Mem. Natl Inst. Polar Res., Spec. Issue, 44, 191-197, 1986

SNOW ALGAL BLOOMS AND THEIR HABITAT CONDITIONS OBSERVED AT SYOWA STATION, ANTARCTICA

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Abstract: Correlations between snow algal blooms and their habitat conditions were studied at Syowa Station, Antarctica, in the austral summer of 1984.

The study site was under artificial eutrophication by the nutrients derived from the carcasses of the Weddell seal. Snow algal blooms occurred abundantly in the places where the meltwater was staying and permeating, and in the upper and under layers of the surface of unconformity where the meltwater was flowing down, but they were not always abundant around the carcasses of the Weddell seal.

The concentrations of chlorophyll-*a* showed the significant correlations with those of phosphate-P and ammonium-N.

1. Introduction

Occurrences of snow algae in Antarctica have been reported by many investigators (KOL and FLINT, 1968; SAMSEL and PARKER, 1972; AKIYAMA, 1974, 1977). More than ten species were found along the Sôya Coast, especially near the rookeries of the Adélie penguin and snow petrel where nutrients are continuously supplied from their feces or guanos (AKIYAMA, 1979).

In the austral summer of 1984 during the 25th Japanese Antarctic Research Expedition (JARE-25), we found the blooms of snow algae in the northeast of Syowa Station, Antarctica, where the dismembered carcasses of the Weddell seal were scattered. Judging from the wire ropes and the dog collars which remained at the site, the carcasses of the Weddell seal were probably provided as the food for the dogs which were working for the JARE-1 as the tractive force of dog sled.

The purpose of this paper is to elucidate the correlations between the snow algal blooms and the habitat conditions such as the nutrients in the artificially eutrophic environment, the meltwater flow and the condition of deposited snow.

2. Methods

The detailed map of the study site was drawn in order to record the irregularities of snow surface by using SAVIGEAR's method (SAVIGEAR, 1965) on February 17, the positions

* JARE-25 BIOLOGY Cont. No. 3.

of carcasses of the Weddell seal, the directions of meltwater flow and the abundance of snow algal blooms. Nine pits of snow were made for the purpose of investigating the vertical profiles of deposited snow and the snow algae and also of collecting the snow samples from different layers on February 17 and 21. After all samples were melted and filtered through Whatman GF/C glass fiber filter in the laboratory, we measured the values of chlorophyll-*a* captured on the filters, and electric conductivity and the concentrations of phosphate-P, ammonium-N, nitrate-N, nitrite-N and silicate-Si of the filtrates. The field studies were carried out from February to March 1984.

3. Results and Consideration

The location map and the detailed map of the study site are shown in Figs. 1 and 2. The study site is situated in the northeast of Syowa Station beside the Kita-no-ura Cove. It has a general slope from south to north, but the irregularities of the snow surface were complicated because the snow around the carcasses of the Weddell seal was melted more rapidly by solar radiation. Deposited snow profiles of the pits are shown in Fig. 3. Green snow was observed widely at this site, but any other colored snow such as orange or red snow could not be observed. Green snow was dominated by coccoidal green alga which was probably identified as the resting stage of *Chloromonas* belonging to Volvocales (personal communication from Prof. M. AKIYAMA) (Fig. 4).

As the result of these field observations, it becomes clear that the locations which abound in blooms of snow algae were as follows: 1) The places where the meltwater

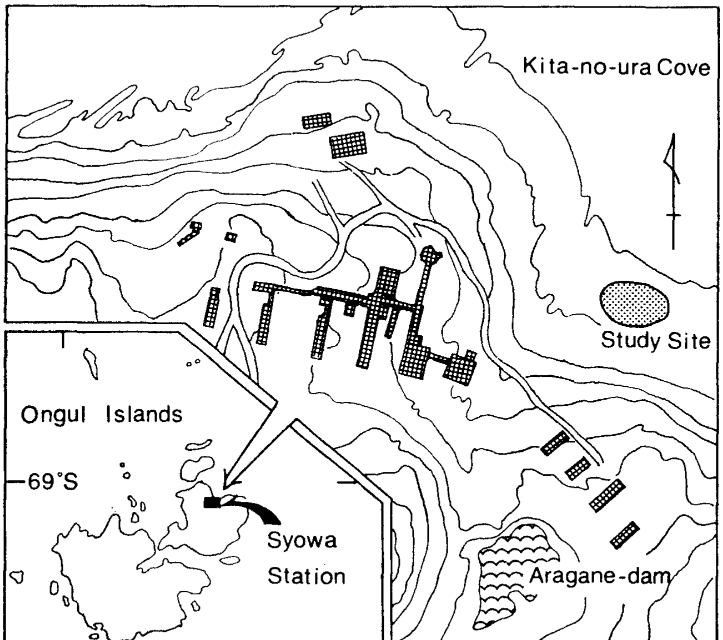

Fig. 1. Map showing the location of the study site at Syowa Station, Antarctica.

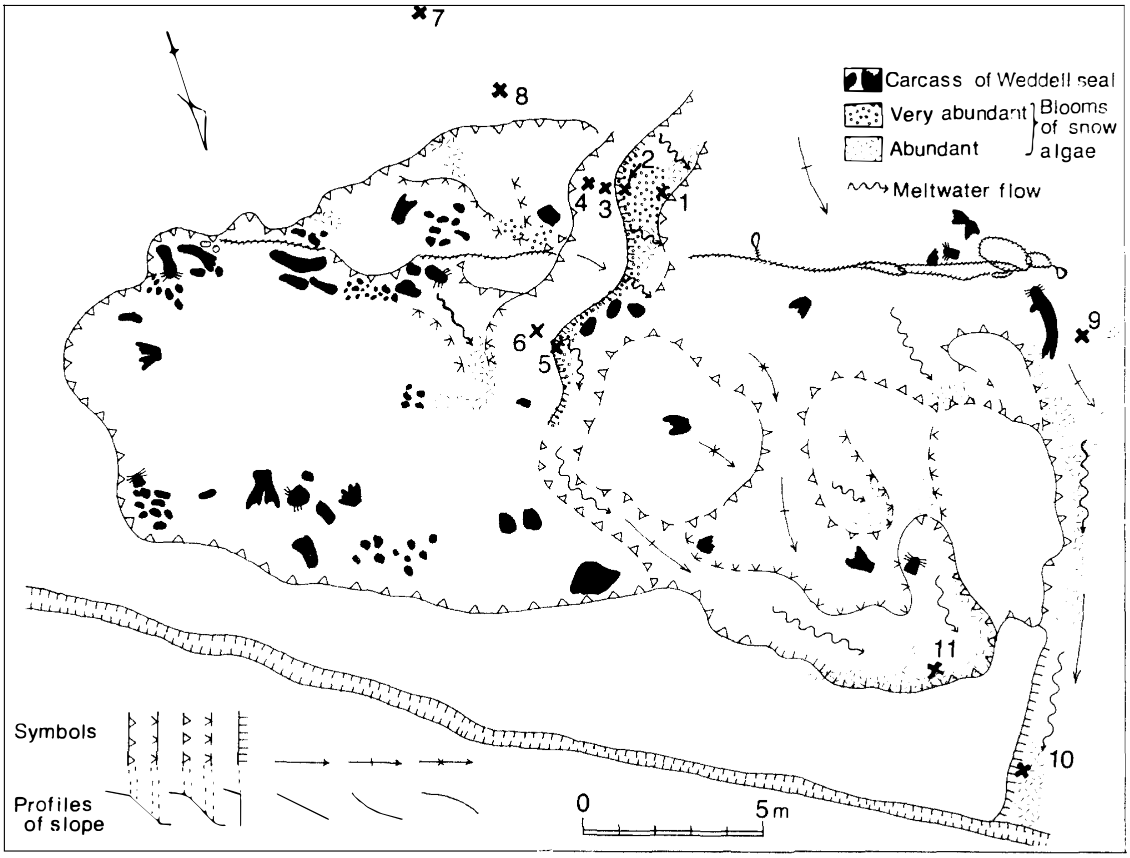

Fig 2. Detailed map of the study site. The numbers show the locations of pits for snow profile survey and for sampling the snow algae.

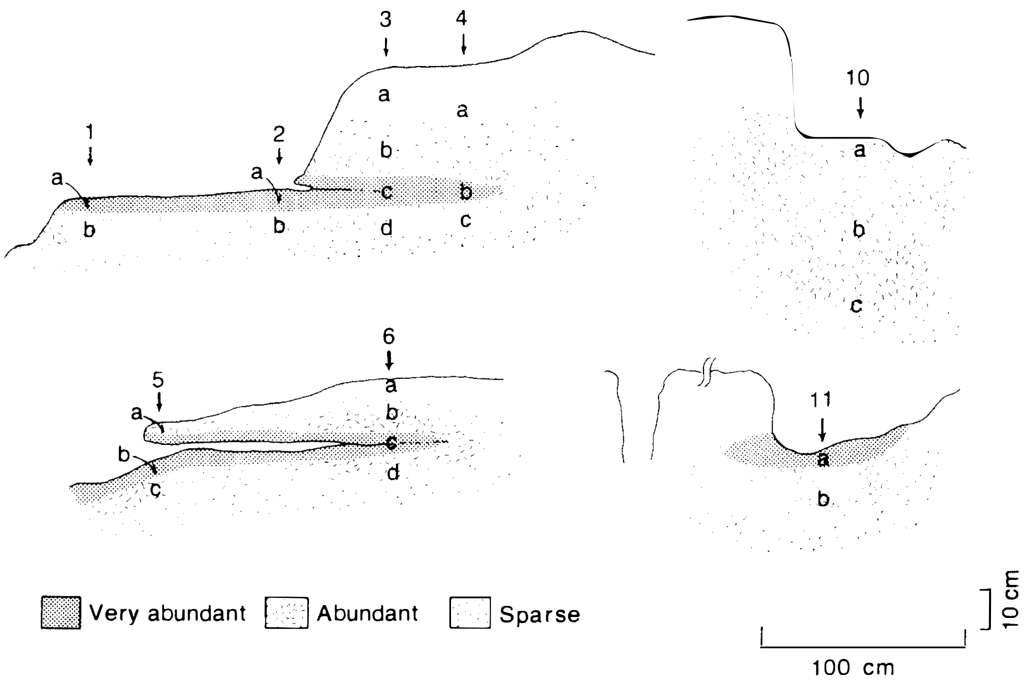

Fig. 3. Deposited snow profiles showing the abundance of the snow algal blooms. The numbers and the alphabets indicate the pits shown in Fig. 2 and the sampling layers of the snow algae, respectively.

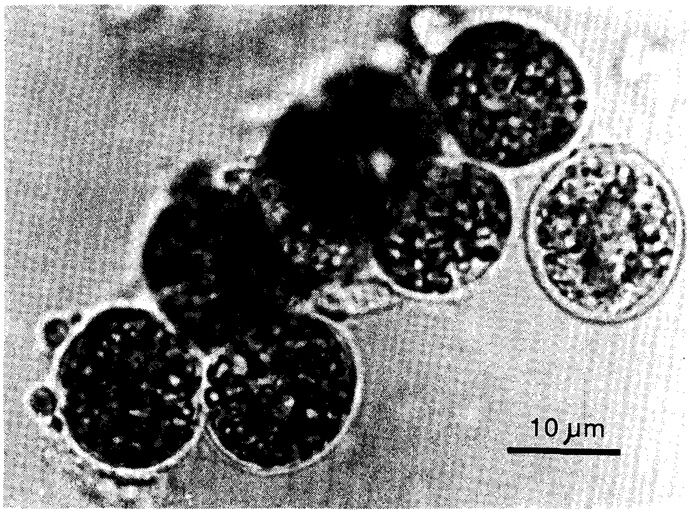

Fig. 4. Dominant green alga, Chloromonas *sp.*

was staying and permeating (sampling localities 10 and 11 in Figs. 2, 3). 2) The upper and under layers of the surface of unconformity where the meltwater was flowing down (sampling localities 3-c, -d, 4-b, -c, and 6-b, -c, -d in Fig. 3). The surfaces of unconformity have often developed into thin gaps. On the other hand, snow algal blooms were not always abundant around the carcasses of the Weddell seal as seen in the left half of Fig. 2 where the topography was rather flat and the meltwater flow was hardly observed.

The result suggested that the meltwater plays the significant role in the transportation of nutrients derived from the carcasses of the Weddell seal and that the existence of water itself may be necessary for the blooms of snow algae as shown in the work of HOHAM (1975a) and HOHAM and MULLET (1977) who studied the life history and ecology of *Chloromonas* spp. in Washington State, U.S. HOHAM (1975b) reported the data concerning temperature optima and temperature ranges for species of snow algae determined by the laboratory experiments. Their work shows that blooms of algae are known to occur in snow when air temperatures remain above the freezing point for extended periods of time; however, hard freezes may occur after snow algae have made their appearance, and some species may survive this environmental stress more easily than others, and one species of genus *Chloromonas* (*Chloromonas pichinchae*) grew best at very cold temperatures (1° and 5°C) with most growth occurring at 1°C. The air temperatures at Syowa Station in January 1984 seemed to be high enough for their growth (the maximum air temperature was 7.0°C, the monthly mean air temperature was −0.1°C), although slight freezes might occur in the night (the minimum air temperature was −7.1°C).

Table 1 summarizes the results of analyses of all samples and controls (sample nos. 7, 8; which might not be exposed to artificial eutrophication). The values of phosphate-P ranged from 6 to 385 μg/*l* and those of ammonium-N ranged from 5 to 572 μg/*l*. These two nutrients varied widely with the sample. On the contrary, there were little variations in the values of nitrate-N and nitrite-N except for a few samples. Through the statistical examination of the correlation between the concentrations of chlorophyll-*a* and those of

Table 1. Data on concentrations of chlorophyll-a, pheopigment of snow algae and of nutrients in each filtrate.

Sample No.	Chl. *a* (mg/m³)	Pheo. P (mg/m³)	PR (%)	PO_4-P (ppb)	NH_4-N (ppb)	NO_2-N (ppb)	NO_3-N (ppb)	SiO_3-Si (ppb)	EC (μS/cm)
1-a	1456.94	121.35	91.9	15.2	13.2	0.28	26.6	109.6	99.8
1-b	472.79	33.77	91.8	16.4	244.4	0.14	15.1	40.0	117.0
2-a	759.18	22.83	97.0	12.7	6.2	0.14	13.6	77.6	92.2
2-b	246.29	11.76	95.6	25.4	153.4	0.28	16.1	62.4	270.0
3-a	5.46	0.00	100.0	6.8	13.9	0.00	15.8	0.0	19.5
3-b	7.85	0.33	95.8	8.1	29.3	0.14	16.7	0.0	113.9
3-c	235.70	2.82	98.9	52.1	66.8	0.00	11.8	0.0	194.8
3-d	54.42	1.78	96.8	14.6	113.3	0.28	12.9	148.4	1.7
4-a	4.23	0.03	99.4	6.5	16.9	0.14	27.6	0.0	159.5
4-b	100.58	0.87	99.1	15.8	26.9	0.28	18.9	58.8	443.0
4-c	30.13	9.39	72.8	23.3	167.0	0.28	87.8	61.6	605.0
5-a	148.21	7.52	95.0	50.5	62.7	0.14	14.6	49.6	35.5
5-b	4652.03	60.88	98.7	299.8	11.3	2.38	24.8	525.3	64.8
5-c	527.39	50.57	91.8	50.2	142.0	0.70	27.4	122.4	63.0
6-a	33.77	10.87	71.8	20.5	47.5	0.00	35.0	0.0	23.8
6-b	114.34	10.91	90.8	16.1	55.4	0.98	13.7	450.0	34.2
6-c	1043.87	52.25	95.1	39.7	43.7	1.26	18.5	198.8	53.2
6-d	248.15	17.03	93.3	37.2	448.0	0.28	15.3	54.0	100.0
7	0.53	0.56	40.0	4.3	4.1	0.00	13.6	42.0	12.5
8	1.16	0.52	68.2	3.7	3.1	0.00	14.6	0.0	11.6
9	1609.84	240.51	85.9	63.2	572.3	1.54	19.7	339.6	169.5
10-a	132.08	30.12	79.2	44.6	5.3	0.14	12.3	38.4	15.8
10-b	375.55	39.89	89.8	62.9	82.7	0.42	15.1	84.8	17.1
10-c	256.63	53.51	81.1	67.6	82.9	0.14	16.2	69.2	26.5
11-a	2651.61	301.71	89.2	385.0	410.2	4.48	15.8	757.7	665.0
11-b	683.94	6.03	99.1	66.3	240.7	0.70	30.7	125.2	36.5

PR: Pigment Ratio

each nutrient, we found the following: 1) The regressions between the concentrations of chlorophyll-*a* (logarithmic scale) and those of phosphate-P and ammonium-N (logarithmic scale) are significant with $P<0.01$, and the correlation coefficients show relatively high values, 0.829 and 0.747, respectively (Figs. 5 and 6). 2) There are nonsignificant correlations between the concentrations of chlorophyll-*a* and those of other nutrients and electric conductivity.

Incidentally, it was observed at the study site that snow algal cells have formed in filmy aggregations in the places where the snow has been melting and decreasing rapidly by the strong and direct sunlight. Under such a condition, snow algae were concentrated and remained in the place, while the nutrients contained in the snow or ice were lost from the place. Therefore, the regressions are based on the data excluding those of such places represented by open circles in Figs. 5 and 6.

The present study is a preliminary one conducted under the conditions subjected to an artificial eutrophication. It is necessary to carry out further studies on the life history of each species, the detailed features of species composition and diversity of snow

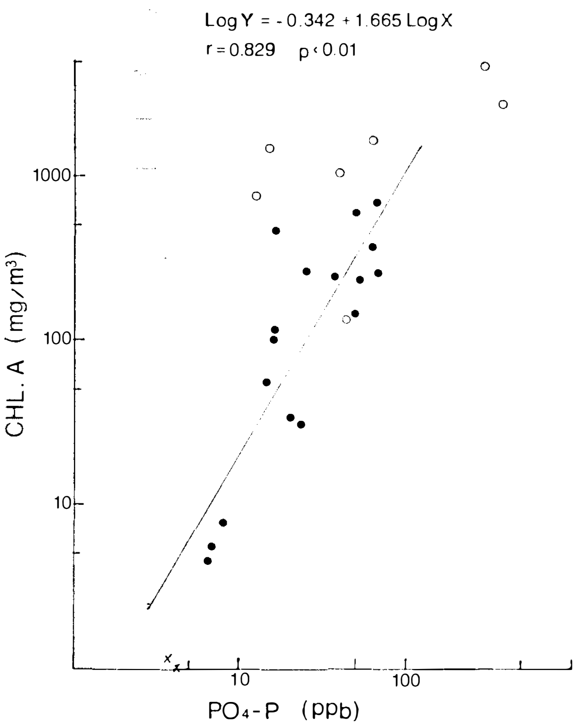

Fig. 5. Correlation between the concentration of chlorophyll-a and that of phosphate-P. The data of some samples shown by open circles were excluded from the regression for the reasons stated in the text. Two crosses at the bottom-left in the figure are the data of controls.

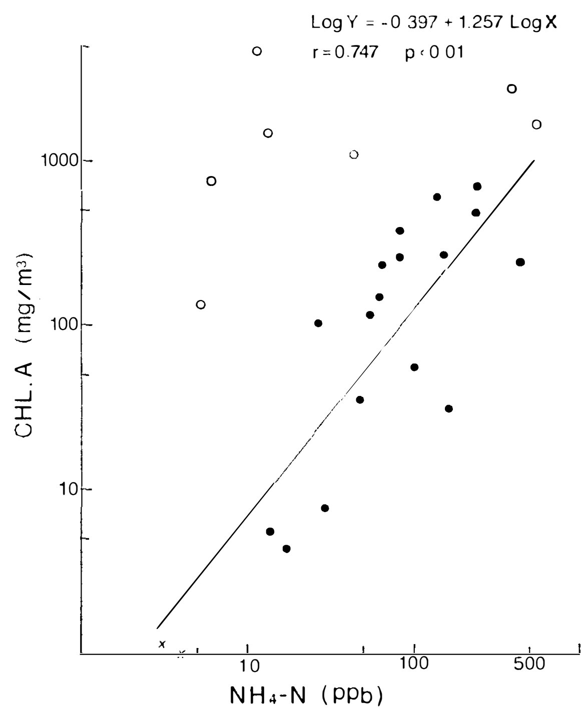

Fig. 6. Same as Fig. 5 except for ammonium-N.

algal communities, succeeding the changes of environmental conditions such as seasonal nutrients variation and the longer-term changes of the condition of deposited snow.

Acknowledgments

We would like to thank Prof. M. AKIYAMA of Shimane University for his kindness in identifying the snow alga.

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(*Received July 14, 1986; Revised manuscript received September 5, 1986*)