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# ECOLOGICAL NOTES ON THE DIFFERENCES IN FLORA AND HABITAT OF LICHENS BETWEEN THE SYOWA STATION AREA IN CONTINENTAL ANTARCTIC AND KING GEORGE ISLAND IN MARITIME ANTARCTIC

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***Abstract:*** Some examples of the differences in flora and habitat of lichens between the Syowa Station area in the continental Antarctic, and a part of King George and Nelson Island (King George Island region) in the maritime Antarctic, are presented by the author who carried out the field surveys in both regions.

A total of 57 species of lichens are enumerated for the Syowa Station area and 198 species for the King George Island region. Although most genera known to occur in the Syowa Station area are also found in the King George Island region, only 20 percent of the species occurring in the Syowa Station area are growing in the latter. Most lichens known from the Syowa Station area are microlichens, whereas in the King George Island region many macrolichens are growing beside microlichens. It might be most plausible to conclude that one of the factors influencing the rich lichen flora including many macrolichens in the maritime Antarctic is the mild weather conditions of the region. The major factor controlling lichens in the Antarctic appears to be not temperature but water supply.

In the Syowa Station area extensive sites lack lichen cover, even where the ground is normally snow free in summer. On the other hand, both macro- and microlichens are growing everywhere in the King George Island region. Higher precipitation in the King George Island region dilutes the salinity brought by the wind-blown sea spray, while not so in the Syowa Station area because of the low precipitation in summer, though accurate meteorological data supporting this assumption are very few.

## 1. Introduction

A large number of lichens have been reported from various parts of the Antarctic by many authors. However, as HALE (1987) mentioned, almost all collections have been made by non-lichenologists and are frequently fragmentary and deformed by the harsh environmental conditions. In addition, most collections brought by many different expeditions are still not reexamined taxonomically. Unfortunately a large number of new taxa, described by DODGE and his co-authors (DODGE and BAKER, 1938; DODGE and RUDOLPH, 1955; DODGE, 1948, 1968, 1973), are in such state. Accordingly, it is very difficult to compare the flora and ecological aspects of Antarctic lichens occurring in different regions by using literature.

Fortunately the author had a chance to visit two different regions of the Antarctic: one is the Syowa Station area of Enderby Land (from January 1986 to February 1987, as a member of the 27th Japanese Antarctic Research Expedition), and the other is King

George Island and Nelson Island (King George Island region) of the South Shetland Islands (from November 1988 to March 1989, as a cooperate member of the 5th Chinese National Antarctic Research Expedition). The former region belongs to a continental Antarctic zone, and the latter to a maritime Antarctic zone as defined by HOLDGATE (1964). The author could devoted his full time to the field work in both regions, and collected about 3000 specimens from the Syowa Station area and about 1800 specimens from the King George Island region.

In this paper the author will present some examples of the differences in flora and habitat between the continental Antarctic zone and the maritime Antarctic zone, although the nomenclature of many lichens is still indistinct.

## 2. Topography

### *2.1. Syowa Station area*

The Syowa Station area, where a vast ice sheet of Enderby Land extends with the margin gently sloping down westwards (Sôya Coast) or north-westwards (Prince Olav Coast), is located in East Antarctica (Fig. 1). Both coasts are surrounded by the fast sea-ice. Many ice-free areas, such as rocky areas abutting on the edge of the ice cap, coastal islands, and a few nunataks are scattered along the coasts. Some rocky areas abutting on the edge of the ice cap are large and mountainous, about 50 to 60 km$^2$ wide and about 300 to 500 m above sea level, while the other areas are mostly small and hilly. Most coastal islands, about sixty in number, scattered off the Sôya Coast within 10 km or so, are less than 1–2 km$^2$ wide and 50 m above sea level. Among them a few islands are somewhat larger and higher, being 8.0 km$^2$ wide and 263.0 m above sea level.

### *2.2. Fildes Peninsula, Barton Peninsula (King George Island) and Harmony Cove (Nelson Island)*

King George Island and the neighboring Nelson Island, members of the South Shetland Islands, are situated at about 150 km northwest of the Antarctic Peninsula (Fig. 1). Ice-free areas of the islands are limited and scattered along the coastline, while a vast bulk of snow and ice covers most part including the mountain ranges and is extending to the sea. The highest part of both islands is more than 600 m above sea level. The Fildes Peninsula, where the author spent almost all his time during the survey, is one of the large ice-free areas in the island with an area of about 30 km$^2$. This peninsula is hilly (highest peak is 156 m above sea level), and many "volcanic necks" and precipitous cliffs are scattered everywhere. The topography of the Barton Peninsula and Harmony Cove (about 5 km$^2$ wide) is similar to that of the Fildes Peninsula. Around the Fildes Peninsula there are many offshore islets and rocks which are less than 450 m in diameter. None of these smaller islets, including Geologist Island and Two Summit Island visited by the author, supports ice cap or rises above 60 m.

## 3. Climate

Table 1 shows some data of climatological elements recorded at Syowa Station (69°00′S, 39°35′E) located in East Ongul Island about 4 km from the continent, and at

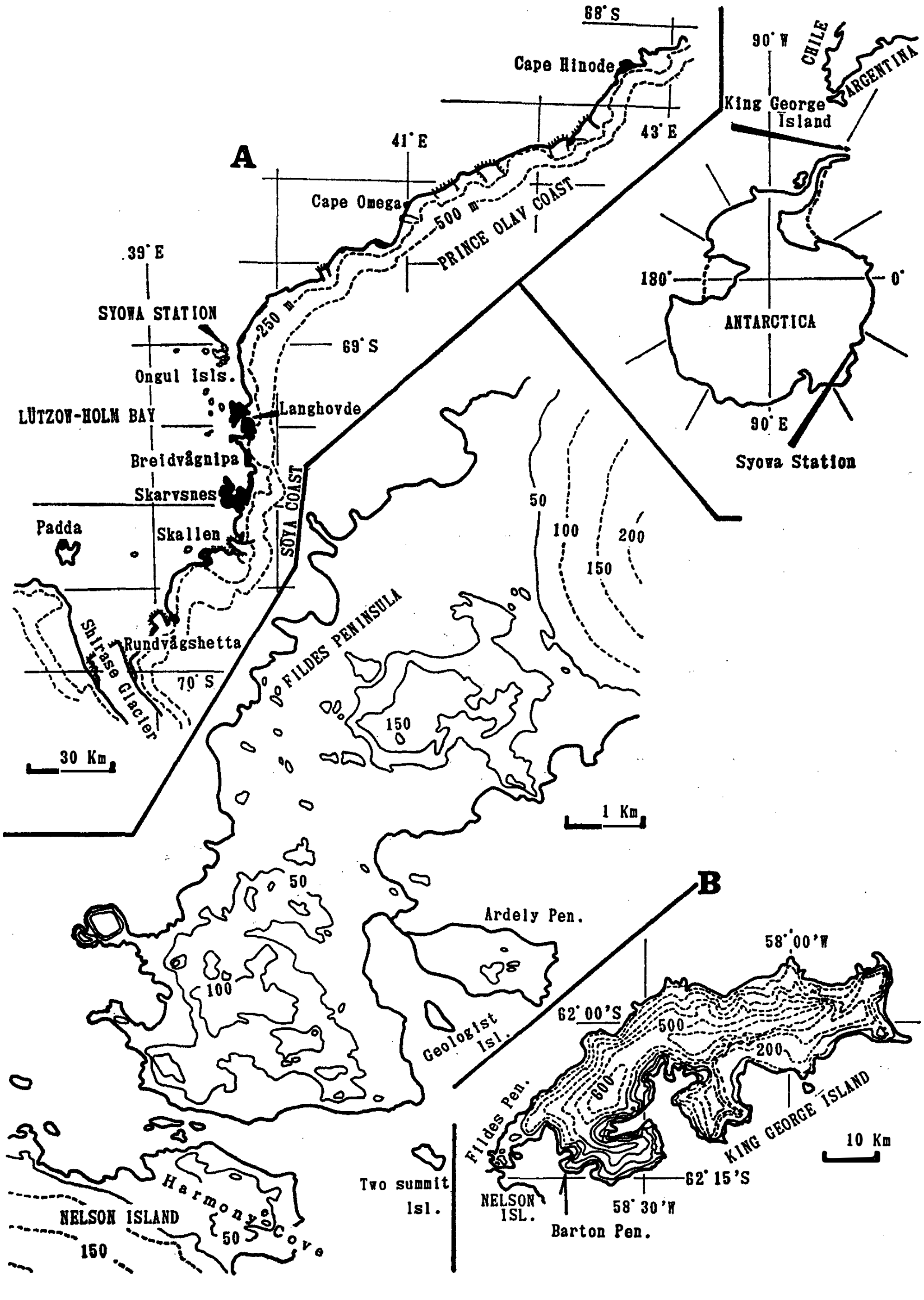


*Fig. 1. Maps showing the region near Syowa Station (A) and King George and Nelson Islands (B). Broken line indicates the contour line on ice or snow area.*

Deception Station (62°59′S, 60°43′W) in Deception Island about 130 km southwest of King George Island.

As shown in Table 1, the climate of the region around King George Island is milder than that of the Syowa Station area except for the monthly mean of daily minimum temperature in the austral summer season. This exception appears to be caused by the

*Table 1. Temperature and wind speed at Syowa Station (1957–1982) and at Deception Station (1944–1967).*

| Climatological elements | Range of the value (Syowa) | Mean values (Deception) |
|---|---|---|
| Annual mean temperatures (°C) | −12.1 to −8.2 | −3.0 |
| Mean summer temperatures (°C) | −2.5 to 0.1 | 1.0 |
| Mean winter temperatures (°C) | −23.2 to −14.1 | −6.6 |
| Monthly mean of daily maximum temperatures in summer (°C) | 0.2 to 4.6 | 8.5 |
| Monthly mean of daily minimum temperatures in summer (°C) | −6.3 to −1.7 | −6.8 |
| Annual mean of wind speed (m/s) | 5.4 to 7.0 | 6.1 |

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summer: December–January, winter: August–September.

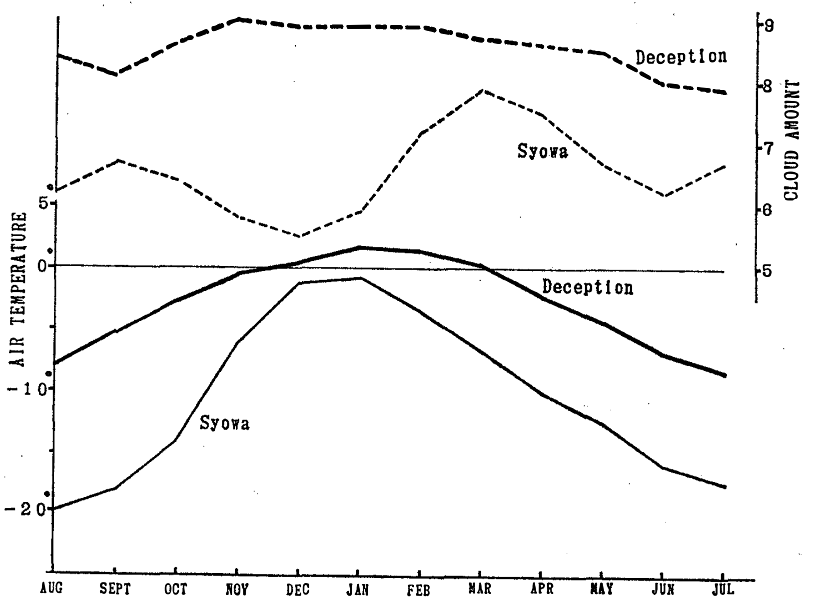


*Fig. 2. Annual changes of monthly mean of cloud amount and air temperature recorded at Syowa Station (1973–1982) and Deception Station (1944–1967).*

bad weather during summer in King George Island. Figure 2 represents the annual changes of monthly mean of cloud amount and air temperature recorded at the both stations. Deception Station exceeds Syowa Station in cloud amount throughout the year, especially during summer. Actually we had only a few fine days during our stay in King George Island, whereas at Syowa Station we had a long spell of fine weather during summer. The Syowa Station area is characterized by higher insolation, lower cloud cover, lower precipitation and lower relative humidity than those of the King George Island region during summer.

## 4. Vegetation

In the Syowa Station area neither phanerogams nor liverworts are known, while two phanerogams, *Colobanthus quitensis* and *Deschampsia antarctica*, and many liverworts are growing in the King George Island region. The phanerogams grow sparsely, and do not form large communities even in the above islands. In the King George Island region macrolichens such as *Usnea aurantiacoatra*, *Himantormia lugubris*, and *Sphaerophorus globosus* form large communities, whereas such lichen communities are not much developed in the Syowa Station area. There are scattered nests of sea birds and concomitant organic debris high in nitrogenous materials in both regions; characteristic communities are developed there.

KASHIWADANI (1970, 1982) reported 20 species of lichens from the region near Syowa Station. NAKANISHI (1977, 1982) and INOUE (1989) referred to the ecology of lichens in the region. GUZMAN and REDON (1981) reported 47 species of lichens from the Ardely Peninsula, and ANDREEV (1988) reported 119 species of lichens from King George Island (mainly from the Fildes Peninsula). REDON (1985) summarized the lichens growing in the Antarctic Peninsula and adjacent islands. LINDSAY (1971) referred to the vegetation of the South Shetland Islands.

## 5. Method

In the Syowa Station area, the author carried out a field survey at 49 localities along the Sôya Coast and the Prince Olav Coast, 68°08′–69°54′S lat., 38°15′–42°42′E long. (Fig. 1). The following are the major ice-free areas investigated, figures in parentheses express size (km$^2$), altitude of the highest peak (m), and period of survey, respectively: Skarvsnes (61.1, 400.4, 24–30 Oct. 1986). Langhovde (50.0, 496.5, 17 Nov. 1986–16 Jan. 1987), Padda (Isl.) (22.8, 263.0, 3–6 Sept. 1986), Skallen (14.4, 186.2, 30 Sept. –2 Oct. 1986), Breidvågnipa (11.4, 316.1, 17–18 Oct., 12 Nov. 1986), West Ongul (Isl.) (8.0, 47.7, 28 Jan.–4 Feb., 21–28 Feb. 1986, 21 Jan., 2 Feb. 1987), Hjartöy (Isl.) (7.6, 100.0, 3 Oct. 1986), Skallevikhalsen (7.6, 277.0, 29 Sept.–3 Oct. 1986), Cape Hinode (6.7, 164.6, 15–17 Sept. 1986), Rundvågshetta (2.6, 159.3, 22–24 Jan. 1987), Cape Omega (2.3, 98.8, 21 Sept. 1986).

In the King George Island region, the following localities were investigated (the sizes and elevations are estimated in Fig. 1): Fildes Peninsula (14 Nov. 1988–4 Mar. 1989), Barton Peninsula (27 Jan. 1989; 3 hours) and Ardely Peninsula (14 Nov. 1988–3 Mar. 1989) of King George Island, Harmony Cove (17, 21 Dec. 1988, 4, 29 Jan. 1989) of Nelson Island, Geologist Island (20 Dec. 1988, 24 Jan. 1989), and Two Summit Island (13, 14 Feb. 1989).

Since most of lichens are not taxonomically specified as yet, the author checked morphological-, anatomical- and chemical features most precisely; the staining agents "lactophenol cotton blue" and "iodine solution" were introduced for studying hyphal structure of apothecium, and the lichen substances in all species were identified or speculated by means of thin-layer chromatography (TLC) using the techniques given by CULBERSON and KRISTINSSON (1970) with a few modifications; the chromatograms were developed in two solvent systems (a mixture of 180 m*l* benzene, 45 m*l* dioxane and 5 m*l* acetic acid; a mixture of 100 m*l* hexane, 80 m*l* ethyl ether, and 20 m*l* formic acid). In recognizing species the author employed taxonomic characters introduced by monographers of each taxa as far as possible.

A few microclimatological elements for temperatures were measured in Langhovde near Syowa Station and at the site near Great Wall Station by using the meteorological instruments of unmanned system for measurements. The data logger used in Langhovde was MES-1103 (Koito Kogyo), and KADEC-U (Kona Co.) at King George Island.

Electroconductivity of the deposited snow, collected from 57 stands in Langhovde and brought to Japan in frozen state, was measured under normal temperature by using the Electroconductive meter (HORIBA DS-8F). The measurement was carried out for all samples in a short time.

## 6. Results and Discussion

### 6.1. *Flora*

The number of lichen species reported from some Antarctic regions based mainly on the collections by recent lichenologists, including the result of the present study, is given in Table 2.

#### 6.1.1. Can the number of lichen species reported from the Antarctic by the experienced lichenologists be accepted as true?

As shown in Table 2, the lichen flora of the region near Syowa Station is richer than those of the Bunger Hills (M.P. ANDREEV, 1989: private communication), Mac. Robertson Land (FILSON, 1966) and North Victoria Land (KAPPEN, 1985) where the climate appears to be similar to that of the former. It is natural that the flora of the Beacon Sandstone Formation (HALE, 1987) and the Scott Glacier Region (CLARIDGE *et al.*, 1971), which are situated in the inland of Antarctica where the climate is severe, appears to be poorer than that of the Syowa Station area. However, we cannot discuss the floristic difference among them impatiently, because the periods for field survey were very different with each other. M. P. ANDREEV (1989: priv. commun.) and KAPPEN (1985) curtailed their prearranged period for a field survey because of the accidents; the former spent about a month, and the latter only 10 days. As mentioned above, KASHIWADANI (1982) enumerated only 20 species of lichens from the Syowa Station area, but most specimens he cited were collected from very restricted sites and only for 2 weeks during the summer season, while the author had been in the field throughout the year except for the austral winter and early spring.

Table 3 implies that the number of species collected depends on the length of the period for a field survey. The figures represent the number of species newly collected during about 10 days in the survey of King George Island region. As shown in Table 3, almost half of the species known from the region were collected within about a month, however, the other half had been accumulating gradually during 2.5 months.

HALE (1987) carried out the field surveys in 3 field (summer) seasons, and collected more than 200 fertile specimens; accordingly, the number in Table 2 he enumerated would be reasonable and is fit for the discussions in various scientific works. The specimens cited by CLARIDGE *et al.* (1971) were collected by non-lichenologists in the austral summer of 1969–70, and so we should be careful in discussion, although the

*Table 2. Number of lichen species reported from Antarctic regions mainly based on the specimens by the recent collectors.*

| Genus | Region* | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII |
| *Acarospora* | 3 | 2 | 1 | 1 | 1 | 4 | 3 |
| *Biatorella* | 1 | 1 | 1 | • | • | 1 | 3 |
| *Buellia* | 8 | 6 | 8 | 2 | 1 | 6 | 18 |
| *Caloplaca* | 3 | 1 | 2 | • | • | 4 | 11 |
| *Candelaria* | • | • | 1 | • | • | 1 | 1 |
| *Candelariella* | 1 | 1 | 1 | • | • | 1 | 1 |
| *Catillaria* | 1 | 1 | 2 | • | • | • | 5 |
| *Heppia* | • | 1 | • | • | • | • | • |
| *Lecanora* (s. lat.) | 3 | 3 | 2 | 1 | 1 | 8 | 9 |
| *Lecidea* (s. lat.) | 4 | 3 | 4 | 2 | 1 | 4 | 24 |
| *Lecidella* | 2 | • | 1 | • | • | 2 | 3 |
| *Lepraria* | 1 | • | 1 | • | • | 1 | 3 |
| *Mastodia* | • | 1 | • | • | • | • | 1 |
| *Ochrolechia* | • | • | 1 | • | • | • | 2 |
| *Pertusaria* | 1 | • | • | • | • | • | 4 |
| *Phaeophyscia* | 1 | • | • | • | • | • | • |
| *Physcia* | 2 | 2 | 2 | • | • | 2 | 2 |
| *Pseudephebe* | 1 | 1 | 2 | • | 1 | 2 | 1 |
| *Rhizocarpon* | 2 | 1 | 2 | • | • | 2 | 5 |
| *Rinodina* | 2 | 1 | 2 | • | • | 4 | 5 |
| *Umbilicaria* | 2 | 2 | 2 | • | 1 | 3 | 3 |
| *Usnea* | 2 | 1 | 2 | • | • | 1 | 2 |
| *Xanthoria* | 2 | 2 | 2 | • | • | 2 | 2 |
| *Cyanolichens* | • | • | • | • | • | 2 | • |
| *Pyrenocarpous lichens* | • | • | • | • | • | 2 | • |
| Unidentified (sterile) lichens | • | • | 1 | • | • | 4 | 4 |
| Total | 42 | 32 | 41 | 7 | 6 | 57 | 112 (198**) |

* I. Bunger Hills (66°17′S, 100°47′E; M.P. ANDREEV, 1989: priv. commun.), II. Mac. Robertson Land (67–68°S, 65°E; FILSON, 1966), III. N. Victoria Land (70°48′–71°12′S, 164°31′–167°00′E; KAPPEN, 1985), IV. Beacon Sandstone Formation, Victoria Land (200 fertile specim., 3 austral summers) (76°30′S–78°30′S, 162°E; HALE, 1987), V. Scott Glacier Region, Queen Maud Range (non-specialist, det. Dr. DODGE) (85°25′–86°13′S, 147–157.7°W; CLARIDGE *et al.*, 1971), VI. Syowa Station area (68°08′–69°54′S, 38°15′–42°42′E; M. INOUE, present study), VII. King George Island (Fildes Peninsula) (62°S, 59°W; M. INOUE present study).

** Eighty-six other lichens: *Bryoria* (1), *Cladonia* (6), *Cornicularia* (2), *Dermatocarpon* (2), *Himantormia* (1), *Hypogymnia* (1), *Leptogium* (1), *Parmelia* (1), *Physconia* (1), *Ramalina* (1), *Sphaerophorus* (1), *Stereocaulon* (3), *Aspicilia* (7), *Bacidia* (4), *Biatora* (2), *Blastenia* (6), *Cystocoleus* (1), *Haematomma* (2), *Lecania* (3), *Lopadium* (1), *Massalongia* (3), *Microglaena* (2), *Pannaria* (2), *Parmeliella* (1), *Phlyctis* (2), *Placopsis* (2), *Placyntium* (1), *Polyblastia* (1), *Polycauliona* (1), *Porina* (2), *Protoblastenia* (1), *Psoroma* (1), *Pyrenocollema* (1), *Pyrenopsidium* (1), *Pyrenopsis* (1), *Staurothele* (1), *Thamnolecania* (2), *Thelidium* (1), *Thelotrema* (1), *Thelidiopsis* (1), *Thelocarpon* (1), *Trapelia* (1), *Tremolechia* (1), *Verrucaria* (8).

*Table 3. Accumulation of lichen species in course of time (1988–1989, Fildes Peninsula of King George Island).*

| Period of survey | Number of species/Total |
|---|---|
| 14–23 Nov. | 38/ 38 |
| 24 Nov.–3 Dec. | 55/ 93 |
| 4–13 Dec. | 1/ 94 |
| 14–23 Dec. | 21/115 |
| 24 Dec.–2 Jan. | 18/133 |
| 3–12 Jan. | 9/142 |
| 13–22 Jan. | 18/160 |
| 23 Jan.–1 Feb. | 10/170 |
| 2–11 Feb. | 9/179 |
| 12–21 Feb. | 11/190 |
| 22 Feb.–4 March | 8/198 |

number may be regarded as reasonable because of its similarity with that of HALE (1987).

The author thinks that it is very difficult to get reasonable numbers of species occurring in the Antarctic regions. On account of its severe geographical and climatological conditions in addition to a vast expanse of continent, the Antarctic prevents us from carrying out usual expeditions as are the cases in other continents.

6.1.2. Floristic differences between the Syowa Station area and the King George Island region

Table 4 shows the genera and the number of species of lichens growing in both regions. Table 5 enumerates the number of species of the macrolichens growing in the King George Island region, but not known from the Syowa Station area. Most genera known from the Syowa Station area are growing in both regions, while only about 20 percent (10 species) of lichens known to occur in the Syowa Station area are growing

*Table 4. Genus and the number of species growing in both the Syowa Station area and the King George Island region.*

| Genus | Number of species | Genus | Number of species |
|---|---|---|---|
| *Acarospora* | (4, 3, 0)* | *Lepraria* | (1, 3, 0) |
| *Biatorella* | (1, 3, 0) | *Physcia* | (2, 2, 2) |
| *Buellia* | (6, 18, 1) | *Pseudephebe* | (2, 1, 1) |
| *Caloplaca* | (4, 11, 2) | *Rhizocarpon* | (2, 5, 0) |
| *Candelaria* | (1, 1, 1) | *Rinodina* | (4, 5, 0) |
| *Candelariella* | (1, 1, 0) | *Umbilicaria* | (3, 3, 1) |
| *Lecanora* | (7, 8, 0) | *Usnea* | (1, 2, 0) |
| *Lecidea* | (4, 24, 0) | *Xanthoria* | (2, 2, 2) |
| *Lecidella* | (2, 3, 0) | | |

* Figures in parentheses represent the numbers of species occurring in the Syowa Station area, King George Island region, and in the both areas, respectively.

*Table 5. Number of species of the macrolichens growing in the King George Island region, but not known from the region near Syowa Station.*

| Genus | Number of species | Genus | Number of species |
|---|---|---|---|
| *Bryolia* | 1 | *Mastodia* | 1 |
| *Cladonia* | 6 | *Parmelia* | 1 |
| *Cornicularia* | 2 | *Physconia* | 1 |
| *Dermatocarpon* | 2 | *Polycauliona* | 1 |
| *Himantormia* | 1 | *Ramalina* | 1 |
| *Hypogymnia* | 1 | *Sphaerophorus* | 1 |
| *Leptogium* | 1 | *Stereocaulon* | 3 |

in the King George Island region. Even the commonest lichen occurring in the Syowa Station area, *Buellia frigida*, which is one of the well known representatives as a continental Antarctic element (LINDSAY, 1977), is not distributed in the King George Island region though the genus comprises many species there. *Caloplaca* and *Lecidea* (s. lat.) comprise many species in both regions, although the species growing in both regions are very few.

A few species belonging to a continental Antarctic element are recognized from the King George Island region though their habitats are not so prominent. For example, *Umbilicaria decussata*, one of the species growing in both regions and was reported from several localities in the continental Antarctic, is known from only 2 sites in the Barton Peninsula and the Fildes Peninsula. Its habitat in the King George Island region is also very meager, while this species occurs in most ice-free areas in the Syowa Station area and is developing well. As is the case with *Umbilicaria decussata*, *Pseudephebe pubescens* is known only from a few sites in King George Island.

Most species growing in both regions are microlichens, and macrolichens are very few in the Syowa Station area in contrast to those in the King George Island region. Most genera of macrolichens are distributed in the northern hemisphere, but *Himantormia*, *Mastodia* and *Polycauliona* are endemic to the Antarctic. It is interesting that most species belonging to these genera are not known from the continental Antarctic zone (*Mastodia mawsonii* was reported from Mac.Robertson Land (FILSON, 1966) and Queen Maud Land (DODGE, 1948)).

Forty-eight genera, which are not known from the Syowa Station area, are known to occur in the King George Island region. As far as the author knows *Aspicilia* and *Verrucaria*, which comprise 7 species and 8 species respectively in the King George Island region, are not known from the continental Antarctic. The occurrences of *Bacidia*, *Blastenia*, *Catillaria*, *Cladonia*, *Pertusaria*, and cyano-lichens in the continental Antarctic are also scanty. The author supposes that they belong to "non-continental Antarctic" genera.

One of the reasons why many cayno-lichens, mostly at moist habitats in the King George Island region, grow in the maritime Antarctic appears to be the long duration of above-zero air temperature (monthly mean) during the summer season, whereas at Syowa Station the monthly mean air temperature does not rise above zero throughout the year (Fig. 2).

As speculated above, it might be most plausible to conclude that one of the factors influencing the rich lichen flora including many macrolichens in the maritime Antarctic is the mild weather conditions of the region. The author thinks it is true, but cannot jump at a conclusion impetuously. Figure 3 shows the changes of the temperatures measured at the bottom of terricolous lichen communities at noon in Langhovde near Syowa Station and King George Island for a whole period of summer season. Langhovde exceeded King George Island in the temperature at the bottom of terricolous lichen communities except when the weather was fine in the latter; at least in the summer season the temperature at the bottom of lichen communities at noon in Langhovde is higher than that of King George Island owing to higher insolation. This result suggests that a major factor controlling lichens in the Antarctic is not temperature but water supply; the precipitation in the Syowa Station area during the summer season might be very little though the definite meteorological data are lacking, while in King George Island during the same season they had snow, sleet, rain and fog frequently. This is similar to the following ecophysiological result; on the basis of the field measurements of carbon dioxide exchange, KAPPEN (1989) reported that *Usnea sphacelata* became photosynthetically active at temperatures below 0°C when the thalli were covered by drifted snow.

There is no microclimate records extending over a long period of time and making

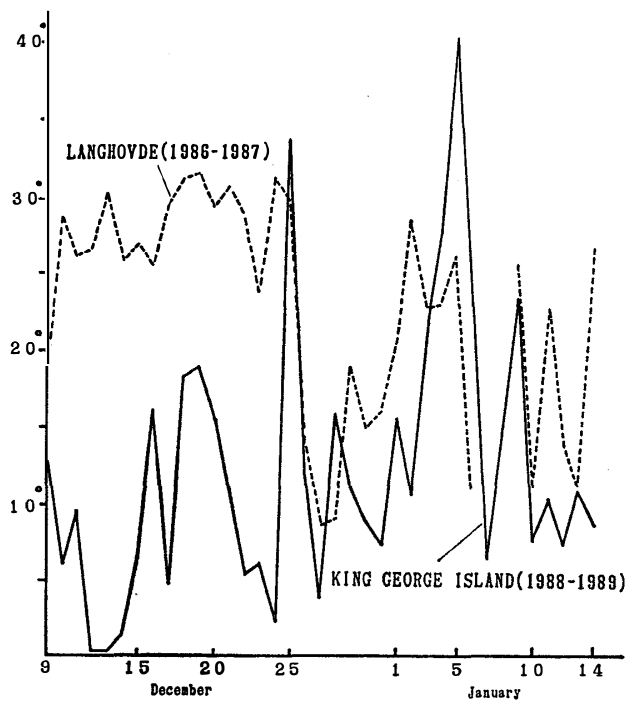


*Fig. 3. Monthly changes of the temperatures measured at the bottom of terricolous lichen communities at noon (1200–1230) in Langhovde (average of 15-min mean) and King George Island (average of 10-min mean). Measurement was made every minute by employing the sensor for copper-constantan thermometer. Lichens are* Rinodina olivaceobrunnea *(Langhovde) and* Pannaria hypnorum *(King George Island).*

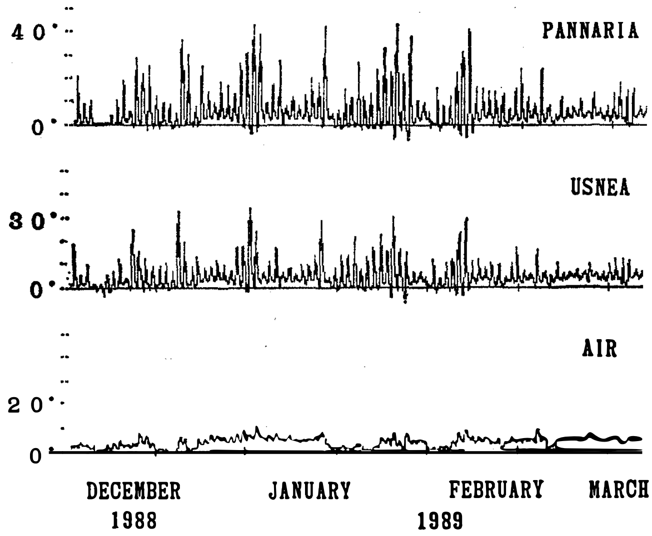


*Fig. 4. Changes of air temperature near ground surface and temperature measured at the bottom of* Psoroma hypnorum *and among* Usnea aurantiacoatra *communities in King George Island.*

it possible to compare between Langhovde and King George Island, because the author finished the measurement of microclimate in Langhovde on 14th of January 1987, whereas in King George Island he was able to continue the measurement until 6th of March 1989. Figure 4 represents the changes of air temperature near the ground surface and the temperature at the bottom of *Psoroma*- and among *Usnea*-communities measured from 8th of December 1988 to 6th of March 1989 in King George Island. Air temperature attained to 10°C at most, the temperature at the bottom of *Pannaria*-community was over 40°C, and the temperature among *Usnea*-communities 30°C. The fluctuation of air temperature was smaller than that of the temperatures near lichens, and it is strange that the temperatures near lichens fell often below zero especially during the summer season (January to February). The author supposes that ice, which was contained in the layer between the ground surface and the permafrost, melted and formed cavities in the layer, causing the cool air in the permafrost to blow through the cavities. This kind of microenvironment cannot be ignored in considering the occurrence of lichens.

### *6.2. Differences in habitat of lichens between the Syowa Station area and the King George Island region*

In the Syowa Station area extensive sites lack lichen cover, even where the ground is normally snow-free in summer. Inoue (1989) concluded that lichens of the region, with a very low precipitation in summer, grew luxuriantly at the sites where an adequate moisture was maintained due to snow and ice brought by the "katabatic wind" over the surface of ice cap, while lichens were absent or poorly developed at the dry sites which were buffeted by cyclonic wind through the surface of sea ice, and the wind-blown sea spray was one of the unfavorable factors for lichens. Before his visit to King George Island, the author had imagined that lichen-less area would be extensive there, since the

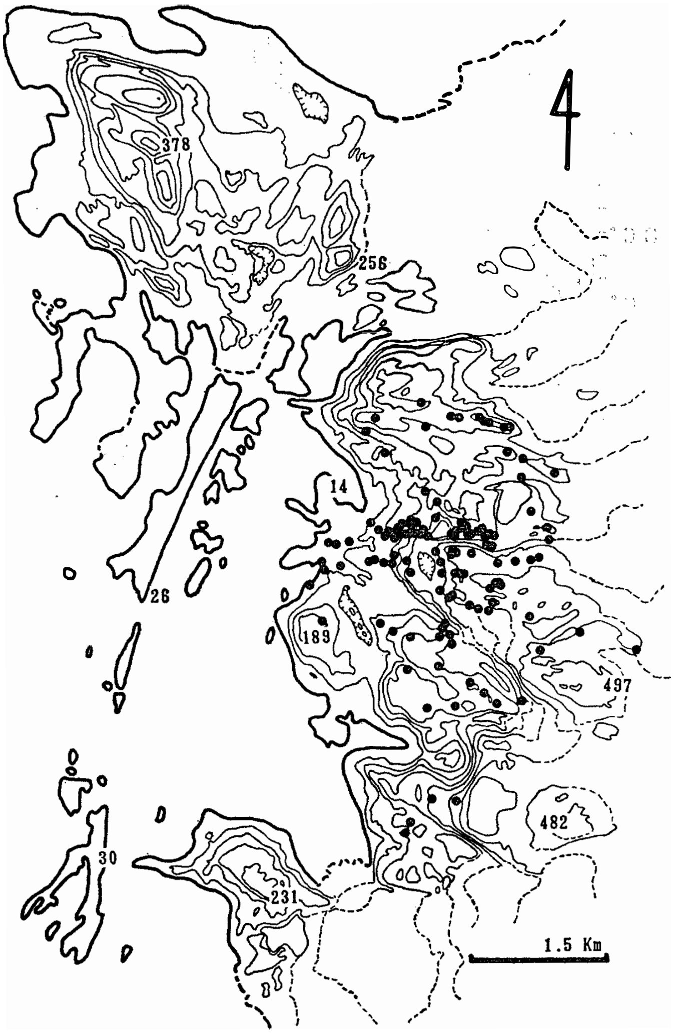


*Fig. 5. Distribution of* Usnea sphacelata *in Langhovde, near Syowa Station. After* INOUE *(1989) with a slight modification.*

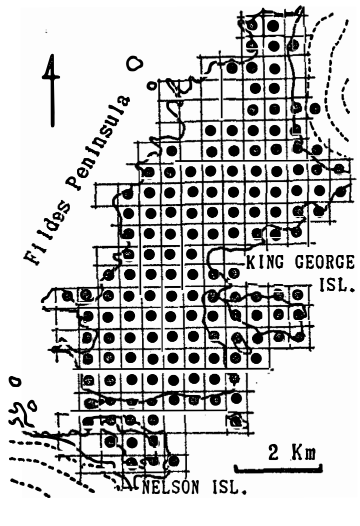


*Fig. 6. Horizontal distribution of* Usnea antarctica *and/or* U. aurantiacoatra *in the Fildes Peninsula, King George Island. Vacant meshes do not mean that lichens are absent but that the author did not visit there.*

Fildes Peninsula is not very large and surrounded by the sea. However, both macro- and microlichens are growing everywhere in the region; they can be seen even on rocks in small offshore islets, in littoral zone including intertidal zone, and in terminal moraine which is unstable. Of course each lichen community is developed at its characteristic habitat. The occurrence of a few species belonging to *Verrucaria* is confined to the

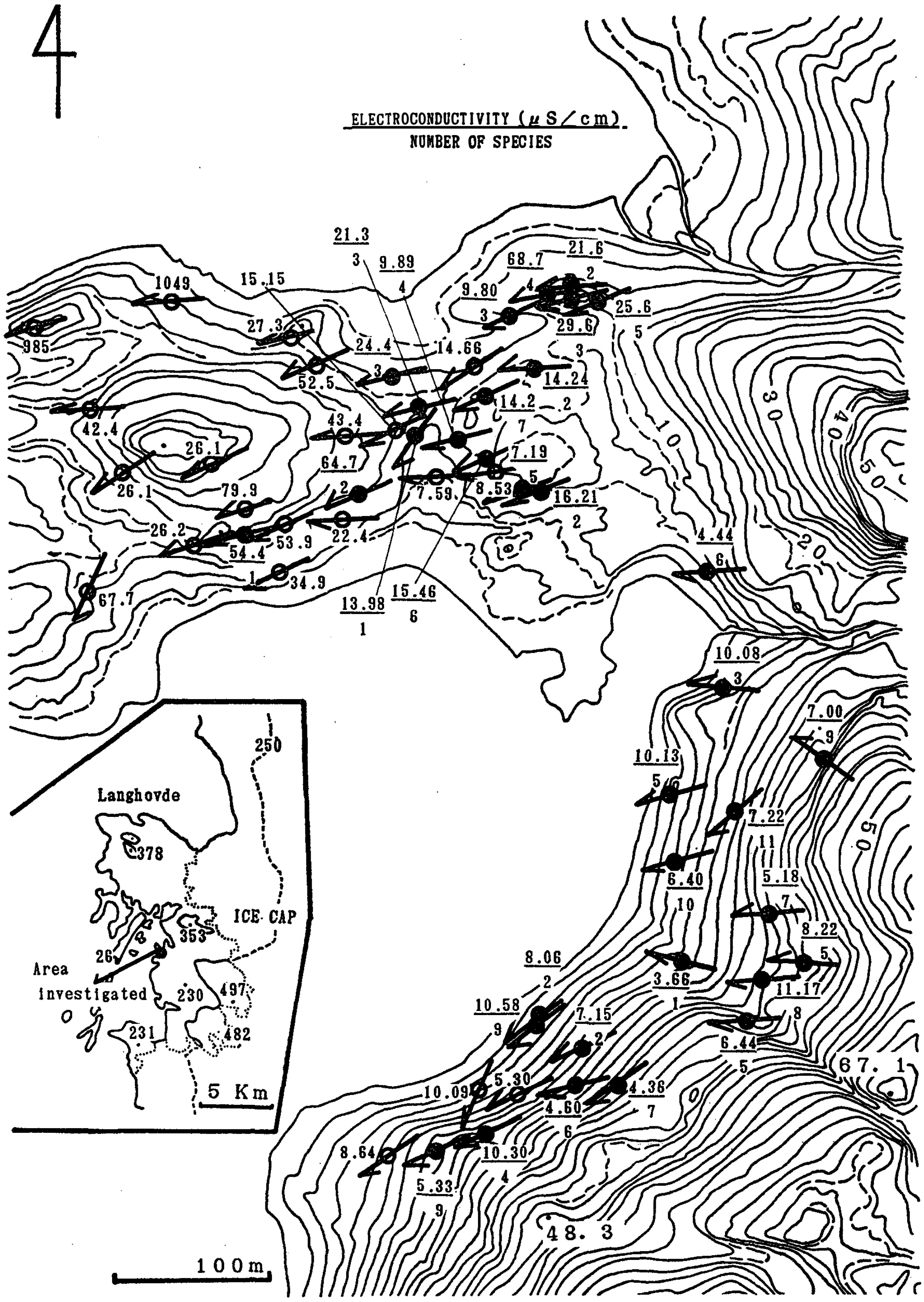


*Fig. 7. Electroconductivity and orientation of flow lines of deposited snow, and number of lichen species around the snow at each stand (Langhovde, 2nd and 5th of December, 1986).*

rocks in intertidal and splash zones, and some species of *Verrucaria*, *Caloplaca* and *Buellia* are growing on rocks in splash zone. Several lichens including macrolichens *Usnea antarctica*, *U. aurantiacoatra* and *Leptogium puberulum* occur on unstable stones in terminal moraine. No lichens are known to occur in such environments in the Syowa Station area.

Figure 5 shows a distribution of *Usnea sphacelata* in Langhovde near Syowa Station based on the author's collections, and Fig. 6 shows a distribution of *Usnea antarctica* and/or *U. aurantiacoatra* in the Fildes Peninsula and Harmony Cove based on the analysis of a large number of pictures taken from various directions by the author. As mentioned in the previous paper (INOUE, 1989), the author visited almost whole areas of Langhovde, but as seen in Fig. 5, the distribution of *Usnea* is one-sided, while not so in the Fildes Peninsula and Harmony Cove. In order to verify the speculation that the wind-blown sea spray is one of the unfavorable factors for lichens in the Syowa Station area, the author measured the electroconductivity, which is one of the parameters of salinity, of snow drift deposited around the foot of the small peninsula in Langhovde. Figure 7 shows the electroconductivity and orientations of flow lines of deposited snow, and the number of lichen species around the snow at each stand. As shown in Fig. 7, 1049 $\mu$S/cm is the maximum and 4.44 $\mu$S/cm is the minimum. Judging from the wind-rose of annual surface observation at Syowa Station (Fig. 8), the direction of prevailling winds in Langhovde appears to be northeastwards to eastwards. The electroconductivity of the snow, which was deposited at the sites protruding to the sea and faced to the predominant wind direction, is higher than that of the sites on the continental slope side which is influenced by the "katabatic wind" blowing over the surface of ice cap. Lichens are absent or poorly developed in the former, while luxuriant in the latter. It is interesting that OSADA *et al.* (1988) obtained a similar dimension of the electroconductivity from a few kinds of snow deposited on sea ice near Langhovde in August, 1986; $2.6 \pm 0.3$ $\mu$S/cm in the snow deposited on continental ice sheet, 16–115 $\mu$S/cm in the snow far from bare sea ice, 250–412 $\mu$S/cm in the snow close to bare sea ice, and 1300–11000 $\mu$S/cm in the snow very close to bare sea ice. The snow samples which the author measured were collected in December 1986. If the region had a usual precipitation the

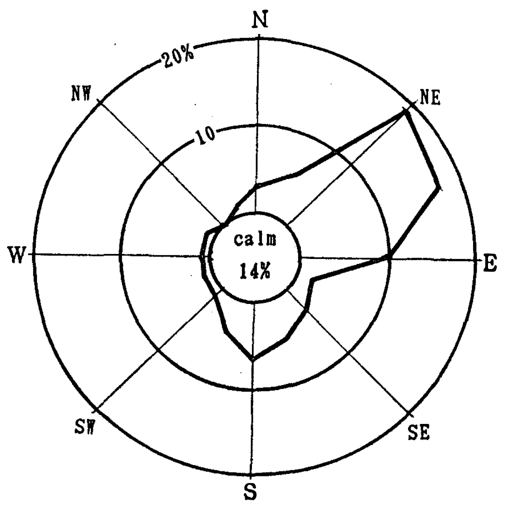


*Fig. 8. Windrose of annual surface observation at Syowa Station, 1978-1979, 8 times a day. After OFFICE OF ANTARCTIC OBSERVATIONS, OBSERVATIONS DEPARTMENT, JAPAN METEOROLOGICAL AGENCY (1981).*

salinity brought by the wind-blown sea spray would be diluted. However, the electroconductivity is similar to each other, and seems to be unchanged at least for 4 months.

Unfortunately the author himself could not obtain the electroconductivity from the snow deposited on the seashore and sea ice in King George Island. However, Mr. QIN of Chinese Academy of Sciences who was the leader of the wintering party of CHINARE-4 measured it with the author (unpublished). His result may support the assumption that high precipitation seems to dilute the salinity.

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