Fifth Report of the Regular Limnological Survey of Lake Biwa (1971) (III) : Phytoplankton

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Fifth Report of the Regular Limnological Survey of Lake Biwa (1971) III. Phytoplankton[1)2)]

By

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This is the report of the regular limnological survey on the phytoplankton in Lake Biwa performed in 1971. The methods of collection of plankton samples, calculation of number of each phytoplankter and others follow those of our former reports (1, 2, 3). The series of reports were edited by the Director of the Station, Syuiti Mori, and the present part, on the phytoplankton, was arranged especially by Kenichiro Negoro and Masami Nakanishi. The samples were collected by T. Narita, T. Ueda and A. Kawabata, and other members of the Otsu Hydrobiological Station have assisted this survey in many ways.

A. List of algae found through this survey

The following algae were found in the samples. An abridged name of each phytoplankton is given in parenthesis behind its full specific name.

Cyanophyta

1) *Microcystis aeruginose* Kutzing (*Micr. aerug.*)
2) *Microcystis* sp. (*Micr.* sp.)
3) *Aphanothece clathrata* W. et G. S. West (*Aph. clath.*)
4) *Aphanocapsa elachista* W. et G. S. West var. *conferta* W. et G. S. West (*Aph. elach.*)
5) *Chroococcus dispersus* (Keissler) Lemmermann (*Chrooc. disp.*)
6) *Merismopedia elegans* A. Braun (*Merism. eleg.*)

1) Contribution from the Otsu Hydrobiological Station, Kyoto University, No. 217.
2) JIBP-PF Publication, No. 174.

7) *Oscillatoria tenuis* Agardh (*Oscil. ten.*)
8) *Phormidium tenue* (Menegh) Gomont (*Phorm. ten.*)
9) *Anabaena* sp. (*Anab.* sp.)

Chrysophyta

10) *Melosira solida* Eulenstein (*Mel. sol.*)
11) *Melosira italica* (Ehr.) Kützing (*Mel. ital.*)
12) *Melosira granulata* (Ehr.) Ralfs (*Mel. gran.*)
13) *Melosira* sp. (*Mel.* sp.)
14) *Stephanodiscus carconensis* Grunow (*Steph. carc.*)
15) *Attheya Zachariasi* J. Brun (*Atth. Zach.*)
16) *Fragilaria crotonensis* Kitton (*Frag. crot.*)
17) *Asterionella formosa* Hassall (*Ast. form.*)
18) *Synedra acus* Kützing (*Syn. acus*)
19) *Synedra beroliensis* Lemmermann (*Syn. berol.*)
20) *Dinobryon divergens* Imhof (*Dinob. div.*)
21) *Mallomonas fastigata* Zacharias (*Mall. fast.*)
22) *Botryococcus Braunii* Kützing (*Botry. Br.*)

Pyrrophyta

23) *Ceratium hirundinella* (O. F. Müller) Schrank (*Cer. hirn.*)
24) *Peridinium* sp. (*Perid.* sp.)

Euglenophyta

25) *Euglena* sp. (*Eugl.* sp.)

Chlorophyta

26) *Pediastrum Biwae* Negoro (*Ped. Biw.*)
27) *Pediastrum duplex* Meyen var. *cohaerens* Bohlin (*Ped. dupl.*)
28) *Sphaerocystis Schroeteri* Chodat (*Sphaer. Schr.*)
29) *Eudorina elegans* Ehr. (*Eud. eleg.*)
30) *Dictyosphaerium pulchellum* Wood (*Dict. pulch.*)
31) *Oocystis* sp. (*Oocy.* sp.)
32) *Coelastrum cambricum* Archer (*Coel. camb.*)
33) *Scenedesmus* sp. (*Scened.* sp.)
34) *Hormidium* sp. (*Horm.* sp.)
35) *Actinastrum* sp. (*Actin.* sp.)
36) *Staurastrum dorsidentiferum* W. et G. S. West var. *ornatum* Grönbl. (*St. dors.*)
37) *Staurastrum pingue* Teiling (*St. ping.*)
38) *Staurastrum tohopekaligense* Wolle (*St. tohop.*)
39) *Closterium aciculare* Tuffen West var. *subpronum* W. et G. S. West (*Cl. acic.*)
40) *Mougeotia* sp. (*Moug.* sp.)
41) *Spirogyra* sp. (*Spir.* sp.)

B. Quantitative composition of pyhtoplankton communities

Tables 1 and 2 show the results obtained at the main basin (northern basin) and at the accessory basin (southern basin), respectively. In the talbes a mark "-" means no specimen was found.

Table 1. Numbers of phytoplankters per m^3 of lake water at Station Ie-1 (northern basin). A unit of number corresponds to ten thousand (10,000).

	0–2m	2–5m	5–10m	10–20m	20–30m	30–50m	50–70m
			12 January, 1971				
Aph. elach.	20	—	—	—	6	5	2
Mel. sol.	71	48	41	18	35	8	7
Steph. carc.	—	—	4	—	2	2	2
Mall. fast.	—	—	4	—	—	—	—
St. dors.	20	14	—	4	2	3	2
St. tohop.	10	—	—	—	—	—	—
Cl. acic.	—	—	—	8	—	2	—
Ped. Biw.	—	—	4	—	—	2	2
Oocy. sp.	—	7	—	—	4	—	—
			10 February, 1971				
Aph. elach.	—	—	4	4	—	1	—
Mel. sol.	530	170	134	71	71	26	13
Steph. carc.	41	34	8	—	2	3	9
Syn. acus	—	—	4	—	—	—	—
St. dors.	41	7	8	—	4	3	2
Cl. acic.	10	14	16	—	2	—	—
Ped. Biw.	—	—	4	—	2	1	1
			12 March, 1971				
Mel. sol.	306	177	93	22	26	18	55
Steph. carc.	20	—	4	2	2	5	2
Ast. form.	—	—	—	—	—	—	2
St. dors.	10	41	4	2	2	3	1
Cl. acic.	41	—	8	4	4	10	3
			16 April, 1971				
Mel. sol.	—	—	4	6	4	1	1
Steph. carc.	—	—	4	2	8	1	1
Ast. form.	41	14	4	2	2	2	3

Syn. scus	31	7	8	—	—	3	5
Dinob. div.	20	14	4	12	4	3	—
Cer. hirn.	10	—	—	—	—	—	—
Perid. sp.	10	7	4	6	2	1	4
St. dors.	71	34	4	2	8	2	—
Cl. acic.	92	88	4	18	8	5	9

12 May, 1971

	0–2m	2–5m	5–10m	10–20m	20–30m	30–50m	50–70m
Mel. sol.	—	—	—	—	—	—	2
Steph. carc.	—	—	—	2	—	—	—
Ast. form.	—	—	4	—	—	—	—
Syn. acus	—	—	—	—	—	—	1
Cer. huirn.	—	—	—	—	2	—	1
St. dors.	133	27	41	18	14	2	4
St. tohop.	—	—	—	—	2	—	—
Cl. acic.	71	34	8	12	8	6	10

14 June, 1971

	0–2m	2–5m	5–10m	10–20m	20–30m	30–50m	50–70m
Chrooc. disp.	—	—	4	—	—	—	—
Cer. hirn.	—	—	—	—	—	—	1
St. dors.	133	95	41	12	10	5	3
Cl. acic.	173	68	32	14	12	7	5
Dict. pulch.	112	27	32	12	4	3	4

13 July, 1971

	0–2m	2–5m	5–10m	10–20m	20–30m	30–50m	50–70m
Steph. carc.	—	—	—	4	6	1	1
Cer. hirn.	—	7	—	—	6	—	1
St. dors.	1477	503	539	171	149	39	49
Cl. acic.	194	68	109	37	49	10	14
Ped. Biw.	10	—	4	—	—	—	1
Sphaer. Schr.	—	20	20	—	12	—	1
Oocy. sp.	—	14	—	—	4	2	3

16 August, 1971

	0–2m	2–5m	5–10m	10–20m	20–30m	30–50m	50–70m
Aph. elach.	51	20	16	8	6	2	4
Mel. ital.	10	—	—	—	2	—	—
Mel. gran.	10	—	—	2	—	—	—
Cer. hirn.	20	—	—	2	—	1	1
St. dors.	3516	619	620	302	169	68	84
Cl. acic.	163	7	—	2	47	1	6
Ped. Biw.	92	27	16	2	2	—	—

Eud. eleg.	—	—	—	—	2	—	—
Coel. camb.	31	7	12	14	6	4	6
Oocy. sp.	61	7	4	4	8	4	4

16 September, 1971

	0–2m	2–5m	5–10m	10–20m	20–30m	30–50m	50–70m
Micr. aerug.	10	—	—	—	—	—	—
Mel. sol.	—	—	—	—	—	—	2
Mel. ital.	10	—	—	4	—	—	—
Mel. gran.	20	—	—	—	—	—	2
Steph. carc.	—	—	—	—	—	—	2
Botry. Br.	—	—	4	—	—	—	—
Cer. hirn.	20	—	—	—	—	—	—
St. dors.	8887	2978	1713	434	442	110	43
Cl. acic.	907	401	178	47	41	13	24
Ped. Biw.	61	48	32	24	16	6	2
Eud. eleg.	10	—	2	2	—	—	—
Coel. camb.	10	—	—	—	—	—	—

15 October, 1971

	0–2m	2–5m	5–10m	10–20m	20–30m	30–50m	50–70m
Aph. elach.	—	—	—	—	4	—	—
Micr. aerug.	—	—	—	4	—	—	—
Mel. sol.	204	—	41	41	20	10	6
Mel. ital.	61	—	—	4	—	—	—
Mel. gran.	20	14	8	—	—	—	—
Steph. carc.	—	14	32	—	8	—	—
Cer. hirn.	—	41	—	12	8	2	—
St. dors.	27680	24895	17353	14933	4838	836	358
Cl. acic.	2038	693	502	334	151	49	28
Ped. Biw.	82	109	73	41	29	4	4
Eud. eleg.	—	—	8	—	—	—	—

17 November, 1971

	0–2m	2–5m	5–10m	10–20m	20–30m	30–50m	50–70m
Mel. sol.	41	27	—	—	8	—	—
Mel. ital.	41	27	—	8	—	—	8
Mel. gran.	82	—	—	—	—	—	—
Steph. carc.	—	27	—	—	—	—	—
Cer. hirn.	—	—	—	—	8	4	4
St. dors.	143183	37906	23137	12031	9129	2177	2100
St. ping.	—	—	—	8	—	—	—
Cl. acic.	8847	2012	648	383	220	159	159
Ped. Biw.	122	27	65	16	—	4	12
Oocy. sp.	41	—	—	—	8	—	—

	16 December, 1971						
	0–2m	2–5m	5–10m	10–20m	20–30m	30–50m	50–70m
Aph. elach.	—	—	—	—	—	—	4
Mel. sol.	41	27	—	—	—	8	—
Mel. ital.	204	54	—	8	—	—	4
Steph. carc.	41	54	32	—	16	—	4
Cer. hirn.	82	—	—	—	8	—	—
St. dors.	105512	28552	9981	9700	5331	1807	1762
Cl. acic.	8154	1958	697	644	375	142	90
Ped. Biw.	41	—	16	—	—	—	—
Coel. camb.	—	—	—	—	—	4	—
Oocy. sp.	—	27	—	—	—	—	—

Table 2. Numbers of phytoplankters per m^3 of lake water at Stations Nb–2, Nb–5 and Na–3 (southern basin). A unit of number corresponds to ten thousand (10,000).

	13 January, 1971			12 February, 1971			15 March, 1971		
	Nb–2	Nb–5	Na–3	Nb–2	Nb–5	Na–3	Nb–2	Nb–5	Na–3
Aph. elach.		—	8	—	—	—	—	—	—
Mel. sol.		—	—	8	—	—	31	—	—
Mel. ital.		—	—	8	—	—	—	—	—
Mel. sp.		31	47	—	8	—	—	—	—
Steph. carc.		8	—	—	8	—	8	—	—
Ast. form.		79	31	47	—	8	31	8	31
Syn. acus		55	24	—	8	8	—	—	—
Dinob. div.		8	—	24	47	71	—	—	—
St. dors.		—	—	—	—	—	—	—	31
Cl. acic.		—	31	8	31	47	71	118	243
Moug. sp.		—	—	—	8	24	—	—	—

	15 April, 1971			13 May, 1971			15 June, 1971		
	Nb–2	Nb–5	Na–3	Nb–2	Nb–5	Na–3	Nb–2	Nb–5	Na–3
Phorm. ten.	—	—	—	—	—	—	31	—	—
Mel. ital.	16	31	8	31	31	39	63	—	—
Mel. gran.	—	—	—	16	8	—	353	8	55
Ast. form.	8	16	8	39	47	24	16	—	24
Steph. carc.	—	8	—	—	—	—	—	—	—
Syn. acus	102	24	24	8	31	8	8	—	31
Atth. Zach.	—	—	—	—	—	—	8	—	—
Frag. crot.	—	—	—	—	—	—	31	—	—
Dinob. div.	16	—	24	—	—	—	—	—	—
Cer. hirn.	—	—	—	—	8	—	31	—	16
St. dors.	16	—	16	31	16	31	24	63	55
Cl. sacic.	71	212	55	236	126	157	369	141	220

	Nb-2	Nb-5	Na-3	Nb-2	Nb-5	Na-3	Nb-2	Nb-5	Na-3
Moug. ssp.	—	—	8	—	—	—	63	8	31
Eud. eleg.	24	—	—	—	—	—	—	—	—
Ped. Biw.	—	—	—	—	—	—	63	16	—
Ped. dupl.	—	—	—	—	—	—	24	—	—
Horm. sp.	—	—	—	—	—	—	8	—	63
Dict. pulch.	—	—	—	—	—	—	—	39	—
	12 July, 1971			17 August, 1971			16 September, 1971		
	Nb-2	Nb-5	Na-3	Nb-2	Nb-5	Na-3	Nb-2	Nb-5	Na-3
Aph. elach.	—	—	—	47	47	2	—	—	—
Aph. clath.	—	—	—	—	2	—	—	—	—
Merism. eleg.	—	—	—	—	—	1	—	—	—
Micr. aerug.	—	—	—	—	2	—	—	—	—
Micr. sp.	—	8	8	—	—	—	—	—	—
Anab. sp.	—	—	—	—	2	—	—	—	—
Mel. ital.	8	—	31	228	39	31	306	—	16
Mel. gran.	39	24	31	471	157	126	1287	39	110
Ast. form.	8	—	—	—	—	—	—	—	—
Syn. acus	—	—	—	8	—	—	—	—	—
Frag. crot.	—	—	—	8	—	24	—	—	—
Cer. hirn.	8	—	—	—	—	—	—	—	—
Eugl. sp.	—	—	—	—	—	—	8	—	—
St. dors.	141	816	777	793	699	322	2324	5032	4993
St. ping.	—	—	—	—	—	—	16	—	8
Cl. acic.	102	267	212	94	204	94	408	879	918
Moug. sp.	8	8	—	63	—	1	—	—	—
Spir. sp.	—	—	—	8	1	—	—	—	—
Ped. Biw.	31	55	24	1562	518	330	738	47	149
Eud. eleg.	8	—	—	—	—	—	8	—	—
Ped. dupl.	—	—	—	16	—	—	—	—	—
Sphaer. Schr.	—	16	—	—	—	—	—	—	—
Scened. sp.	—	—	—	—	1	—	—	—	—
Oocy. sp.	—	—	—	39	31	—	—	—	—
Actin. sp.	—	—	—	8	—	—	—	—	—
Dict. pulch.	—	—	—	8	—	—	—	—	—
Coel. camb.	—	—	—	—	—	—	1	—	—
	14 October, 1971			18 November, 1971			17 December, 1971		
	Nb-2	Nb-5	Na-3	Nb-2	Nb-5	Na-3	Nb-2	Nb-5	Na-3
Oscil. ten.	31	—	—	94	—	—	—	—	—
Phorm. ten.	—	—	—	911	1476	816	157	63	31
Mel. sol.	—	—	—	—	—	—	—	—	31

	Nb–2	Nb–5	Na–3	Nb–2	Nb–5	Na–3	Nb–2	Nb–5	Na–3
Mel. ital.	565	220	79	1382	283	126	—	220	—
Mel. gran.	1099	424	722	345	314	188	31	—	31
Steph. carc.	—	16	—	—	—	—	—	—	—
Syn. acus	—	—	—	63	—	—	—	—	—
Syn. berol.	—	—	—	31	—	—	—	—	—
Frag. crot.	—	—	—	126	63	—	31	31	—
St. dors.	21886	23268	36189	25246	47665	20975	10488	29704	36707
St. tohop.	—	—	—	31	—	—	—	—	—
Cl. acic.	1570	1931	1994	628	2198	1319	1507	2386	3234
Ped. Biw.	691	215	769	126	283	126	—	—	31
Oocy. sp.	—	63	79	31	63	—	—	31	31
End. eleg.	—	16	—	—	31	—	—	—	—

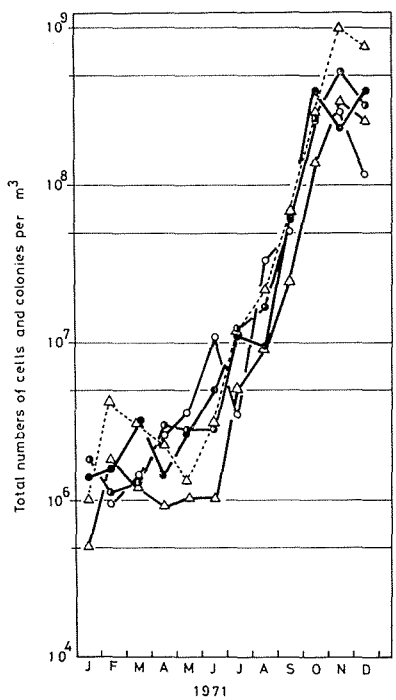

Fig. 1. Seasonal change of the total cell and colony numbers of planktonic algae at different stations in Lake Biwa.
—△—: Sta. Ie–1 (in total water column)
···△···: Sta. Ie–1 (in surface layer)
—○—: Sta. Nb–2 (in surface water)
—◑—: Sta. Nb–5 (in surface water)
—●—: Sta. Na–3 (in surface water)

C. Change in number of cell and colony of phytoplankton with progress of the season

Change in total numbers of cells and colonies of phytoplankton in both total layer and surface layer (0–5 m depth) of water at Ie-1 and in surface water at Nb–2, Nb–5 and Na–3 are shown in Fig. 1. The pattern of seasonal change was principally similar with each other, that is, the number was maintained at relatively low level ($10^5/m^3$) during the first half of the year (until May or June), but afterwards it increased remarkably and attained to the level of as high as $10^8/m^3$. This great increase from autumn to winter was caused by the outbreak of primarily, *Staurastrum dorsidentiferum* and secondarily, *Closterium aciculare*. It has usually been observed that the number of cells and colonies of phytoplankton in Lake Biwa is maintained at the level of $10^5/m^3$, so that the propagation mentioned above is an extraordinary one. The similar phenomenon was once recorded in 1965–66 by Negoro (1), and

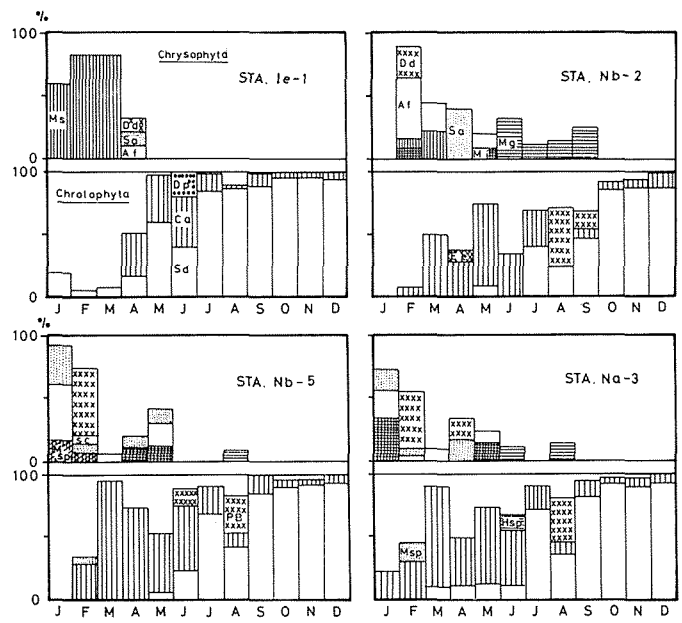

Fig. 2. Seasonal change in the composition (percentage of the total cell and colony numbers) of planktonic algae in surface water or water column at different stations in Lake Biwa.
Chrysophyta, Ms: *Melosira solida*, Mg: *Melosira granulata*, Mi: *Melosira italica*, Msp: *Melosira* sp., Af:*Asterionella formosa*, Sa: *Synedra acus*, Sc:*Stephanodiscus carconensis*, Dd: *Dinobryon divergens*
Chlorophyta, Sd: *Staurastrum dorsidentiferum*, Ca: *Closterium aciculare*, Dp: *Dictyosphaerium pulchellum*, PB:*Pediastrum Biwae*, Msp: *Mougeotia* sp., Hsp: *hormidium* sp.

the cause of these outbreaks is remained unsolved.

Seasonal changes of composing ratios (percentages) of dominant species in phytoplankton communities are shown in Fig. 2. It was commonly observed at all stations that the species belonging to Chrysophyta occupied higher percentages of composition during January to March, but as the season marched, with the increase of *Staurastrum dorsidentiferum* and *Closterium aciculare*, the relative abundance of Chlorophyta was enhanced instead of Chrysophyta. Especially after October *S. dorsidentiferum* occupied more than 80 % at all stations. Dominant species of Chrysophyta at the northern station (Ie-1) was *Melosira solida*, whereas at the southern stations (Nb–2, Nb–5, Na–3) they were composed of many species- *Synedra acus*, *Asterionella formosa*, *Melosira granulata* and *Dinobryon divergens*.

Further examination of seasonal change in number of cells and colonies was tried with each phylum, which is shown in Fig. 3.

Cyanophyta: Frequency of appearance was small at all stations, but in November the increase of *Phormidium tenue* and *Oscilatoria tenuis* was noticeable at the southern three stations.

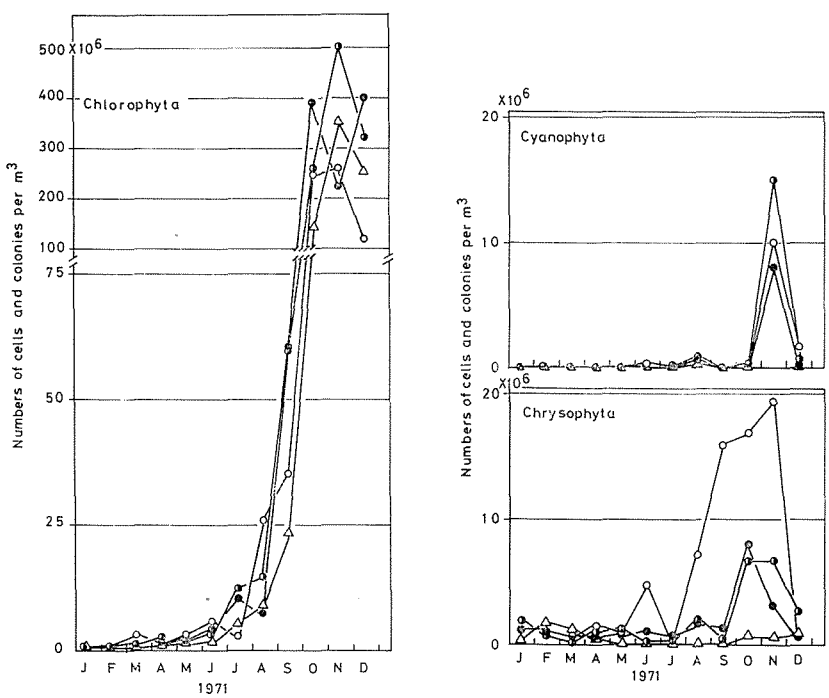

Fig. 3. Seasonal change of the cell and colony numbers of planktonic algae belonging to Cyanophyta, Chrysophyta and Chlorophyta at different stations in Lake Biwa. Symbols in the figure are the same as in Fig. 1.

Chrysophyta: Seasonal change at Ie-1 was small, whereas it was remarkable in the southern stations because of increase of *Melosira granulata* and *M. italica*.

Chlorophyta: *Closterium aciculare* occupied the major part of the community during the first half of the year, but an abnormal increase of *Staurastrum dorsidentiferum* was observed in the latter half of the year.

Pyrrophyta: *Ceratium hirundinella* was found, though in small number, at all stations.

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