Nb-3) and Station Na-3 (a western littoral point, formerly Na-2) stand in a line transversely across the lake. Station Na-3 is located near the Ôtsu Hydrobiological Station. These collecting stations are seemed to be fairly typical for the study of the plankton of Lake Biwa-ko.

II. Methods

For the collection of the Plankton samples was used throughout the course of the survey a closing tow-net, Kitahara's quantitative plankton net manufactured by Rigôsha Co. Ltd. (Tokyo). This net resembles in its shape and construction the Wisconsin plankton net and is 15 cm in mouth (upper ring) diameter

* In this article, the results of our several preliminary surveys (from the end of May to Sept. 1965) were also described.

Contributions from the Otsu Hydrobiological Station, Kyoto University, No. 189.

and approx. 86 cm in overall length, consisting of 2 cones. The upper truncated cone is made of canvas, 28 cm long, and gradually enlarged to the bottom so as to permit a better flow of water. The lower cone is made of bolting cloth, the mesh of which corresponds to No. XX-13 of the Japanese standard (129 meshes per inch), and is 26 cm in mouth (lower ring) diameter, about 58 cm in length.

The plankton samples were collected at Station Ie-1 by vertical hauls in six or seven zonal water columns and at three stations of the accessory basin by straining 40 l surface water through the net cloth. The samples were preserved in 3 to 5% formalin solution. The records of the temperature, pH, and the dissolved oxygen amount of the water were taken in connection with the samples collected.

The volume of the total plankton was obtained by allowing the fixed material to stand for 48 hours in graduated sedimentation tube until it has completely settled, and from this figure the volume per cubic meter of the original lake water was calculated.

The number of the plankton organisms was enumerated by using Sedgwick-Rafter counting cell. Then 10 fields under the microscope were counted at 150 × magnification. The averages so obtained were used to compute the number of plankters per cubic meter of lake water.

III. The volume of the total plankton

By using the precipitated material, the reading of the phytoplankton volume may often be easily done, but it is sometimes almost difficult when the phytoplankton is perfectly mixed with the zooplankton. Hence only the volumes of the total plankton are described here (Table 1 and 2).

Table 1. The volume of the total plankton in cm³ per cm³ of lake water at Station Ie-1

(1)

Date	1965 VI-15	1965 VII-15	1965 VIII-16	1965 IX-15	1965 X-18	1965 XI-16	1965 XII-15	Average from July to Dec.
Zone								
0~5 m	2.19	4.90	46.44	21.93	14.19	19.35	25.80	22.10
5~10 m	0.90	1.94	9.68	5.16	2.97	5.16	4.77	4.94
10~20 m	0.07	1.30	10.38	0.65	0.65	3.12	1.62	2.95
20~30 m	0.07	0.33	4.54	0.65	0.26	1.49	1.95	1.54
30~50 m	0.10	0.49	0.91	0.81	0.16	0.42	0.65	0.57
50~70 m	0.03	0.13	0.81	0.32	0.39	0.39	0.39	0.41
Average	0.56	1.52	12.13	4.92	3.10	4.99	5.86	

(2)

Date	1966 I-13	1966 II-16	1966 III-16	1966 IV-18	1966 V-13	1966 VI-15	Average
Zone							
0~ 5 m	10.58	4.52	10.32	10.32	7.74	21.93	10.90
5~10 m	2.97	1.29	1.55	2.58	1.55	7.74	2.95
10~20 m	1.23	0.65	0.97	1.30	1.17	2.47	1.30
20~30 m	1.17	0.52	0.65	0.78	0.78	0.65	0.76
30~50 m	0.55	0.65	0.19	0.23	0.23	0.39	0.37
50~70 m	0.13	0.19	0.10	0.32	0.42	0.49	0.28
Average	2.77	1.30	2.30	2.59	1.98	5.61	

(3)

Date	1966 VII-15	1966 VIII-19	1966 IX-13	1966 X-14	1966 XI-16	1966 XII-15	Average
Zone							
0~ 2 m	12.33	9.74	10.32*	9.74	3.90	9.09	8.96
2~ 5 m	11.91	1.95		4.76	6.50	4.33	5.89
5~10 m	0.30	0.13	2.32	0.28	0.39	0.52	0.66
10~20 m	2.60	1.75	1.49	1.95	0.84	4.41	2.17
20~30 m	0.65	0.39	0.52	0.45	0.52	3.89	1.07
30~50 m	0.65	0.32	0.23	0.26	0.26	2.75	0.75
50~70 m	1.04	1.62	0.26	—	0.19	0.23	0.67
Average	4.21	2.27	2.52	2.91	1.80	3.60	

* Values from the zone of 0 ~ 5 m depth.

On an average the volume of the plankton was largest in August of 1965 and smallest in June of 1965. It was also very small in the following months; July of 1965, February of 1966, May of 1966, and December of 1966. These considerable fluctuations in the volume of the total plankton were seemed to be mainly due to the amount of the zooplankton.

The zonal distribution of the plankton in volume was generally normal for the last half-year of 1965 and the first half-year of the next year, but abnormal for the last half-year of 1966, because the unexpected small volume was shown in the 5~10 m zone.

Table 2. The volume of the plankton in cm³ per m³ of the surface lake-water at Stations Nb-2, Nb-5, and Na-3

Station	Nb-2 (Tsudaë)	Nb-5 (Nb-3)	Na-3 (Shimo-sakamoto)	Average
Date				
1965-V-31	2.00	1.25	1.00	1.42
1965-VI-9	1.25	1.75	0.75	1.25
1965-VII-8	5.00	12.50	150.00	55.83
1965-VIII-2	32.50	15.00	0.50	16.00
1965-VIII-17	7.50	7.50	10.00	8.33
1965-IX-1	8.75	10.00	2.50	7.08
1965-X-1	16.25	11.25	22.50	16.67
1955-X-15	32.50	22.50	32.50	29.17
1965-XI-2	37.50	17.50	8.75	21.25
1965-XII-2	2.50	10.00	8.75	7.08
1965-XII-13	6.25	5.00	1.00	4.08
1966-I-5	5.00	3.75	3.00	3.92
1966-I-17	5.00	8.75	6.25	6.67
1966-II-1	2.25	2.50	6.25	3.67
1966-II-17	2.25	2.50	2.50	2.42
1966-III-2	1.25	2.25	5.00	2.83
1966-III-18	42.50	50.00	12.50	35.00
1966-III-31	12.50	15.00	7.50	11.67
1966-IV-12	7.50	7.50	2.50	5.83
1966-IV-30	15.00	22.50	27.50	21.67
1966-V-16	50.00	30.00	21.25	33.75
1966-V-30	2.50	5.00	3.75	3.75
1966-VI-13	30.00	1.25	1.50	10.92
1966-VII-16	20.00	15.00	20.00	18.33
1966-VIII-18	2.50	5.00	1.25	2.92
1966-IX-16	5.75	5.00	2.50	4.42
1966-X-15	11.25	3.75	7.50	7.50
1966-XI-19	3.75	1.25	0.75	1.92
1966-XII-19	1.50	2.00	2.00	1.83
Average	12.84	10.25	12.82	

The average volume of three stations was largest on 8th July, 1965, owing to the remarkable occurrence of the zooplankters, especially *Eodiaptomus japonicus*, and smallest in the preceding month, namely on 9th June, 1965.

It was generally small during the period from December of 1965 to the beginning of March of the next year. But this was perhaps the normal phenomenon in winter.

The average volume of the plankton throughout all surveys was greater in both littoral portions (Nb-2 and Na-3) than in the middle portion (Nb-5).

IV. The zonal distribution and the seasonal succession of the phytoplankton

A. At Station Ie-1

The following algae were found in the samples collected at Station Ie-1 during one year and a half of our survey :

Chrysophyta

- 1) *Melosira solida* Eulenstein
- 2) *Melosira italica* (Ehr.) Kützing
- 3) *Stephanodiscus carconensis* Grunow and var. *pusilla* Grunow
- 4) *Asterionella formosa* Hassal
- 5) *Dinobryon cylindricum* Imhof
- 6) *Mallomonas fastigata* Zacharias
- 7) *Botryococcus Braunii* Kützing

Pyrophyta

- 8) *Ceratium hirundinella* (O.F. Müller) Schrank

Chlorophyta

- 9) *Pediastrum Biwae* Negoro and var. *triangulatum* Negoro
- 10) *Oocystis* sp. (new species ?)
- 11) *Sphaerocystis Schroeteri* Chodat
- 12) *Ankistrodesmus falcatus* (Corda) Ralfs
- 13) *Dictyosphaerium pulchellum* Wood
- 14) *Chlamydomonas* sp. (now still unidentified)
- 15) *Eudorina elegans* Ehrenberg
- 16) *Staurastrum dorsidentiferum* W. et G. S. West
var. *ornatum* Grönbl.
- 17) *Staurastrum pingue* Telling
- 18) *Staurastrum limneticum* Schmide
var. *Burmense* W. et G. S. West
- 19) *Spondylosium Lütkemülleri* Grönbl.
- 20) *Cosmocladium constrictum* Arch.
- 21) *Closterium aciculare* Tuffen West
var. *subbronum* W. et G. S. West

Cyanophyta

- 22) *Microcystis aeruginosa* Kützing
- 23) *Chroococcus dispersus* (v. Keissler) Lemmermann

The composition and the zonal distribution of the phytoplankton in each month were as follow :

(5)

1965-X-18

	<i>Melosira solida</i>	<i>Ceratium hirundinella</i>	<i>Pediastrum Biwae</i>	<i>Oocystis sp.</i>	<i>Eudorina elegans</i>	<i>Staurastrum dorsidentiferum</i>	<i>Staurastrum pingue</i>	<i>Closterium aciculare</i>	<i>Chroococcus dispersus</i>
0~5m	16	16	49	-	-	6335	65	97	-
5~10m	32	-	49	16	-	3759	16	49	-
10~20m	-	-	-	-	-	701	8	16	-
20~30m	-	-	24	-	-	709	8	16	24
30~50m	-	-	4	4	4	195	4	4	-
50~70m	-	-	4	-	-	277	4	16	4

(6)

1965-XI-16

	<i>Melosira solida</i>	<i>Stephanodiscus carconensis</i>	<i>Ceratium hirundinella</i>	<i>Pediastrum Biwae</i>	<i>Oocystis sp.</i>	<i>Sphaerocystis Schroeteri</i>	<i>Staurastrum dorsidentiferum</i>	<i>Staurastrum pingue</i>	<i>Cosmo- cladium constrictum</i>	<i>Closterium aciculare</i>
0~5m	146	-	-	113	32	16	13529	178	-	421
5~10m	-	-	-	97	16	49	5428	16	16	113
10~20m	57	-	8	33	8	24	2291	16	-	49
20~30m	8	16	-	41	-	8	2038	8	-	16
30~50m	4	24	-	4	8	-	476	-	-	12
50~70m	4	-	-	-	4	-	346	-	-	-

(7)

1965-XI-15

	<i>Melosira solida</i>	<i>Stephanodiscus carconensis</i>	<i>Pediastrum Biwae</i>	<i>Oocystis sp.</i>	<i>Staurastrum dorsidentiferum</i>	<i>Staurastrum pingue</i>	<i>Closterium aciculare</i>
0~5m	259	-	16	-	13804	227	729
5~10m	32	-	32	16	3046	-	65
10~20m	33	8	24	8	2217	41	8
20~30m	8	-	24	-	1467	8	73
30~50m	4	-	12	4	851	4	16
50~70m	4	-	-	4	704	4	28

(8)

1966-I-13

	<i>Melosira solida</i>	<i>Stephanodiscus carconensis</i>	<i>Pediastrum Biwae</i>	<i>Staurastrum dorsidentiferum</i>	<i>Staurastrum pingue</i>	<i>Closterium aciculare</i>
0~5m	686	-	-	17547	-	817
5~10m	97	-	-	2965	-	113
10~20m	73	-	-	1793	16	90
20~30m	57	-	-	1035	16	24
30~50m	20	-	-	663	8	16
50~70m	16	24	8	553	8	8

(9)

1966-II-16

	<i>Melosira solida</i>	<i>Staurastrum dorsidentiferum</i>	<i>Closterium aciculare</i>
0 ~ 5 m	810	4537	826
5 ~ 10 m	259	2916	211
10 ~ 20 m	90	1117	57
20 ~ 30 m	163	864	49
30 ~ 50 m	49	362	49
50 ~ 70 m	94	269	33

(10)

1966-III-16

	<i>Melosira solida</i>	<i>Astrionella formosa</i>	<i>Staurastrum dorsidentiferum</i>	<i>Closterium aciculare</i>
0 ~ 5 m	956	65	6675	1410
5 ~ 10 m	275	16	1896	324
10 ~ 20 m	245	-	986	139
20 ~ 30 m	139	-	766	114
30 ~ 50 m	81	-	431	28
50 ~ 70 m	33	-	232	20

(11)

1966-IV-18

	<i>Melosira solida</i>	<i>Melosira italica</i>	<i>Stephano- discus carconensis</i>	<i>Asterio- nella formosa</i>	<i>Dinobryon cylind- dricum</i>	<i>Ceratium hirun- dinella</i>	<i>Staurastrum dorsiden- tiferum</i>	<i>Clostrum aciculare</i>
0~5m	616	-	-	843	-	16	2690	2690
5~10m	324	-	-	49	-	-	254	421
10~20m	106	8	-	65	-	-	334	228
20~30m	163	-	-	16	-	-	253	155
30~50m	61	-	-	4	4	-	134	37
50~70m	77	-	8	16	-	-	126	110

(12)

1966-V-13

	<i>Melosira solida</i>	<i>Stephano- discus carconensis</i>	<i>Asterio- nella formosa</i>	<i>Dinobryon cylind- ricum</i>	<i>Ceratium hirundi- nella</i>	<i>Ankistro- desmus falcatus</i>	<i>Staurastrum dorsiden- tiferum</i>	<i>Closte- rium aciculare</i>
0~5m	81	-	211	470	32	32	2204	4909
5~10m								
10~20m	49	-	90	16	-	-	660	424
20~30m	33	16	33	33	-	-	187	220
30~50m	33	-	12	-	-	-	122	94
50~70m	175	20	-	-	-	-	146	77

(13)

1966-VI-15

	<i>Melosira solida</i>	<i>Stephanodiscus carconensis</i>	<i>Ceratium hirundinella</i>	<i>Staurastrum dorsidentiferum</i>	<i>Closterium aciculare</i>
0 ~ 5 m	32	32	81	356	5703
5 ~ 10 m	81	65	16	113	1410
10 ~ 20 m	8	8	-	82	448
20 ~ 30 m	-	8	-	90	359
30 ~ 50 m	12	-	-	37	155
50 ~ 70 m	16	-	-	12	77

(14)

1966-VII-15

	<i>Ceratium hirundinella</i>	<i>Sphaerocystis Schroeteri</i>	<i>Ankistrodesmus falcatus</i>	<i>Staurastrum dorsidentiferum</i>	<i>Staurastrum pingue</i>	<i>Closterium aciculare</i>
0~2m	41	-	-	122	-	3506
2~5m	27	27	-	272	27	1196
5~10m	-	32	-	162	-	745
10~20m	-	24	8	24	-	253
20~30m	-	16	-	16	-	334
30~50m	-	8	-	8	-	85
50~70m	-	-	-	16	-	90

(15)

1966-VIII-19

	<i>Melosira solida</i>	<i>Stephano- discus carconensis</i>	<i>Ceratium hirun- dinella</i>	<i>Pedia- strum Biwae</i>	<i>Oocy- stis sp.</i>	<i>Sphaero- cystis Schroeteri</i>	<i>Staura- strum dorsiden- tiferum</i>	<i>Staura- strum limne- ticum</i>	<i>Closte- rium acicu- lare</i>
0~2m	-	-	41	41	-	-	2690	41	204
2~5m	-	-	109	54	-	27	1659	-	109
5~10m	-	-	-	-	-	-	470	16	-
10~20m	-	-	-	8	-	-	310	-	82
20~30m	-	-	-	-	-	-	90	-	49
30~50m	-	-	8	-	4	-	24	-	8
50~70m	16	8	-	-	-	-	-	-	-

(16)

1966-IX-13

	<i>Melosira solida</i>	<i>Ceratium hirundi- nella</i>	<i>Pedia- strum Biwae</i>	<i>Oocystis sp.</i>	<i>Staura- strum dorsidentiferum</i>	<i>Staura- strum pingue</i>	<i>Staura- strum limneticum</i>	<i>Closte- rium aciculare</i>
0~5m	-	324	16	16	15052	16	32	16
5~10m	-	113	16	-	3419	16	97	16
10~20m	-	41	8	-	1166	8	-	8
20~30m	-	24	-	-	709	-	-	8
30~50m	4	16	-	-	415	8	-	-
50~70m	-	16	4	-	370	-	-	-

(17)

1966-X-14

	<i>Ceratium hirundinella</i>	<i>Pediastrum Biwae</i>	<i>Oocystis</i> sp.	<i>Dictyosphaerium pulchellum</i>	<i>Staurastrum dorsidentiferum</i>	<i>Staurastrum limneticum</i>	<i>Closterium aciculare</i>	<i>Microcystis aeruginosa</i>
0~ 2m	82	-	41	-	3506	204	245	-
2~ 5m	-	-	-	-	571	-	109	109
5~10m	16	49	-	16	843	-	49	16
10~20m	-	33	8	-	1149	65	24	-
20~30m	-	8	-	-	106	-	24	-
30~50m	4	-	-	-	20	-	4	-
50~70m								

(18)

1966-XI-16

	<i>Melosira solida</i>	<i>Melosira italica</i>	<i>Stephanodiscus carconensis</i>	<i>Ceratium hirundinella</i>	<i>Pediastrum Biwae</i>	<i>Staurastrum dorsidentiferum</i>	<i>Staurastrum limneticum</i>	<i>Microcystis aeruginosa</i>
0~ 2m	815	41	-	82	-	-	41	-
2~ 5m	189	-	-	27	-	27	-	-
5~10m	162	16	-	-	16	16	65	-
10~20m	33	-	8	-	8	16	8	-
20~30m	-	-	-	-	16	33	8	8
30~50m	16	-	12	-	4	12	-	4
50~70m	12	-	8	4	8	12	-	-

(19)

1966-XII-15

	<i>Melosira solida</i>	<i>Melosira italica</i>	<i>Stephanodiscus carconensis</i>	<i>Mallomonas fastigata</i>	<i>Ceratium hirundinella</i>	<i>Chlamydomonas</i> sp.	<i>Staurastrum dorsidentiferum</i>	<i>Staurastrum limneticum</i>	<i>Cosmostridium constrictum</i>	<i>Microcystis aeruginosa</i>
0~ 2m	3792	82	-	122	41	41	41	326	815	41
2~ 5m	761	27	82	-	-	-	-	27	82	-
5~10m	405	-	-	-	-	-	16	81	113	8
10~20m	636	33	33	-	-	-	16	16	187	-
20~30m	269	16	-	-	-	-	-	8	57	-
30~50m	501	24	-	-	-	-	8	33	102	-
50~70m	37	4	12	-	-	-	-	8	4	-

Table 4. Number of the component species of the phytoplankton and number of cells or colonies of the total phytoplankton per m³ of water in epilimnion (0~5m). A unit of number of cells or colonies is shown in 10,000 (10⁴).

Date	Number of the component species	Number of cells or colonies of the total phytoplankton
1965-VI-15	7	36
1965-VII-15	6	97
1965-VIII-16	7	987
1965-IX-15	11	6237
1965-X-18	9	6578
1965-XI-16	10	14435
1965-XII-15	7	15035
1966-I-13	6	19050
1966-II-16	3	6173
1966-III-16	4	9106
1966-IV-18	8	6855
1966-V-13	8	7934
1966-VI-15	5	6204
1966-VII-15	6	5218
1966-VIII-19	9	4975
1966-IX-13	8	15472
1966-X-14	8	4867
1966-XI-16	8	1222
1966-XII-15	10	6280

Based on the previous table, the number of the component species of the phytoplankton and the number of cells or colonies of the total phytoplankton per cubic meter of water in epilimnion were summarized in Table 4.

From this table it is clearly seen that the individual number of phytoplankton began to increase gradually from July of 1965 and came to the enormous multiplication in November of the same year. Then the maximum multiplication was reached in January of the next year. Though the number of the component species greatly decreased in the following months, namely in February and March of 1966, the number of the cells of phytoplankton had scarcely any diminution received. This prosperity continued nearly to the end of the year 1966.

The most striking feature on the phytoplankton during the period of our present survey was the remarkable occurrence of *Staurastrum dorsidentiferum* var. *ornatum* together with its maximum multiplication in winter. The already mentioned, enormous cell-number of the total phytoplankton in the cold season seems to practically due to the remarkable multiplication of this alga.

Another impressive fact was that, to the author's experience, in the main basin of Lake Biwa, *Melosira solida* and *Stephanodiscus carconensis* used to appear in winter at the same time in enormous quantity as main plankters;

however during this period of the survey the former of these two semi-endemic diatoms occurred in a considerable amount in winter, but the latter appeared scarcely through all seasons in the epilimnion, remaining mostly in the deep zone near the bottom.

B. At Stations Nb-2, Nb-5, and Na-3

Besides the algae found at Station Ie-1, the following forms were added here as components of the phytoplankton to the flora of Lake Biwa-ko :

Chrysophyta

- 1) *Melosira granulata* (Ehr.) Ralfs
- 2) *Melosira granulata* var. *angustissima* Müller
- 3) *Melosira varians* C.A. Agardh
- 4) *Synedra ulna* (Nitzsch) Ehrenberg
- 5) *Fragilaria crotonensis* Kitton
- 6) *Dinobryon divergens* Imhof

Chlorophyta

- 7) *Micractinium pusillum* Fresenius
- 8) *Selenastrum gracile* Reinsch
- 9) *Spirogyra* sp. (without zygospores)

Cyanophyta

- 10) *Merismopedia elegans* A. Br.
- 11) *Anabaena macrospora* Klebahn
- 12) *Anabaena spiroides* Klebahn
- 13) *Lyngbya limnetica* Lemmermann

Table 5. Phytoplankters per m³ of lake water at Stations Nb-2, Nb-5, and Na-3. A unit of number corresponds to ten thousand (10,000).

(1)	1965-V-31		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	126	63	-
<i>Dinobryon cylindricum</i>	-	31	-
<i>Eudorina elegans</i>	-	31	-
(2)	1965-VI-9		
	Nb-2	Nb-5	Na-3
<i>Melosira solida</i>	1476	1319	157
<i>Stephanodiscus carconensis</i>	-	-	31
<i>Dinobryon divergens</i>	157	126	63

(3)		1965-VII-8		
	Nb-2	Nb-5	Na-3	
<i>Melosira italica</i>	879	879	157	
<i>Melosira granulata</i>	31	-	-	
<i>Pediastrum Birwae</i>	-	63	31	
<i>Eudorina elegans</i>	31	-	-	
<i>Staurastrum dorsidentiferum</i>	31	157	-	
<i>Staurastrum limneticum</i>	31	-	-	
<i>Closterium aciculare</i>	-	31	-	

(4)		1965-VIII-2		
	Nb-2	Nb-5	Na-3	
<i>Melosira italica</i>	1068	1476	283	
<i>Pediastrum Birwae</i>	-	126	63	
<i>Staurastrum dorsidentiferum</i>	126	3548	628	
<i>Staurastrum pingue</i>	-	-	31	
<i>Spondylosium Lütke-mülleri</i>	63	-	-	
<i>Closterium aciculare</i>	-	-	31	
<i>Spirogyra</i> sp.	31	126	-	
<i>Merismopedia elegans</i>	-	31	-	

(5)		1965-VIII-17		
	Nb-2	Nb-5	Na-3	
<i>Melosira italica</i>	2512	973	408	
<i>Melosira granulata</i>	-	31	-	
<i>Pediastrum Birwae</i>	31	-	-	
<i>Staurastrum dorsidentiferum</i>	942	785	2292	
<i>Staurastrum limneticum</i>	-	63	94	
<i>Spondylosium Lütke-mülleri</i>	-	-	31	
<i>Closterium aciculare</i>	-	-	31	
<i>Spirogyra</i> sp.	63	63	-	
<i>Microcystis aeruginosa</i>	31	-	94	
<i>Anabena macrospora</i>	-	-	31	

(6)		1965-IX-1		
	Nb-2	Nb-5	Na-3	
<i>Melosira italica</i>	9169	3485	1287	
<i>Melosira granulata</i>	345	-	-	
<i>Pediastrum Birwae</i>	63	-	-	
<i>Oocystis</i> sp.	31	-	-	
<i>Staurastrum dorsidentiferum</i>	1382	816	942	
<i>Staurastrum pingue</i>	-	31	31	
<i>Staurastrum limneticum</i>	31	-	31	
<i>Spondylosium Lütke-mülleri</i>	94	94	94	

<i>Cosmocladium constrictum</i>	-	63	31
<i>Closterium aciculare</i>	-	-	31
<i>Spirogyra</i> sp.	31	157	31
<hr/>			
(7)	1965-X-1		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	7096	942	-
<i>Melosira granulata</i>	220	63	-
<i>Ceratium hirundinella</i>	-	-	63
<i>Pediastrum Biwae</i>	31	126	126
<i>Staurastrum dortidentiferum</i>	7505	10111	11681
<i>Staurastrum pingue</i>	-	94	63
<i>Closterium aciculare</i>	220	188	283
<hr/>			
(8)	1975-X-15		
	Nb-2	Nb-5	Na-3
<i>Melosira solida</i>	-	-	63
<i>Melosira italica</i>	3956	251	502
<i>Melosira granulata</i>	-	63	-
<i>Pediastrum Biwae</i>	31	31	63
<i>Oocystis</i> sp.	-	-	31
<i>Staurastrum dorsidentiferum</i>	8164	16485	17898
<i>Staurastrum pingue</i>	-	188	188
<i>Closterium aciculare</i>	63	534	565
<hr/>			
(9)	1965-XI-2		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	377	502	94
<i>Melosira granulata</i>	31	-	-
<i>Oocytis</i> sp.	31	31	-
<i>Sphaerocystis Schroeteri</i>	-	63	-
<i>Micractinium pusillum</i>	31	-	-
<i>Staurastrum dorsidentiferum</i>	5432	12591	8541
<i>Staurastrum pingue</i>	63	63	31
<i>Closterium aciculare</i>	314	879	597
<hr/>			
(10)	1965-XII-2		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	188	377	220
<i>Oocystis</i> sp.	31	-	31
<i>Staurastrum dorsidentiferum</i>	3642	8729	7191
<i>Staurastrum pingue</i>	31	126	126
<i>Closterium acicuare</i>	314	628	628

(11)	1965-XII-13		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	16	126	204
<i>Synedra ulna</i>	16	-	-
<i>Pediastrum Birwae</i>	-	-	16
<i>Staurastrum dorsidentiferum</i>	958	4255	3690
<i>Staurastrum pingue</i>	16	16	31
<i>Closterium aciculare</i>	298	424	361
<i>Spirogyra</i> sp.	-	-	16

(12)	1966-I-5		
	Nb-2	Nb-5	Na-3
<i>Melosira solida</i>	-	-	94
<i>Melosira italica</i>	534	-	-
<i>Oocystis</i> sp.	31	-	-
<i>Staurastrum dorsidentiferum</i>	4522	5244	6657
<i>Staurastrum pingue</i>	-	31	-
<i>Closterium aciculare</i>	345	565	785

(13)	1966-I-17		
	Nb-2	Nb-5	Na-3
<i>Melosira solida</i>	-	31	31
<i>Melosira italica</i>	-	126	-
<i>Asterionella formosa</i>	-	31	-
<i>Synedra ulna</i>	-	31	-
<i>Dinobryon cylindricum</i>	-	-	31
<i>Mallomonas fastigata</i>	-	31	-
<i>Oocystis</i> sp.	-	-	31
<i>Staurastrum dorsidentiferum</i>	3485	4584	7662
<i>Cosmocladium constrictum</i>	31	-	-
<i>Closterium aciculare</i>	471	973	659

(14)	1966-II-1		
	Nb-2	Nb-5	Na-3
<i>Melosira solida</i>	-	31	31
<i>Asterionella formosa</i>	-	31	31
<i>Synedra ulna</i>	-	31	31
<i>Staurastrum dorsidentiferum</i>	4804	2575	4522
<i>Closterium aciculare</i>	471	502	754

(15)	1966-II-17			
		Nb-2	Nb-5	Na-3
	<i>Oocystis</i> sp.	-	31	31
	<i>Staurastrum dorsidentiferum</i>	4741	2261	3705
	<i>Closterium aciculare</i>	628	691	597
(16)	1966-III-2			
		Nb-2	Nb-5	Na-3
	<i>Melosira solida</i>	-	31	-
	<i>Staurastrum dorsidentiferum</i>	1193	2355	3140
	<i>Closterium aciculare</i>	565	565	879
(17)	1966-III-18			
		Nb-2	Nb-5	Na-3
	<i>Melosira italica</i>	2606	597	283
	<i>Asterionella formosa</i>	-	126	63
	<i>Ceratium hirundinella</i>	-	94	-
	<i>Pediastrum Bivae</i>	31	31	-
	<i>Selenastrum gracile</i>	31	-	-
	<i>Staurastrum dorsidentiferum</i>	3548	2700	1130
	<i>Closterium aciculare</i>	26376	6343	2826
	<i>Spirogyra</i> sp.	-	31	-
(18)	1966-III-31			
		Nb-2	Nb-5	Na-3
	<i>Melosira italica</i>	440	94	31
	<i>Asterionella formosa</i>	31	126	157
	<i>Dinobryon cylindricum</i>	-	31	-
	<i>Staurastrum dorsidentiferum</i>	3799	4365	2324
	<i>Staurastrum pingue</i>	31	31	-
	<i>Closterium aciculare</i>	1476	2010	1784
(19)	1966-IV-12			
		Nb-2	Nb-5	Na-3
	<i>Melosira italica</i>	126		
	<i>Melosira granulata</i> var. <i>angustissima</i>	31		
	<i>Dinobryon cylindricum</i>	31		
	<i>Staurastrum dorsidentiferum</i>	785		
	<i>Closterium aciculare</i>	879		

(20)	1966-IV-30		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	188	157	659
<i>Asterionella formosa</i>	126	220	126
<i>Synera ulna</i>	251	31	157
<i>Dinobryon divergens</i>	31	-	-
<i>Staurastrum dorsidentiferum</i>	408	1287	1507
<i>Closterium aciculare</i>	2324	3014	3737

(21)	1966-V-16		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	848	314	471
<i>Melosira varians</i>	-	-	31
<i>Asterionella formosa</i>	157	63	188
<i>Synedra ulna</i>	-	31	31
<i>Fragilaria crotonensis</i>	-	-	63
<i>Dinobryon cylindricum</i>	-	-	31
<i>Dinobryon divergens</i>	-	-	31
<i>Pediastrum Biwae</i>	31	-	-
<i>Staurastrum dorsidentiferum</i>	4773	3831	2355
<i>Closterium aciculare</i>	22671	10362	6939

(22)	1966-V-30		
	Nb-2	Nb-5	Na-3
<i>Melosira solida</i>	-	63	31
<i>Melosira italica</i>	502	188	94
<i>Synedra ulna</i>	63	-	-
<i>Fragilaria crotonensis</i>	-	31	-
<i>Eudorina elegans</i>	-	-	31
<i>Staurastrum dorsidentiferum</i>	1225	3171	2512
<i>Cosmocladium constrictum</i>	-	-	31
<i>Closterium aciculare</i>	5212	6782	5401

(23)	1966-VI-13		
	Nb-2	Nb-5	Na-3
<i>Melosira solida</i>	-	8	-
<i>Melosira italica</i>	7034	243	204
<i>Pediastrum Biwae</i>	31	-	-
<i>Staurastrum dorsidentiferum</i>	126	-	-
<i>Closterium aciculare</i>	5652	-	-

(24)	1966-VII-16		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	1978	94	911
<i>Melosira granulata</i>	-	-	31
<i>Asterionella formosa</i>	31	-	-
<i>Eudorina elegans</i>	-	-	31
<i>Staurastrum dorsidentiferum</i>	63	126	283
<i>Closterium aciculare</i>	1696	7819	4930
<i>Spirogyra</i> sp.	-	-	31

(25)	1966-VIII-18		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	864	754	785
<i>Melosira granulata</i>	94	63	16
<i>Ceratium hirundinella</i>	-	8	-
<i>Pediastrum Biwae</i>	16	16	8
<i>Staurastrum dorsidentiferum</i>	345	298	298
<i>Closterium aciculare</i>	8	126	-
<i>Spirogyra</i> sp.	79	24	16
<i>Merismopedia elegans</i>	-	-	8
<i>Anabaena macrospora</i>	-	-	63
<i>Lynngbya limnetica</i>	79	283	1444

(26)	1966-IX-16		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	5150	973	1005
<i>Melosira granulata</i>	63	31	-
<i>Ceratium hirundinella</i>	126	31	-
<i>Pediastrum Biwae</i>	63	-	-
<i>Oocystis</i> sp.	-	31	-
<i>Eudorina elegans</i>	31	-	-
<i>Staurastrum dorsidentiferum</i>	3360	3768	1633
<i>Closterium aciculare</i>	63	-	-
<i>Spirogyra</i> sp.	63	63	126
<i>Anabaena macrospora</i>	1319	502	502
<i>Anabaena spiroides</i>	126	188	126
<i>Lynngbya limnetica</i>	1476	534	440

(27)	1966-X-15		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	1567	816	1853
<i>Melosira granulata</i>	-	-	31
<i>Botryococcus Braunii</i>	-	31	-
<i>Pediastrum Biwae</i>	-	63	31

<i>Oocystis</i> sp.	-	31	-
<i>Staurastrum dorsidentiferum</i>	377	1382	1727
<i>Staurastrum limneticum</i>	-	-	63
<i>Closterium aciculare</i>	283	31	220
<hr/>			
(28)	1966-XI-19		
	Nb-2	Nb-5	Na-3
<i>Melosira italica</i>	565	817	722
<i>Pediastrum Biwae</i>	-	94	31
<i>Staurastrum dorsidentiferum</i>	1162	-	659
<i>Staurastrum limneticum</i>	-	-	31
<i>Closterium aciculare</i>	63	-	63
<hr/>			
(29)	1966-XII-19		
	Nb-2	Nb-5	Na-3
<i>Melosira solida</i>	8	141	110
<i>Melosira italica</i>	8	24	8
<i>Asterionella formosa</i>	71	16	8
<i>Mallomonas fastigata</i>	31	31	31
<i>Staurastrum dorsidentiferum</i>	8	8	16
<i>Staurastrum limneticum</i>	16	8	8
<i>Cosmocladium constrictum</i>	-	55	47
<i>Closterium aciculare</i>	-	8	-

Table 6. Number of the component species of the phytoplankton at three stations of the accessory basin

Date	Station		
	Nb-2	Nb-5	Na-3
1965-V-31	1	3	0
1965-VI-9	2	2	3
1965-VII-8	5	4	2
1965-VIII-2	4	5	5
1965-VIII-17	5	5	7
1965-IX-1	8	6	8
1965-X-1	5	6	5
1965-X-15	4	6	7
1965-XI-2	7	6	4
1965-XII-2	5	4	5
1965-XII-13	5	4	6
1966-I-5	4	3	3
1966-I-17	3	7	5
1966-II-1	2	5	5
1966-II-17	2	3	3
1966-III-2	2	3	2
1966-III-18	5	7	4

1966-III-31	5	6	4
1966-IV-12	5		
1966-IV-30	6	5	5
1966-V-16	5	5	9
1966-V-30	4	5	6
1966-VI-13	4	2	1
1966-VII-16	4	3	6
1966-VIII-18	7	8	8
1966-IX-16	11	9	6
1966-X-15	3	6	6
1966-XI-19	3	2	5
1966-XII-19	6	8	7

Table 7. Number of cells or colonies of the total phytoplankton per m³ of lake water. A unit of number is shown in 10,000 (10⁴),

Date	Station			Average
	Nb-2	Nb-5	Na-3	
1965-V-31	126	125	0	84
1965-VI-9	1633	1445	251	1110
1965-VII-8	1003	1130	188	774
1965-VIII-2	1288	5307	1036	2544
1965-VIII-17	3579	1915	2981	2825
1965-IX-1	11146	4646	2478	6090
1965-X-1	15072	11524	12216	12937
1965-X-15	12214	17552	19310	16359
1965-XI-2	6279	14129	9263	9890
1965-XII-2	4206	9860	8196	7421
1965-XII-13	1304	4821	4318	3481
1966-I-5	5432	5840	7536	6269
1966-I-17	3987	5807	8414	6069
1966-II-1	5275	3170	5369	4605
1966-II-17	5369	2983	4333	4228
1966-III-2	1758	2951	4019	2909
1966-III-18	32592	9922	4302	15605
1966-III-31	5777	6657	4296	5577
1966-IV-12	1852			
1966-IV-30	3328	4709	6186	4741
1966-V-16	28480	14601	10140	17740
1966-V-30	7002	10235	8100	8446
1966-VI-13	12843	251	204	4433
1966-VII-16	3768	8039	6217	6008
1966-VIII-18	1485	1572	2638	1898
1966-IX-16	11840	6121	3832	7118
1966-X-15	2167	2354	3925	2815
1966-XI-19	1790	911	1506	1402
1966-XII-19	142	291	228	220

From Table 7 we can know that there were several times of the high production of the phytoplankton, namely October 1st, 1965, October 15th, 1965, March 18th, 1966, May 16th, 1966 etc. The enormous multiplication in October of 1965 corresponds probably to that of the main basin from Nov. 1965 to Jan. 1966. Station Nb-2 in the eastern littoral region had more often the times of the high production than other two stations.

It is striking that the considerable occurrence of *Melosira italica* was found throughout almost all seasons, with an exception of the severe winter in February 1966.

Three species of the blue-green algae, namely *Anabaena macrospora*, *Anabaena spiroides*, and *Lyngbya limnetica*, appeared abundantly in the late summer of 1966.

V. References

- Negoro, K., 1954a. The plankton of Lake Biwa. Sci. Rep. Shiga Exp. Fish. Stat., Spec. Publ. in 1954, pp. 1-40, 10 plates with 101 figures, 2 tables. (In Japanese.)
- 1954b. Two noteworthy diatoms from Lake Biwa. Kagaku, 24: 420. (In Japanese.)
- 1954c. *Pediastrum Biwae* spec. nov., eine neue planktische Grünalge aus dem Biwasee. Acta Phytotax. Geobot., 15: 135-138.
- 1956. The phytoplankton of the main basin of Lake Biwa-ko. Jap. J. Limnol., 18: 37-46. (In Japanese, with English summary.)
- 1957. The water quality of Lake Biwa-ko. Jap. J. Limnol., 19: 1-22. (In Japanese, with English summary.)
- 1957b. The plankton of Lake Ibanai (or Nakanoumi) as trophic indicators. Jap. J. Limnol., 19: 68-71. (Japanese, with English summary.)
- 1959. Some noticeable plankton-algae of Lake Biwa and its effluent. Algal indicators of a water system. Mem. Coll. Sci., Univ. Kyoto, Ser. B, 26: 311-314.
- 1960. Some remarkable changes in the plankton of Lake Biwa in recent years. Mem. Coll. Sci., Univ. Kyoto, Ser. B, 27: 145-150.