Airborne pollen and spore registrations at Ny-Ålesund, Svalbard, summer 1986

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Sampling of airborne pollen and spores at Ny-Ålesund on Spitsbergen in the summer of 1986, by means of a Burkard pollen and spore trap, revealed only very low concentrations of air spora: a cumulative diurnal mean for the whole season of less than 200 pollen grains and just in excess of 9,000 moss and fungal spores. The most frequent pollen types recorded were those of the local taxa: *Saxifraga*, *Salix* and *Oxyria digyna*, whereas the share of pollen of exotic taxa, *Betula*, *Pinus*, *Juniperus* and *Alnus*, contributed only 9% of the total pollen sum. Back trajectories and pollen registrations at various aerobiological stations in Scandinavia designate central Finland as a possible source area both for the *Betula* and *Pinus* pollen. The maximum diurnal mean concentration of *Cladosporium* was merely 40 spores per m^3 air. One may assert that the air at Ny-Ålesund is almost free from allergenic pollen and spore types.

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True aerobiological investigations published so far from Svalbard comprise only Levin's (1899) studies on airborne bacteria and Polunin's (1955) analyses of sticky slides exposed in Sarsbukta on western Spitsbergen in July–August 1950. The latter revealed a small deposition of pollen, including both local and exotic taxa.

Palaeo-ecologists who have been working in Svalbard have used surface samples for their studies of recent pollen and spore deposition. By analysing moss cushions Środoń (1960) found that the share of exotic pollen varied from about 1 to 65% of the total pollen count, depending on the height of the sites above sea level. Van der Knaap (1985), studying surface samples from north-western Spitsbergen, demonstrated that the share of pollen brought in by long-distance transport exceeded 10% of the total pollen count only in sites where the local plant cover was extremely sparse.

The purpose of the investigation reported in this paper was to gain further knowledge as to the type and concentration of air spora (airborne pollen and spore material) in a remote, high-arctic region such as Svalbard by direct analysis of the air masses by means of a Burkard volumetric pollen and spore trap. Of particular interest was the catch of exotic pollen grains, their being evidence of the transport routes of air masses to this remote area. The recordings were also expected to document the type and concentration of allergenic pollen and spore material in the outdoor air at Ny-Ålesund.

The research station in Ny-Ålesund, at 78°55′N, 11°56′E, where the sampling took place, has served as a monitoring site for arctic air pollution since the late 1970s (Fig. 1). The station also provides access to local meteorological data which have been observed regularly since 1970.

The area at the research station is a rather even tundra plain with large parts deprived of vegetation because of former mining activity. To the south and west the tundra plain merges into a mountaineous area with extensive glaciers, which occupies most of the Brøgger peninsula.

Climatically, Svalbard often lies in the border zone between the cold, arctic air masses in the Polar Basin and the mild, maritime air to the south. The Vest-Spitsbergen current, which is a branch of the Gulf Stream, as well as the frequent currents of mild air being brought up from lower latitudes have a favourable influence on the Svalbard climate (Hisdal 1976). According to the yearly means for the period 1971–80, the precipitation in Ny-Ålesund is 385 mm and the annual mean temperature not lower than −5.8°C.

The most common plant communities occurring around Ny-Ålesund are the *Saxifraga oppositifolia*, *Tomenthypnum nitens*, *Luzula confusa* and *Deschampsia alpina* communities (Brattbakk 1981). *Salix polaris* is the most abundant dwarf-shrub, and the genus *Saxifraga* is represented in

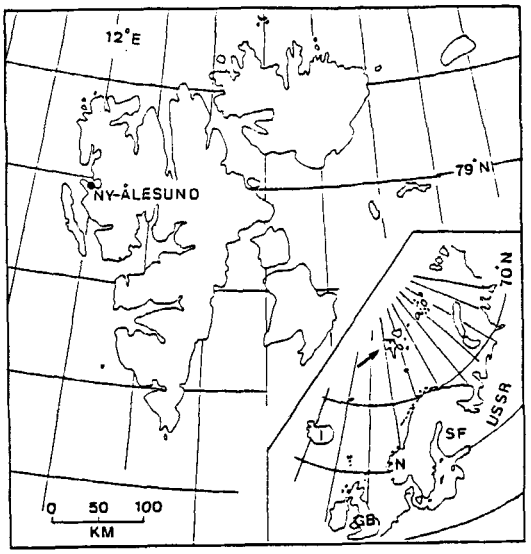

Fig. 1. Survey map of Svalbard and its geographical position (the key map), with the location of Ny-Ålesund, the sampling spot, indicated.

all communities by *S. oppositifolia*, *S. caespitosa* and *S. cernua*. Other tundra herbs, occurring in varying numbers, are *Oxyria digyna*, *Polygonum viviparum*, *Cochlearia officinalis*, *Cerastium arcticum* and *Draba corymbosa*. The most frequent grasses, sedges and rushes are *Poa alpina*, *Deschampsia alpina*, *Luzula confusa* and *Juncus biglumis* (Brattbakk 1986, Table 2).

Material and methods

A Burkard seven days recording volumetric pollen and spore trap (Gregory 1973) was operated from 25 April to 25 August 1986, standing on the roof of the Norwegian Polar Research Institute research station in Ny-Ålesund, 8.7 m above the ground (Fig. 2). The air flow through the trap was controlled once a week through the whole sampling period and each time showed a constant flow of 10 l per minute. The pollen and spores were collected on a tape coated with a thin film of vaselin-paraffin wax dissolved in toluene.

The drum with the exposed tape was changed once a week and sent to Trondheim for preparation in glycerine gelatine and analysis in the pollen laboratory at the Botanical Institute of the University. The microscopical analyses were performed in 500–600× magnification and the

Fig. 2. The Burkard pollen and spore trap on the roof of the research station in Ny-Ålesund. Photo: S. Johansen 1986.

number of pollen grains and spores sticking to the tape counted in a transverse field of vision at 2 mm distance, i.e. at every second hour's deposition. The pollen identification was controlled by means of a reference pollen collection worked out for the species flowering in the vicinity of the research station. Spores of the ubiquitous, and allergenic, genus *Cladosporium* were also recorded, but the rest of the airborne fungus flora was recorded only collectively. Moss spores and diatoms occurring on the tape were also counted, viz. collectively for each category. Cenospheres, i.e. spherical particles from incomplete combustion of coal and fuel oil (Reid & Allitt 1981), occurred occasionally and were counted as well.

The diurnal concentration of air spora was calculated by multiplying the number of pollen grains, spores, diatoms or cenospheres counted in each two hour transverse section by a factor determined partly by the width of the microscope's field of vision and partly by the air flow through the trap. The results, expressed as number per m^3, have been exposed graphically in a 'pollen calendar' and a 'spore calendar', respectively (Figs. 2 and 3). In order to provide an outline of the amount of the various taxa through the whole flowering season, cumulative values were calculated by adding up the diurnal means for each category.

Results

Seasonal concentration

It appears from Tables 1 and 2 that the amount of air spora recorded in Ny-Ålesund during the summer season 1986 totals less than 200 pollen grains and only a little more than 9,000 spores of

Table 1. Cumulative diurnal means, calculated as pollen grains (pg) per m^3 air and percentages of the total pollen sum, of the pollen categories recorded with the Burkard pollen and spore trap in Ny-Ålesund, Spitsbergen, in the period 25 April–25 August 1986.

Pollen type	pg/m^3	%
Alnus	1	0.5
Betula	6	3.2
Juniperus	2	1.1
Pinus	8	4.3
Salix	49	26.2
Brassicaceae	3	1.6
Oxyria digyna	25	13.4
Saxifraga	84	44.9
Indet.	9	4.8
Total pollen	187	100.0
Arboreal	66	35.3
Non-arboreal	112	59.9

fungi and mosses. Of the former, herb pollen dominates with about 60% of the total pollen sum. Of this, *Saxifraga* pollen alone contributes 45%. Of the fungal spores, less than 2% belonged to the form genus *Cladosporium*.

The most abundant arboreal pollen type was *Salix*, totalling about 26% of the entire pollen sum. The remaining tree pollen types being trapped, *Betula*, *Pinus*, *Juniperus* and *Alnus*, must have been transported over great distances from sources far outside Svalbard. Of species producing those pollen types, only the Dwarf Birch *(Betula nana)* grows in Svalbard, at a few localities in the inner part of the Isfjord area (Rønning 1979). However, in 1986 these localities were covered with snow both in May and during the first half of June and could hardly be responsible for the birch pollen grains being trapped. Including the *Betula* pollen, the amount of exotic pollen being trapped during the summer season 1986 totals 17 pollen grains, i.e. 9% of the total pollen sum.

Table 2. Cumulative diurnal means of the spore categories and diatom valves, calculated as spores (sp) or valves per m^3 air, recorded with the Burkard pollen and spore trap in Ny-Ålesund, Spitsbergen, during the period 25 April–25 August 1986.

Spore category	sp/m^3
Cladosporium spores	185
Indet. fungal spores	8,906
Moss spores	216
Diatom valves	8
Total sum	9,315

Seasonal distribution

The distribution over the season of air spora (Figs. 3 and 4) shows that the greatest concentration did not occur until July and August, when the local flowering season takes place in Svalbard. The very first pollen records were made on 4 May and comprised types of distant origin only, viz. 3 pollen grains per m^3 of *Betula* and less than 1 pollen grain per m^3 of *Pinus*. Except for one grain of the latter pollen type, recorded on 10 May, the next episodes of pollen registration did not occur until one month later, on 3 June when small amounts of *Betula* and *Pinus* pollen were found, on 10 June when less than 1 grain per m^3 of *Pinus* was found and on 13 June when one pollen grain of *Juniperus* was trapped together with 4 pollen grains of *Pinus* and 6 of *Saxifraga oppositifolia* type.

As seen from the pollen calendar (Fig. 3), the local pollen season at Ny-Ålesund in 1986 was confined almost exclusively to July, when *Salix* (cf. *polaris* type), *Saxifraga* and *Oxyria digyna* – the most frequent pollen types recorded – occurred with maximum diurnal means of 17, 50 and 7 grains/m^3, respectively.

Spores of *Cladosporium* and other unspecified, fungal taxa were recorded occasionally or very sparsely already from the start of the recording in late April and onwards, but did not become more frequent until the middle or later part of June, when also the trapping of moss spores was initiated. The seasonal maximum of *Cladosporium*, 44 spores/m^3, was registered on 1 August, whereas the bulk of fungal spores occurred with its maximum values after 10 August, when concentrations up to 600 spores/m^3 were recorded. In July and August the tape occasionally also contained a few valves of diatoms, of the order Pennales. A few cenospheres also occurred, on 15 June, forming a diurnal mean of maximum 9 spheres per/m^3 (Fig. 4). A possible source of the cenospheres is the oil-heated power station in Ny-Ålesund.

Discussion

The low pollen concentration

The extremely low concentration, as well as the very restricted number of pollen types being recorded, reflect most clearly the high-arctic situation of Svalbard. Of the eight pollen categories

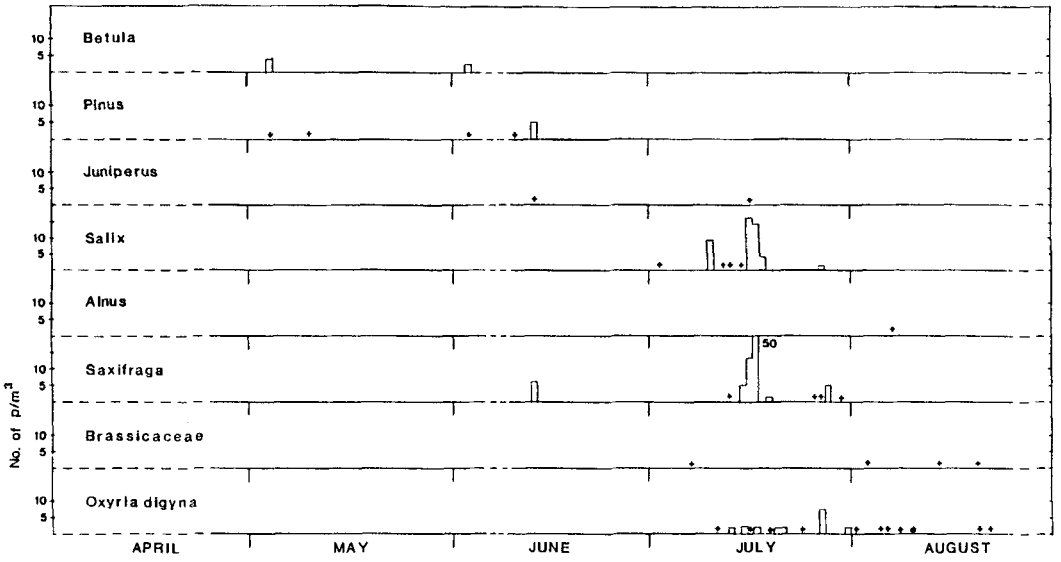

Fig. 3. Pollen calendar for Ny-Ålesund, showing the seasonal distribution of the 8 pollen types recorded in 1986. Concentrations less than 1 pollen grain per m^3 are marked by + signs and interruptions in the sampling by broken base lines.

recorded, only four, *Salix*, *Saxifraga*, *Oxyria digyna* and Brassicaceae type, represent the local flora, although this contains as much as 164 flowering plants (Rønning 1979). The remaining four pollen categories, *Alnus*, *Betula*, *Pinus* and *Juniperus*, no doubt find their explanation in long-distance transport from sources in distant areas. Little is known about how long pollen and spores can float or remain in the air masses. As maintained by Fægri & Iversen (1975) 'the rate of fall is a rather unimportant quantity compared to the velocities of the air masses, and pollen grains in the open can be considered part of the air mass transporting them'. According to the exotic pollen grains recorded on the remote islands of Tristan da Cunha and Gough Island in the South Atlantic, the distance that pollen grains are able to travel seems almost unlimited (Hafsten 1960).

It might appear somewhat surprising that not a single grass pollen grain was recorded, even

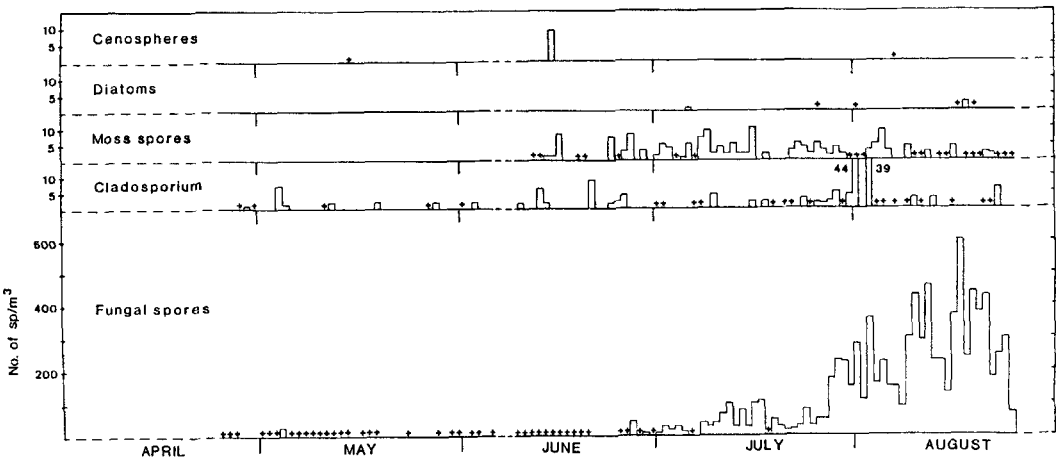

Fig. 4. Spore calendar for Ny-Ålesund, showing the seasonal distribution of the spore categories, diatom valves and cenospheres recorded in 1986. Concentrations less than 1 spore per m^3 are marked by + signs and interruptions in the sampling by broken base lines.

though a plant community dominated by *Deschampsia alpina* occurs around Ny-Ålesund. A plausible explanation of this might be the frequency of viviparity among the local grass types in high-arctic regions, e.g. both in *Poa alpina* and *Deschampsia alpina*. The trap's height above the ground (8.7 m) should not influence the possibility of an exact recording of the grass types, if they were not viviparous, as their pollen grains are particularly adapted to wind pollination.

The source of the relatively frequent *Oxyria* pollen must be the Mountain Sorrel *(O. digyna)*, which is a wind pollinated species (Lewis et al. 1983) with a widespread distribution in Svalbard. It should be noticed though, that the high peaks of *Salix* and *Saxifraga* pollen recorded in the middle of July do not necessarily prove that these taxa are among the most frequent air spora in Svalbard. The reason for this reservation is that the tape exposed on those days contained 1–3 midges of the Chironomidae subfamily Orthocladinae, which might have been responsible for an abnormal pollen concentration of these taxa on the exposed tape. The midges are definitely not due to contamination, as they were well embedded in the tape coating when arriving in Trondheim.

The paucity of air spora of the local, high-arctic flora demonstrated here tallies well with results obtained by other research workers using sticky glass slides for sampling. Thus, Polunin (1955) and Kalugina et al. (1981) report to have trapped only 8 and 13 pollen types on Spitsbergen and Severnaya Zemlya, respectively. The scarcity of grass pollen among the air spora in the Arctic has also been demonstrated by analyses of glass slide exposures and of moss cushions by Polunin (1955), Środoń (1960) and Van der Knaap (1985), who found only small or very moderate amounts of Poaceae pollen on Spitsbergen.

The exotic pollen types and their source areas

The pollen records at Ny-Ålesund comprised, as indicated, 9% of exotic pollen types, of which *Betula* and *Pinus* were the most frequent ones (Table 1). The dominance of these pollen types agrees well with the results of the investigations carried out by Polunin (1955), Środoń (1960) and Van der Knaap (1985) in other parts of Svalbard. Of the two other exotics trapped at Ny-Ålesund, *Juniperus*, encountered twice, has never before been reported among air spora recorded in Svalbard, neither by glass slide exposures nor in moss cushion samples. The very delicate juniper pollen grains are, as a matter of fact, known for their bad preservation and also for being easily overlooked in the analyses. *Alnus*, the last exotic being trapped, appeared so late in the season, on 7 August, that the record probably has to be interpreted as an event of re-entrainment during stormy weather.

The episodes on 4 May and 13 June

The cases when more than one exotic pollen grain was trapped occurred on 4 May and on 3 and 13 June (Fig. 3). In order to trace the possible source areas and transport routes of the exotic pollen grains on these occasions, we have examined back trajectories provided by the Norwegian Meteorological Institute and pollen registration reports for various aerobiological stations in Scandinavia for the days preceding 4 May and 13 June.

For the episodes on 4 May and 13 June the trajectories for the air masses four days back in time gave no answer as to the geographical origin of the exotic pollen being recorded, because the air masses reaching Ny-Ålesund on those occasions had not passed over land. A possible explanation of this is that the exotic pollen grains had reached the region prior to the four-day period examined, and had been held back in the arctic troposphere which, particularly during the winter season, represents a well mixed reservoir of aerosols (Heidam 1984). Explaining the records as redeposition makes no sense, at any rate not on 4 May and 3 June because the ground was still covered by snow on those occasions. On 13 June, however, redeposition might well have taken place.

The episode on 3 June

The geographical origin of the *Betula* and *Pinus* pollen grains which were trapped on 3 June seems, on the other hand, rather obvious from studies of the back trajectories for the air masses reaching Ny-Ålesund at that time (Fig. 5). The air masses reaching Svalbard on the very first days of June passed over Finland and Russia on 29 and 30 May and over the northernmost part of Norway on 31 May and 1 June. Judging from the aerobiological registrations carried out in Finland and northern Norway at that time, one finds that central Finland might have been the source area of both pollen

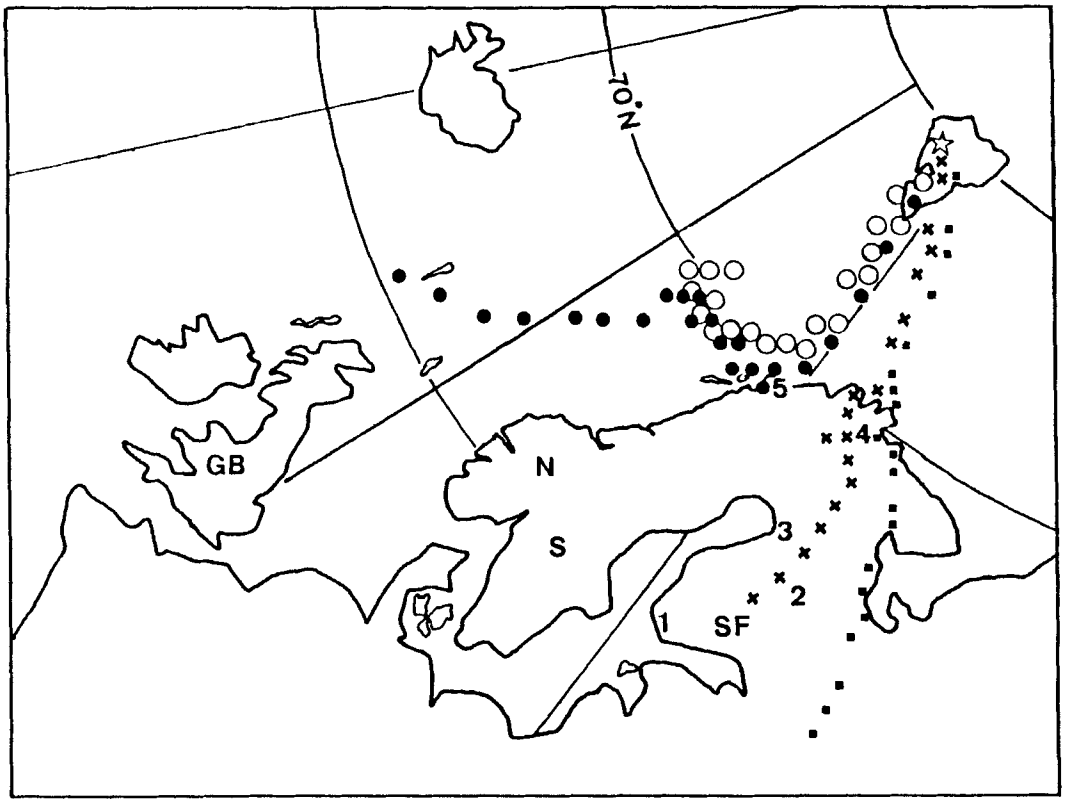

Fig. 5. Computed back trajectories (1,000 mb) ending at Ny-Ålesund on 1 and 2 June 1986, at 1200 hrs. or 2400 hrs. GMT. The symbols indicate the position at every 4 hours. SF = Finland, S = Sweden, N = Norway, GB = Great Britain, ☆ = Ny-Ålesund. 1 = Turku (Åbo), 2 = Kuopio, 3 = Oulu, 4 = Kevo, 5 = Tromsø.
● Start 30.05.1986 at 0400 hrs. GMT, arrival 02.06 at 2400 hrs. GMT
○ Start 29.05.1986 at 2400 hrs. GMT, arrival 02.06 at 1200 hrs. GMT
× Start 29.05.1986 at 2000 hrs. GMT, arrival 01.06 at 2400 hrs. GMT
■ Start 29.05.1986 at 0400 hrs. GMT, arrival 01.06 at 1200 hrs. GMT

categories, viz. the rather high values of birch pollen (200–300 grains/m^3) still being recorded in Oulu and the start of pine flowering, totalling 103 grains/m^3, on 1 June (Kupias & Pohjola 1986). At Turku (Åbo) and Kuopio in southern and central Finland, respectively, the birch flowering was over at that time, whereas in Kevo farthest north in Finland and in Tromsø in northern Norway the flowering of birch and pine had not yet started (Kupias & Pohjola 1986; Ramfjord 1987).

The Cladosporium *recording*

The recording of fungal spores presented here is the first in its kind in Svalbard. Concentrations of the ubiquitous and allergenic conidiospores of *Cladosporium*, a form genus of Fungi Imperfecti, were generally very low compared with records in more temperate regions and reached here a seasonal peak concentration of merely 44 spores/m^3. The maximum concentration measured in Tromsø that season was about 80 and in Bodø about 600 spores/m^3 (Ramfjord 1987).

The tendency of increased concentration of *Cladosporium* spores during the episodes of exotic pollen recording, particularly on 4 May and 13 June, indicates that this spore type also is subject to long-distance dispersal. This agrees well with the dominating *Cladosporium* concentrations found by Pady & Kapica (1953) when sampling air spora from aircraft over Canada, including the magnetic north pole as well. In Ny-Ålesund where the sampling took place at a height of only 8.7 m above the ground, *Cladosporium* is naturally outnumbered by spores from the many

macro and micro fungi which are known to sporulate on the arctic tundra in July and August.

Concluding remarks

This paper should not be concluded without pointing to the fact that the aerobiological results obtained here refer to only one season's sampling and, therefore, may be random. In order to secure more general information as to 1) the concentration of air spora in Svalbard, 2) the diversity of source areas for the exotic types and 3) the possible long-term trends in the concentration of air spora in Svalbard, one needs to repeat the sampling over more seasons and, preferably, extend the investigations to Bjørnøya and possibly also to Jan Mayen.

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