

## EPIPHYTIC ALGAE ON THE MOSS COMMUNITY OF *GRIMMIA LAWIANA* AROUND SYOWA STATION, ANTARCTICA

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**Abstract:** The epiphytic algae on the moss community of *Grimmia lawiana* around Syowa Station were taxonomically and ecologically investigated. Based on the moss samples from the Prince Olav Coast, the Sôya Coast and the Sør Rondane Mountains, East Antarctica, 19 species of blue-green algae, dominated by *Nostoc* sp. and *Stigonema minutum* and a single diatom species were recognized. Among the nine localities of moss colonies, Strandnibba and Sør Rondane Mountains were considered to have more favorable habitats for the presence of epiphytic algae. The prominent algal flora on the moss colonies might be caused by the abundant water supply from the continental glacier during the summer season and by the rich nutrients from the excrement of resting sea birds.

### 1. Introduction

It is well known that moss colonies predominating in Antarctic vegetation are often covered with epiphytic algae. Subsequent ecological and taxonomic studies of the epiphytic algae have been carried out in the maritime Antarctic (BROADY, 1977, 1979a, b) and in the continental Antarctic (FUKUSHIMA, 1959; TORIUMI and KATÔ, 1961; AKIYAMA, 1974; BROADY, 1982a; OHTANI, 1986). Although knowledge of algal flora on moss colonies has been accumulated, the relationships between environmental factors around the moss community and the algal flora present remain unclarified.

*Grimmia lawiana* J. H. WILLIS is one of the endemic mosses to Antarctica, and it has most interesting ecological aspects. The community grows in various habitats in the ice-free areas around Syowa Station. The community usually prefers the dry sites on sandy soils in the moraine zone, but sometimes grows on the wet or even submerged rocks along streams in periglacial areas (KANDA, 1981, 1986). The community was also found near sea bird nests in the Sør Rondane Mountains (KANDA, 1987). In the present study, the species composition of the epiphytic algae on the moss community of *G. lawiana* collected from nine localities around Syowa Station are shown with reference to their habitat conditions.

### 2. Materials and Methods

The moss samples used in this study were collected in the ice-free areas along the

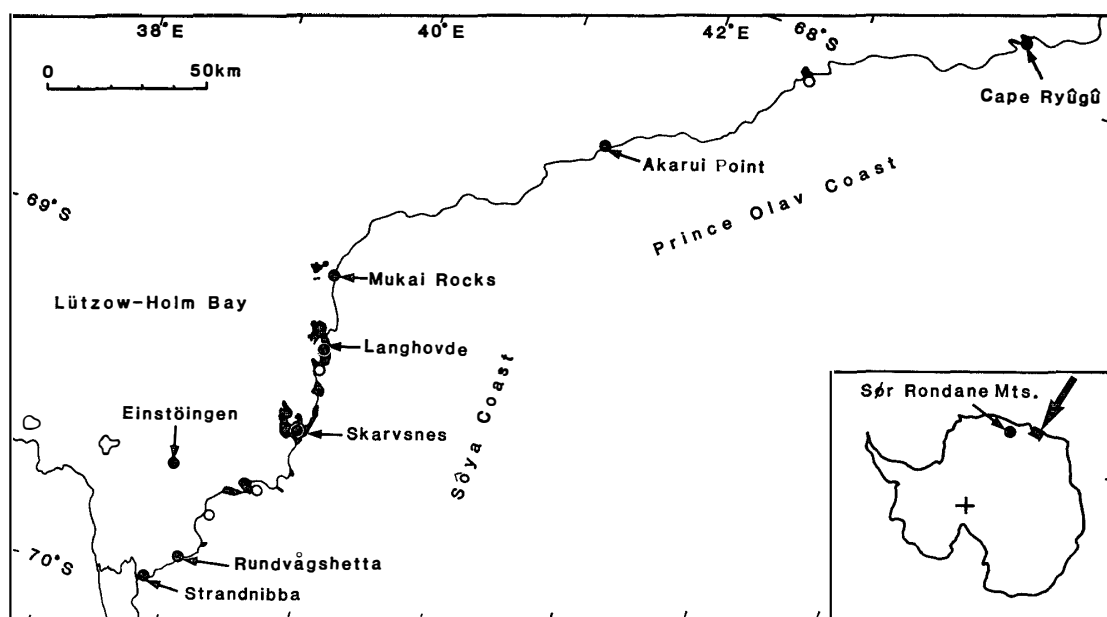


Fig. 1. Map showing the distribution of *G. lawiana* around Syowa Station. ●: moss samples used for the present study. ○: moss samples not used for the present study.

Prince Olav Coast, the Sôya Coast, and the Sør Rondane Mountains which are about 700 km southwest of Syowa Station. Distribution of *G. lawiana* around Syowa Station is shown in Fig. 1. All moss samples were taken back and stored as dried material in the Herbarium of National Institute of Polar Research (NIPR). In making a preparation, a moss sample was rewetted with distilled water for a few minutes. Algae were then scraped from the surface of a small piece (about 10 mm<sup>2</sup>) of moss with a needle under a binocular microscope. Most blue-green algae seemed to have been undamaged by desiccation and appeared to be in the same condition as those kept in formalin solution and those on frozen moss samples. On the other hand, green algae could not be identified, because their chloroplasts were strongly damaged by desiccation. A summary of moss specimens examined is shown in Table 1. Microscopic illustrations were prepared using a camera lucida attachment.

### 3. Results

The number of algal species associated with the moss community of *Grimmia lawiana* was rather small, consisting of 19 species of blue-green algae and a single diatom (Table 2). *Nostoc* sp. and *Stigonema minutum* which were heterocystous blue green algae were predominant in each moss colony. A few dead cells of a diatom species (*Pinnularia borealis*) were found on a moss colony in Langhovde. Several species of green algae (cf. *Chlorella* and cf. *Stichococcus*) were frequently found on moss colonies but were scarce in quantity.

Abundance of blue-green algae and paucity of diatoms on the moss colonies have been reported also in the maritime Antarctic (BROADY, 1977, 1979b) and the continental Antarctic (BROADY, 1982a; OHTANI, 1986). There were fewer algal species on *G. lawiana* than on the other moss species distributed around Syowa Station and they

Table 1. Summary of moss specimens of *G. lawiana* used for study.

Sample No. (NIPR)	Abbreviation	Substrate and habitat condition	Feature of moss colony
<b>Cape Ryûgû</b>			
780821-066	CR- 1	silty sandy soil	very poor
780821-067	CR- 2	silty sandy soil	very poor
780821-068	CR- 3	silty sandy soil	very poor
780821-076	CR- 4	sandy soil	poor
780821-077	CR- 5	sandy soil	vigorous
780821-079	CR- 6	silty sandy soil	very poor
780821-080	CR- 7	silty sandy soil	very poor
780821-081	CR- 8	sandy soil	very poor
780821-083	CR- 9	silty sandy soil	very poor
780822-007	CR-10	sandy soil	poor
<b>Akarui Point</b>			
800711-012	AP- 1	sandy soil	vigorous
<b>Mukai Rocks</b>			
<sup>1</sup> 192	MR- 1	sandy soil	poor
<sup>1</sup> 989	MR- 2	sandy soil	poor
<sup>1</sup> 990	MR- 3	sandy soil	poor
<sup>1</sup> 991	MR- 4	sandy soil	poor
<b>Langhovde</b>			
800704-044	LH- 1	sandy soil	vigorous
800704-048	LH- 2	sandy soil	poor
800704-050	LH- 3	sandy soil	poor
<sup>1</sup> 984	LH- 4	sandy soil	poor
<sup>1</sup> 1019	LH- 5	sandy soil	poor
<b>Skarvsnes</b>			
800710-072	SK- 1	sandy soil	poor
800712-004	SK- 2	sandy soil	poor
<b>Rundvågshetta</b>			
840906-003	RH- 1	sandy soil	poor
840906-004	RH- 2	sandy soil	vigorous
840911-035	RH- 3	sandy soil, submerged	poor
840911-036	RH- 4	sandy soil, wet	vigorous
840911-038	RH- 5	sandy soil, moist	poor
840911-043	RH- 6	sandy soil, moist	vigorous
840911-044	RH- 7	sandy soil	poor
840911-045	RH- 8	sandy soil	poor
<b>Strandnibba</b>			
840914-005	SN- 1	sandy soil, moist	vigorous
840914-006	SN- 2	sandy soil, moist	vigorous
840914-021	SN- 3	sandy soil, beside stream	vigorous
<b>Einstöingen</b>			
840912-039	E- 1	sandy soil, meso	poor
840912-040	E- 2	sandy soil, meso	poor
<b>Sør Rondane Mts.</b>			
<sup>1</sup> 1202	SR- 1	sandy soil, near bird nest	vigorous
<sup>1</sup> 1203	SR- 2	sandy soil, near bird nest	vigorous
<sup>1</sup> 1214	SR- 3	sandy soil, near bird nest	vigorous

<sup>1</sup> Frozen moss sample.

Table 2. The algal species on the moss community of *G. lawiana* around Syowa Station.

Species	Sør Rondane (3) <sup>1</sup>	Strand- nibba (3)	Mukai Rocks (4)	Lang- hovde (5)	Rundvågs- hetta (8)
Cyanophyceae					
<i>Gloeocapsa dermochroa</i>	1 <sup>2</sup>	—	—	—	—
<i>Gl. magma</i>	—	—	1	—	5
<i>Gl. sp. 1</i>	1	—	—	—	—
<i>Gl. sp. 2</i>	1	—	—	—	—
<i>Gl. sp. 3</i>	—	—	—	—	3
<i>Synechococcus aeruginosus</i>	1	2	1	1	—
<i>Stigonema minutum</i>	—	2	1	3	1
<i>St. ocellatum</i>	—	1	—	—	—
<i>St. hormoides</i>	—	—	—	—	2
<i>Calothrix parietina</i>	—	1	—	—	—
<i>Petalonema velutinum</i>	2	1	1	—	—
<i>Nostoc commune</i>	1	—	—	—	—
<i>Nostoc sp.</i>	1	2	2	1	—
<i>Phormidium antarcticum</i>	1	—	—	—	—
<i>P. frigidum</i>	—	1	—	—	—
<i>Lyngbya perelegans</i>	1	—	—	—	—
<i>L. sp.</i>	—	—	—	1	—
<i>Plectonema sp.</i>	—	1	—	—	—
<i>Schizothrix sp.</i>	1	—	—	—	—
Others					
<i>Pinnularia borealis</i>	—	—	—	1	—
Unicellular green algae	1	2	2	5	1

<sup>1</sup> Number of moss sample. <sup>2</sup> Frequency of occurrence in each locality.

were particularly scarce than those in submerged habitats (HIRANO, 1979, 1983; BROADY, 1982b), such as streams, ponds and lakes. Although OHTANI (1986) found a desmid, *Actinotaenium cucurbita*, on moss colonies of *Bryum pseudotriquetrum* and *Ceratodon purpureus* in Langhovde, the alga was never found on any of the moss samples of *G. lawiana* collected from the nine localities in the present survey.

Enumeration of species identified and remarks are provided as follows.

#### Cyanophyceae

##### *Gloeocapsa dermochroa* NÄG.

Cells spherical or elliptical, 2–3  $\mu\text{m}$  in diameter with a thin sheath, yellowish brown in color, forming irregularly shaped mass.

Found in sample SR-3 (Fig. 2a).

##### *Gloeocapsa magma* (BRÈB.) HOLLERBACH

Cells spherical or elliptical, 4–6  $\mu\text{m}$  in diameter with a thin sheath, reddish-brown in color, forming irregularly shaped mass.

This species was frequently found in Rundvågshetta and rarely found in Mukai Rocks.

Found in samples RH-1, 2, 3, 4, 8, MR-2, 3 (Fig. 2b).

##### *Gloeocapsa sp. 1*

Cells spherical or elliptical, 3–7  $\mu\text{m}$  in diameter, with thin dark purple walls which appear to be penetrated by numerous pores.

Table 2 (continued).

Species	Cape Ryūgtū (10)	Skarvsnes (2)	Einstöingen (2)	Akarui Point (1)
Cyanophyceae				
<i>Gloeocapsa dermochroa</i>	—	—	—	—
<i>Gl. magma</i>	—	—	—	—
<i>Gl. sp. 1</i>	—	—	—	—
<i>Gl. sp. 2</i>	—	—	—	—
<i>Gl. sp. 3</i>	—	—	—	—
<i>Synechococcus aeruginosus</i>	—	—	—	—
<i>Stigonema minutum</i>	3	1	—	—
<i>St. ocellatum</i>	—	—	—	—
<i>St. hormoides</i>	—	—	—	—
<i>Calothrix parietina</i>	—	—	—	—
<i>Petalonema velutinum</i>	4	—	—	—
<i>Nostoc commune</i>	—	—	—	—
<i>Nostoc sp.</i>	4	2	—	—
<i>Phormidium antarcticum</i>	—	—	—	—
<i>P. frigidum</i>	—	—	—	—
<i>Lyngbya perelegans</i>	—	—	—	—
<i>L. sp.</i>	—	—	—	—
<i>Plectonema sp.</i>	—	—	—	—
<i>Schizothrix sp.</i>	—	—	—	—
Others				
<i>Pinnularia borealis</i>	—	—	—	—
Unicellular green algae	5	1	2	—

This species was found on a moss colony collected near sea bird nests in the Sør Rondane Mountains. This species had been also found on moss colonies of other species collected from such nutrient rich sites in Langhovde (OHTANI, 1986).

Found in sample SR-3 (Fig. 2c).

#### *Gloeocapsa sp. 2*

Cells spherical, elliptical or irregular, 4–10  $\mu\text{m}$  in diameter, with a thin sheath, orange in color.

Found in sample SR-3 (Fig. 2d).

#### *Gloeocapsa sp. 3*

Cells spherical or elliptical, 6–10  $\mu\text{m}$  in diameter, reddish-brown in color with a thick lamellated sheath.

Found in samples RH-5, 6, 7 (Fig. 2e).

#### *Synechococcus aeruginosus* NÄG.

Cells blue-green, elliptical or cylindrical, 7–14  $\mu\text{m}$  wide, 16–27  $\mu\text{m}$  long.

Found in samples LH-4, MR-2, 3, SN-1, 2, SR-3.

#### *Calothrix parietina* THURET

Filaments 8–10  $\mu\text{m}$  wide at the base, gradually attenuate to the hairy part, trichomes 6  $\mu\text{m}$  wide at the base, 2  $\mu\text{m}$  at the apex, slightly constricted at the cross walls, sheaths yellowish brown and lamellated. Cells about 0.5–1 times as long as wide.

A few specimens of this species were found on a moss colony collected beside a stream in Strandnibba.

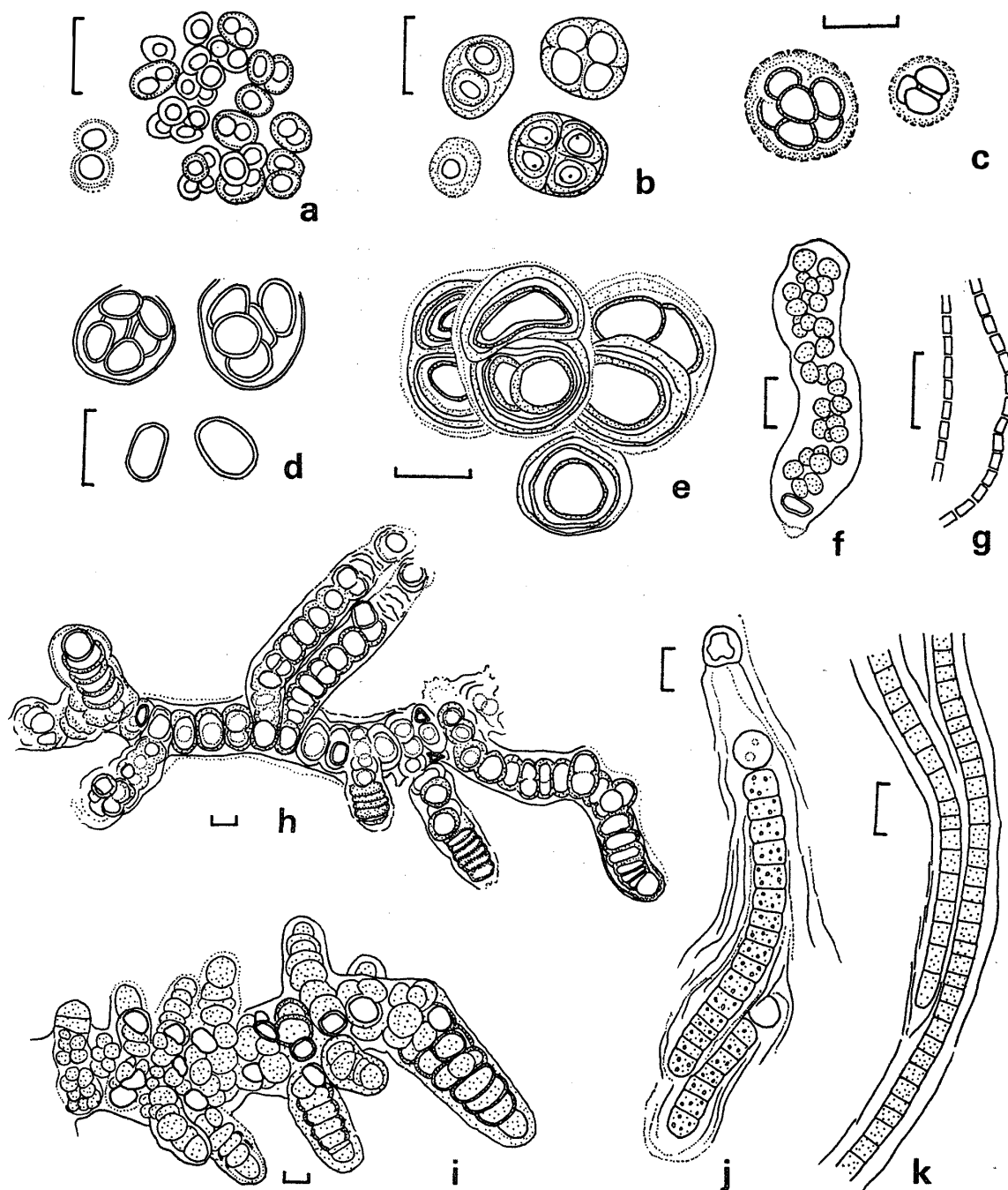


Fig. 2. a: *Gloeocapsa dermochroa*, b: *Gloeocapsa magma*, c: *Gloeocapsa* sp. 1, d: *Gloeocapsa* sp. 2, e: *Gloeocapsa* sp. 3, f: *Nostoc* sp., g: *Phormidium frigidum*, h: *Stigonema ocellatum*, i: *Stigonema minutum*, j: *Petalonema velutinum*, k: *Plectonema* sp. Scale: 10  $\mu$ m.

Found in sample SN-3.

*Petalonema velutinum* (RABENH.) MIGULA

Sheath thick, lamellated yellowish brown in the old sheath, trichomes 6–8  $\mu$ m wide, cells 3–4  $\mu$ m long, filaments 20–26  $\mu$ m wide with irregular false branches.

This species was dominant in Strandnibba and Sør Rondane Mountains.

Found in samples CR-2, 3, 4, 5, MR-3, SN-3, SR-1, 3 (Fig. 2j).

*Stigonema minutum* (AG.) HASSALL

Filaments 16–30  $\mu\text{m}$  in width, cells arranged in one row or several rows in the sheath, cells spherical or elliptic 5–12  $\mu\text{m}$  wide, each having an individual sheath within the common sheath.

This species was the most abundant species on the moss colony of *Grimmia lawiana*. This alga formed algal crusts which sometimes completely covered the surface of moss colonies in Strandnibba.

Found in CR-3, 4, 8, LH-1, 2, 4, MR-2, 3, RH-5, SN-1, 2, SK-1 (Fig. 2h).

*Stigonema ocellatum* THURET

Filaments 18–23  $\mu\text{m}$  in width, cells arranged in one row in the sheath, cells spherical or elliptic 10–13  $\mu\text{m}$  wide, each having an individual sheath within the common sheath.

This species was found on a moss colony in Strandnibba, sometimes making algal crusts on moss surface.

Found in sample SN-3 (Fig. 2i).

*Stigonema hormoides* (KÜTZ) BORNET et FLAHL.

Filaments 10–14  $\mu\text{m}$  in width, cells arranged in one row in the sheath, cells spherical or elliptic 5–6  $\mu\text{m}$  wide, each having an individual sheath within the common sheath.

Found in samples RH-7, 8.

*Nostoc commune* VAUCH.

Thalli blue-green to yellowish brown. Trichomes highly entangled, cells barrel-shaped or spherical, 3–5  $\mu\text{m}$  in diameter, heterocyst spherical to elliptic 5–7  $\mu\text{m}$  in diameter, with individual sheath.

Found in sample SR-3.

*Nostoc* sp.

Colony microscopic, punctiform, bright blue-green to yellowish brown, up to about 200  $\mu\text{m}$  in diameter.

The alga was found on most moss colonies examined.

Found in samples CR-2, 4, 5, 7, SK-1, 2, LH-4, MR-2, 3, SN-1, 3, SR-1 (Fig. 2f).

*Phormidium antarcticum* W. WEST et G. W. WEST

Trichomes narrow in width, entwined irregularly with each other, 0.5  $\mu\text{m}$  wide. Cells about 1–2 times as long as wide.

Found in sample SR-3.

*Phormidium frigidum* FRITSCH (Fig. 2g)

Trichomes pale blue-green, entwined densely with each other, 0.8–1.0  $\mu\text{m}$  wide, usually constricted at cross walls. Cells about 1.5–2 times as long as wide.

Found in sample SN-3.

*Lyngbya perelegans* LEMM.

Trichomes pale blue-green, entwined densely with each other, 1.0–1.5  $\mu\text{m}$  wide, in a thin hyaline sheath, with a granule present at both apices. Cells about 1.5–2 times as long as wide.

Found in sample SR-3.

*Lyngbya* sp.

Trichome straight, pale blue-green, 6–7  $\mu\text{m}$  wide, without constriction, gradually attenuated to the apex, the terminal cells forming a circular calyptra, cells 3–4  $\mu\text{m}$

long.

Found in sample LH-4.

*Plectonema* sp.

Filaments brown and entwined densely with each other, 8–10  $\mu\text{m}$  wide. Trichomes 4–5  $\mu\text{m}$  wide. Cells 0.5 to 1.5 times as long as wide.

This species formed algal crusts on a moss colony collected beside a pond in Strandnibba.

Found in sample SN-1 (Fig. 2K).

*Schizothrix* sp.

Sheath very thick, colorless and not lamellated. Trichome blue-green, 4–5  $\mu\text{m}$  wide, and without constriction at the cross walls. Cells about 0.5–1.0 times as long as wide.

Found in sample SR-3.

Bacillariophyceae

*Pinnularia borealis* EHR.

Valves sublinear, lateral margin slightly convex, with broadly rounded apices, 9–11  $\mu\text{m}$  wide, 27–46  $\mu\text{m}$  long, striations 5–6 in 10  $\mu\text{m}$ .

This species was the only diatom found on moss colony of *G. lawiana*. A few dead cells were found only in Langhovde.

Found in sample LH-4.

#### 4. Discussion

Scarce colonies of *G. lawiana* were collected in periglacial regions, except at Cape Ryûgû, Strandnibba, and Rundvågshetta where there were extensive colonies. However, some colonies also occurred near sea bird nests in the Sør Rondane Mountains. The locations of collecting sites of *G. lawiana* are shown in Fig. 1.

##### a) Cape Ryûgû, Prince Olav Coast

At the Cape Ryûgû area, the moss vegetation of *G. lawiana* grew on sandy soil or among moraine gravels near the continental ice sheet. These communities develop on dry sites with gentle slopes exposed to the strong winds and sunshine (KANDA, 1981). The epiphytic algae on *G. lawiana* at this locality was rather poor in quantity and number of species. No epiphytic algae was found from four moss samples containing silty soils. In the remaining samples, *Stigonema minutum*, *Petalonema velutinum* and *Nostoc* sp. occurred frequently. Small amounts of unicellular green algae were also found, but no diatoms were observed in the Cape Ryûgû area.

##### b) Rundvågshetta and Strandnibba, Sôya Coast

In the Rundvågshetta area, moss communities of *G. lawiana* occur on wet rocks covered partially with mineral-rich sandy soil near the coast away from the continental glacier. The composition of algal species at the Rundvågshetta was remarkably different from other regions. *Nostoc* and *Stigonema minutum*, which commonly occurred at most localities around Syowa Station, were scarcely found in this region. In contrast, *Gloeocapsa magma* and *Gloeocapsa* sp. 3 occurred frequently in moss colonies collected in this region.

In the Strandnibba area, the community of *G. lawiana* usually occurred along



stream margins and often on submerged rocks. The community was supplied with meltwater during the summer season. Compared with those of other regions, the epiphytic algae on mosses in this area were rather abundant in quantity. The moss colonies on submerged rocks were occasionally completely covered with algae composed mainly of *Stigonema minutum* and *Plectonema* sp. Although OHTANI (1986) found diatoms on wet moss colonies along stream margins at Langhovde, such diatoms were hardly found in this area.

c) The Sør Rondane Mountains, Queen Maud Land

The Sør Rondane Mountains are located at about 700 km southwest of Syowa Station, and about 100 km south of the coast regions of Breid Bay. There are some Snow petrel (*Pagodroma nivea*) nests among rocks on the northern face of the mountains. The moss colonies of the area were considered to be influenced by sea bird excrement. One of the most characteristic aspects of this vegetation is that *Bryum pseudotriquetrum* and *Ceratodon purpureus* communities, occurring commonly in the Syowa Station area, are not found in the mountains. In the moss colony, *Petalonema velutinum* and a few species of *Gloeocapsa* are abundant. OHTANI (1986) also found the abundance of *Gloeocapsa* sp. 1 in the moss colony of *G. lawiana* collected near sea bird nests at Langhovde. The presence of *Gloeocapsa* sp. 1 may be related to the presence of sea bird excrement.

The algal species composition on the moss community of *G. lawiana* is locally distinctive as described above. The species number and its abundance were rich in moss colonies of Strandnibba. These colonies supported a high number of algal species often in abundance, and were supplied with meltwater from the continental ice sheet during the summer season. Colonies of Sør Rondane Mountains are influenced by sea bird excrement. It is concluded that the water availability and nutrient supply for moss growth largely influence the presence of the epiphytic algae.

### Acknowledgments

We wish to express our deep gratitude to Prof. M. AKIYAMA of Shimane University, and Dr. M. WATANABE of National Science Museum for their constructive criticism of the manuscript.

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*(Received August 22, 1987; Revised manuscript received October 6, 1987)*