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Distribution of two sympatric *Asterionella formosa* populations in Sagami and Tsukui Lakes, Kanagawa Prefecture, Japan

Takeshi NAMIKI*, Kho MARUYAMA** and Shigeo HAYAMA*

*Department of Biology, Tokyo Agricultnral University, Tokyo 156
**Institute of Applied Microbiology, University of Tokyo, Tokyo 113, Japan

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The cell size distributions and standing crops of *A. fomosa* populations at twelve stations in Sagami and Tsukui lakes in early spring in 1981 were examined.

It was found that two sympatric populations with cell lengths ranging from 44.7±1.8 to 46.6±1.9 μm (S populations) and from 63.1±2.5 to 71.1±2.1 μm (L populations) were distributed all around the two lakes. Differences between populations were observed in the widths of the central region on both valve and girdle sides. Both populations resembled *A. formosa* in their cell dimensions, but the number of striae in 10 μm was fewer. The numbers of cells in S populations were 200/ml at the upper stations and 1,100/ml at the downstream ones, while those in L populations were 100/ml and 5,000/ml respectively. The L populations showed higher density than S populations in the downstream stations. These S and L populations are considered to be the cell populations at different reproduction cycle.

Key Index words: Asterionella formosa; *cell size distributions*; *Sagami Lake*; *standing crops*; *sympatric populations*; *Tsukui Lake*.

The freshwater diatom, *Asterionella gracillima* has been reverted to *A. formosa* based on the morphological characteristics at the level of optical and electron microscopy of the field and culture populations (KÖRNER, 1970; HOAGLUND and ROSOWSKI, 1978). In order to clarify the architecture of the natural population of *A. formosa*, the cell size distributions and standing crops of populations were examined in Sagami and Tsukui lakes.

Sagami and Tsukui lakes are dam-made ones, located in the northern district of Kanagawa Prefecture and in the Sagami water system. The Sagami River is mainly formed by the confluence of the Katsura River originating from both lakes of Yamanaka and Kawaguchi and the Doshi River pouring into it just in the south shore of the Tsukui Lake. The flow includes the Sagami Lake, the Numamoto Control Pond and the Tsukui Lake in this order (Fig. 1).

The Sagami Lake began to store water in 1945 and its length attained to about 7 Km at the full. The flow of this lake was rapid along the old river and the water changed in 8 or 9 days during stagnation (SHIRAISHI et al., 1953; AKAZAWA and HASHIMOTO, 1974). The water was eutrophic and inorganic nitrogen (total ammonia, nitrate and nitrite) and orthophosphate were 1 mg/l (measured in 1971) and 0.1 mg/l (measured in 1970) respectively (AKAZAWA and HASHIMOTO, 1974).

Materials and Methods

** To whom reprint requests should be addressed.

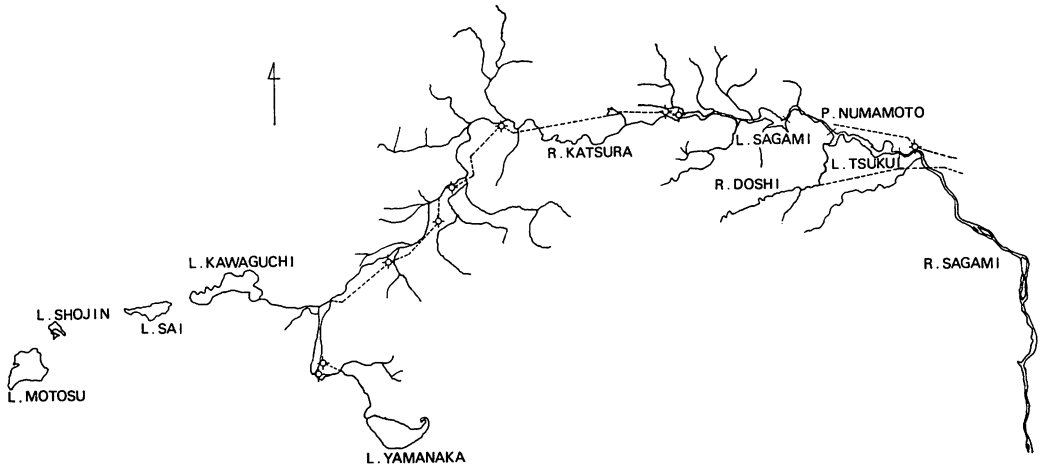


Fig. 1. The dam-made lakes Sagami and Tsukui in the Sagami water system. Dams are indicated by dashes: broken lines, aqueducts; and ⊙, power plants.

Twelve sampling stations were chosen, nine in the Sagami Lake (Stations 1-9) and three in Tsukui Lake (Stations 10-12) (Fig. 2). Analyses were done on surface water samples, collected in 500 ml polythylene bottles on March 17, 1981. The water temperature, pH and conductivity were measured, the latter two by using a pH meter and a portable conductivity meter.

The standing crops and cell size distributions in the diatom populations were estimated at all the stations. 300 ml water was centrifuged at 3,000 rpm for 15 min, the sediment resuspended in 1 to 3 ml water and fixed in 10% formalin. For light microscopy, cells were examined both in living and cleaned conditions. Cleaning of the samples at stations 8 and 12 was done by heating the samples in concentrated sulphric acid, bleaching with hydrogen peroxide and washing with distilled water. Preparations were mounted in Pleurax for microscopical examination.

Population estimates were based on triplicate cell counts and expressed as number of cells per ml. The length and width of basal, central and apical regions of the frustules were also measured in about 200 cells in each population from all stations. At stations 8 and 12, the number of striae in 10 μm were measured adding to the above measurements.

The statistical analysis was done by microcomputer and averages, standard deviations and size distributions were calculated.

Results and Discussion

Environmental conditions: The water temperature, pH and conductivity of the surface water were fairly the same at all stations (Fig. 2). The water temperatures were about 10°C, pH were weak alkaline and conductivities were about 100 μ mho/cm.

Cell numbers in colonies: The average cell numbers constituting a colony ranged from 5.3 ± 2.9 to 8.2 ± 4.2 with a maximum of 26 (Table 1).

Population density: The cell population at each station is shown in Fig. 3. Measurements could not be done at stations 1 and 2 because they were out of scale and cells were very few at stations 3, 4 and 6. At stations 5, 7 to 9 in Sagami Lake and at station 10 in Tsukui Lake, 200 to 400 cells per ml were measured. The populations at Sagami Lake are thought to have been endemic to this region and those at Tsukui to be drift-alga because of the same density as those in Sagami. Those of stations 11 and 12 at

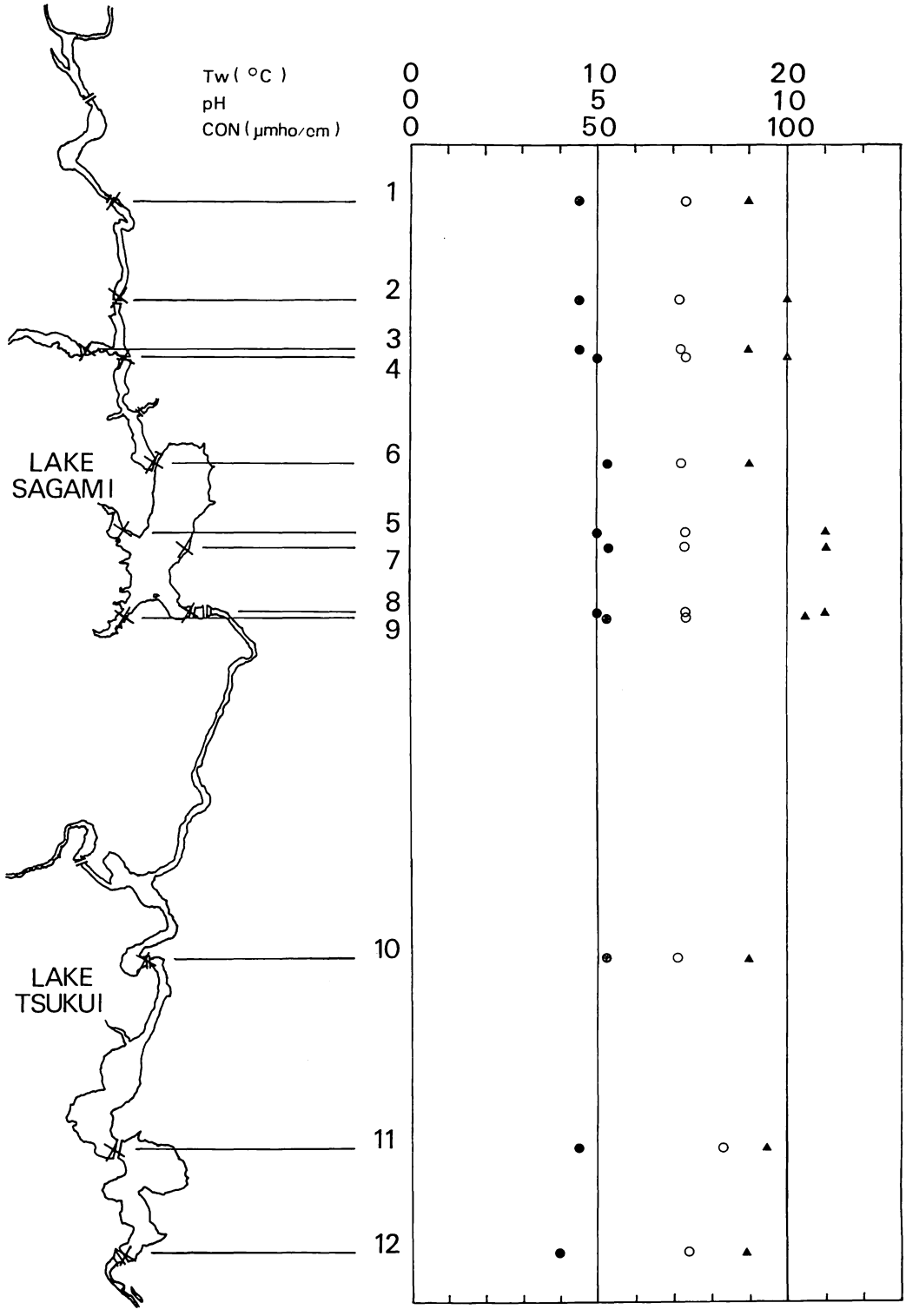


Fig. 2. Water temperature (solid circle), pH (open circle) and conductivity (solid triangle) of the surface water of the lakes Sagami and Tsukui on March 17, 1981.

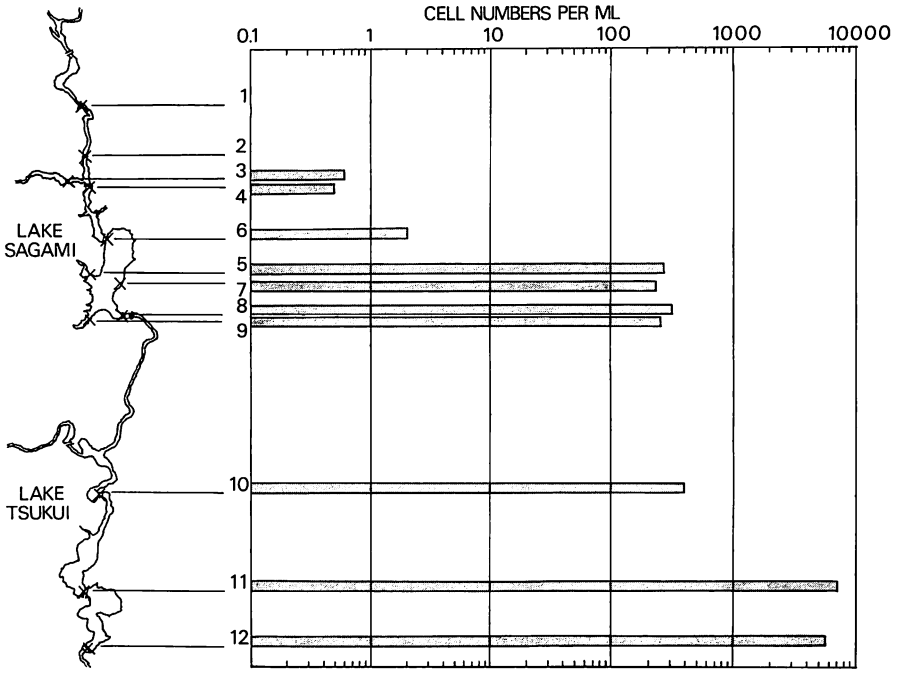


Fig. 3. Cell numbers per ml of *Asterionella formosa* in Lakes Sagami and Tsukui.

Table 1. Cell numbers in a colony of *Asterionella formosa* at Lakes Sagami and Tsukui.

Station No.	Average	Minimum	Maximum
5	7.3±4.1	1.0	17.0
7	6.7±3.1	1.0	17.0
8	8.2±4.2	2.0	25.0
9	6.6±3.4	1.0	26.0
10	5.3±2.9	1.9	16.0
11	5.9±3.1	1.0	20.0
12	—	—	—

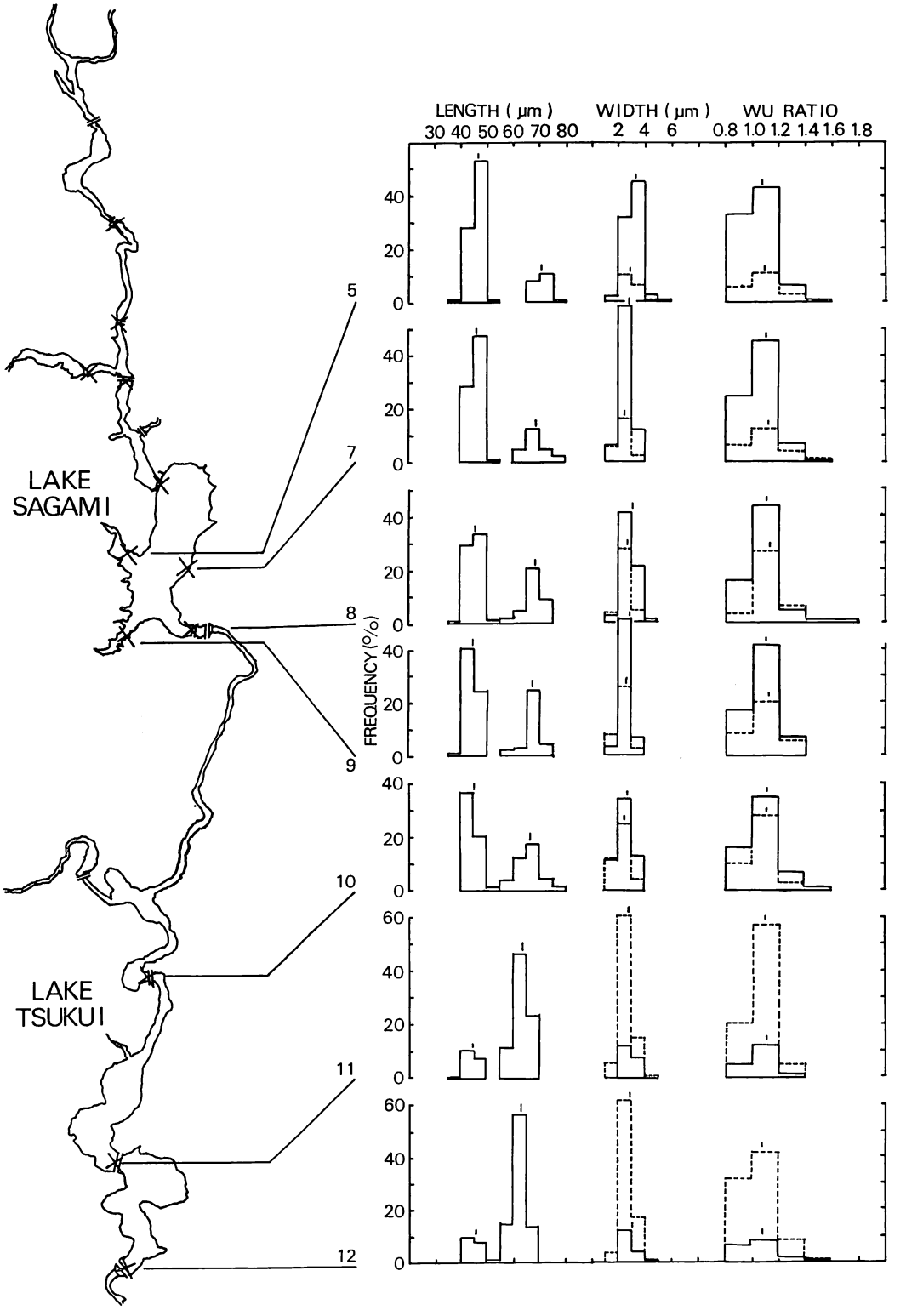
Tsukui Lake were 5,000 to 7,000 cells per ml and equivalent to the cell divisions from 4 to 5 times of the above populations.

Cell size distributions of the populations:

a. *Cell length.* The distribution of living cell lengths of each population was the same and had two separate distribution ranges as shown in Fig. 4. One was designated as the small cell size populations (S populations) with cell dimension ranging from 44.7±1.8 μm to 46.6±1.9 μm and another was the large (L populations) ranging from 63.1±2.5 μm to 71.1±2.1 μm. The ratio of S to L populations was high at stations 5 to 10, while at stations 11 to 12 the inverse relationship was found between the two populations. The cell size distribution at the station 10 of Tsukui Lake was fairly of the same pattern as those in Sagami Lake, indicating that they are drift-alga of Sagami Lake. The average cell sizes and the distribution ranges of L populations became gradually smaller at the down-stream stations. The cell sizes of populations corresponded four to five times of the cell division and became smaller.

b. *Cell width.* In the cell width of the central region, the average sizes and the

Fig. 4. Frequency distribution of cell size of *Asterionella formosa* at Lakes Sagami and Tsukui. Dashes represent average cell sizes; and broken lines, large cell size populations.


LENGTH (μm)
30 40 50 60 70 80
WIDTH (μm)
2 4 6
WU RATIO
0.8 1.0 1.2 1.4 1.6 1.8
FREQUENCY (%)
LAKE SAGAMI
LAKE TSUKUI
5
7
8
9
10
11
12

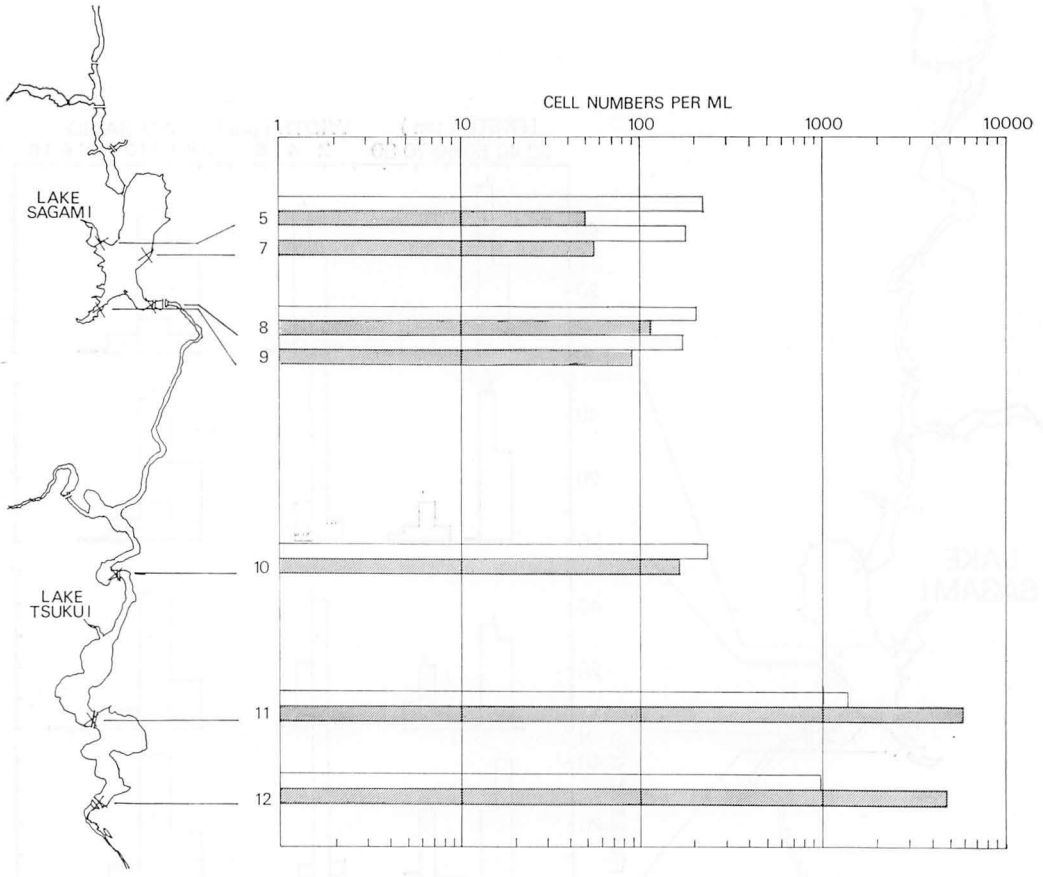


Fig. 5. Population density of the small (S) and the large cell size (L) *Asterionella formosa* populations at Lakes Sagami and Tsukui. Open, S. populations; hatched, L populations.

distribution ranges were smaller in L populations (2.5±0.5 μm to 2.9±0.6 μm), and larger in S populations (2.7±0.6 μm to 3.3 ±0.6 μm) (Fig. 4).

c. *Ratio of apical (U) and basal (W) widths.* There was no difference in the average ratios and the distribution patterns of populations as shown in Fig. 4.

Cell numbers of S and L populations: Fig. 5 expresses the cell numbers of the S and L populations as ratios of the S to L populations. The numbers of S populations were about 200 cells per ml at stations 5 to 10 and about 1,000 cells per ml at station 11 and 12 in Tsukui Lake. Those of L populations were 50 to 100 cells per ml at station 5 to 10 and about 5,000 cells per ml at station 11 and 12. In the down-stream stations of Tsukui Lake, the populations L showed higher cell density than S.

Sizes of valve view: The cell size distributions of cleaned populations of stations 8 and 12 are shown in Fig. 6.

a. *Length.* The cell lengths of the populations ranged from 43.5±2.0 μm to 45.5±1.9 μm and from 63.6±2.9 μm to 65.2±2.5 μm in populations S and L respectively.

b. *Width of central region.* Two populations were distinguished in the ranges of 2.9±0.3 μm to 3.0±0.2 μm for S and 2.7± 0.3 μm for L.

c. *Ratios of apical (U) and basal (W) width.* The two populations were not different in the averages and distribution patterns.

d. *Number of striae.* The number of striae ranged from 19.0±1.4 μm to 20.6±1.8 μm

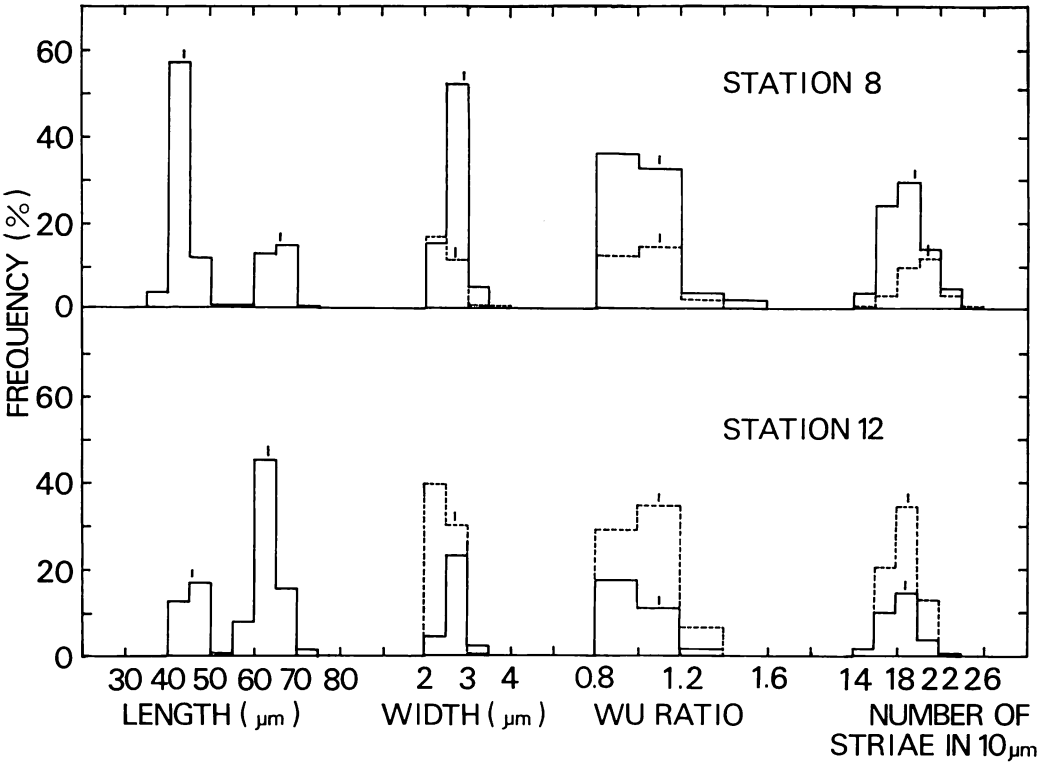


Fig. 6. Frequency distribution of cell size of cleaned populations at Station 8 in Lake Sagami and 12 in Lake Tsukui. Dashes represent average cell size; and broken lines, the large cell size populations.

and the two populations were similar.

The present form comes very close to *A. formosa*. The frustule dimensions of *A. formosa* have been described as (30-)40-70 (-160) μm long, 1.3-6 μm broad at the central region of valve view with 24-28 striae in 10 μm. The lengths and the widths of central region in these present populations are very close to the above description. But, the number of striae is comparatively fewer. Thus these populations could represent ecological variants. Although the two local populations were separated in these lakes, they show a sympatric distribution all around the surface layer of water in both lakes by an area of about 6 Km^2. Thus the differences in the two populations can be ascribed to the different cycles of reproduction. A progressive decrease in cell size of the population in *A. formosa* under culture conditions is known (KÖRNER, 1970). The ecophysiology of this species will become clear by further studies on its seasonal changes, population dynamics in the lakes, Yamanaka and Kawaguchi, mating frequency, fine structure and biochemical characters.

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並木岳志*・丸山　晃・端山重男*：相模，津久井両湖の同所的 *Asterionella formosa* 集団の分布**

1981年初春，相模，津久井両湖表層12箇所で採集された *Asterionella formosa* の細胞サイズ分布，現存量などが調べられた。両湖全域に分布する殻長（μm）44.7±1.8—46.6±1.9（S集団）と 63.1±2.5—71.1±2.1（L集団）をもつ，*A. formosa* の同所的2集団が見出された。両集団は，殻面と殻帯面の中央幅でも差異が認められた。両集団の細胞の大きさは，*A. formosa* の原記載に合うが，10 μm 中の条線数は少なく，地方集団とみなされる。1ml 中の個体数は，上流と下流域で，それぞれS集団ではおよそ200と 1,100，L集団では 100と 5,000で，下流域でSに比べL集団は，高密度であった。これら2集団は，生殖サイクルの異なる同一種の細胞集団であると推定される。（*156 東京都世田谷区桜丘 1-1-1　東京農業大学生物学教室，**113 東京都文京区弥生 1-1-1 東京大学応用微生物研究所）