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MOULD ALLERGY

I. *An investigation of the airborne fungal spores in Stockholm, Sweden*

By

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HISTORY

Many years have passed since it was first observed that airborne fungal spores could bring about allergic diseases. As early as 1873 in his book, "Hay-fever, its causes, treatment and effective prevention", *Charles Harrison Blackley* (1) described briefly an experiment, which he carried out on himself, as follows: "By inhaling the spores of the *Penicillium* in an involuntary experiment a severe attack of hoarseness going on to complete aphony was brought on. This lasted for a couple of days and ended in a sharpish attack of bronchial catarrh which almost unfitted me for duty for a day or two". He concluded his report as follows, "...it is a subject which calls for much more careful and extensive investigation than it has yet received".

Nevertheless more than 50 years were to pass before Blackley's observations began to be considered seriously. It was the rapid development of aero-biological work which gave rise in the twenties to a renewed interest in airborne fungal spores as an aetiological element in hay-fever and asthma. Between 1910 and 1915 there were encouraging reports on the question of hyposensibilisation with pollen extracts. In 1924 *W. Storm van Leeuwen* (2), Holland, presented a work in which he claimed

that asthma was particularly prevalent in the Lowlands and he attributed this to the higher concentration of fungal spores in damp and lowlying places. He found a relatively pronounced hypersensitivity to *Aspergillus fumigatus* (3). He treated successfully several asthma patients with extract from this fungus. In 1924 *F. Y. Cadham* (4), Canada, reported on three cases of uredinous fungus asthma in the wheat district of Canada, and in 1928 *K. Hansen* (5, 6), Germany, published reports on several cases of asthma which could be brought about by fungi of the *Aspergillus* and *Penicillium* species. Since then there have been many reports on hypersensitivity to fungal spores. (7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20).

Many of the early investigations into mould allergy were based entirely upon the results of intracutaneous tests with different fungal extracts and their results were manifestly varied. *Jiménez-Díaz et alii* (9), Spain, in 1932 diagnosed only 17 fungus-hypersensitive patients out of a group of 292 allergic patients, i.e. 5.8 per cent, while *Schonwald* (21), America, in 1938 reported 57 per cent positive skin reactions to fungus out of a total of 150 allergic patients. At first it was thought that the wide difference partially could be attributed to latent allergy (22), i.e. positive skin reaction without clinical significance. As a result of this, numerous investigations into fungal allergy were carried out, both with the help of intracutaneous tests and provocation tests (23, 24, 25), but considerable differences were also observed between these. Thus *Nilsby* (26), Sweden, was unable to produce asthma or rhinitis by provocation tests on patients known to be sensitive to fungus with intracutaneous tests, while *Duchaine & Spapen* (27), Belgium, were able to establish 29 per cent fungal allergy using provocation tests in skin positive patients. There are many explanations for these wide discrepancies, as climatic variations, methods of preparing, preserving and administering the extract, patient-material and the choice of fungi for the intracutaneous and the provocation test.

The choice of fungi is undoubtedly of great importance in the study of fungus allergy; hence a knowledge of the fungi

present in the air and their seasonal and twentyfour-hourly variations must be investigated. Many investigations in this field have been made. *Durham* (28) and *Bernstein & Feinberg* (29) showed that *Alternaria* and *Cladosporium* are the most common fungi in America. *Hara & Durham* (30) showed that those fungi are just as common in Japan. *Durham* (31) showed that there are very few fungi in Alaska. In Madrid and Valencia the most common airborne fungi are *Cladosporium*, *Penicillium* and Yeast fungus (32). In Cardiff the most common fungi, during the summer months in particular are *Cladosporium*, *Pullularia pullulans*, *Alternaria*, *Botrytis* and *Epicoccum* and during the winter months *Aspergillus* and *Oospora* (33). In Copenhagen *Cladosporium*, *Pullularia pullulans* and *Penicillium* are the most usual (34), and the same is the case in Örebro, Sweden (26). These investigations relate to outdoor frequency scales. Several investigations have revealed a difference between fungi indoors and outdoors (26, 32, 34). Thus there is a higher concentration of *Penicillium* indoors than outdoors, while the indoor frequency of *Cladosporium* is lower than the outdoor frequency. In 1946 in Stockholm *Rennerfelt* (35) investigated the fungal spore content indoors and outdoors by putting out glass dishes with fungal media every 14 days. He found that *Cladosporium*, Yeast fungi and *Pullularia pullulans* were the most common fungi outdoors, while *Penicillium*, *Cladosporium* and Yeast fungi were the most common fungi indoors.

Various points of view have been put forward relating to the importance of using several different species from the same genera when selecting fungi for intracutaneous tests. Many investigations into cross reacting in fungal allergy have been made, but the results are not concurrent. In "Allergy in Practice" *Feinberg* states, "I am inclined to believe that it is a biological law that group specificity is the rule", and *Pratt & Roorbach* (36) have supported this hypothesis through experiments with four different *Alternaria* varieties. These experiments "indicated a common atopic excitent in the genus *Alternaria*". *Rackeman et alii* (37), after having described

three cases of allergy in garden workers, derived from hypersensitivity to *Cladosporium fulvum*, maintain that there is a species specificity concerning the antigen equipment for this fungus. They claim that this specificity also applies to other species of fungi. Many authors have claimed species-specificity in different fungi species (26, 38, 39, 40, 41). *Longbottom, Augustin & Hayward's* (42) gel diffusion test is further evidence of the existence of species-specificity, "...the predominant picture is one of great species differences".

Since it is not possible entirely to refute the idea of species-specificity, it is of considerable importance—before a fungus is selected for intracutaneous tests—to have some knowledge of which species of the same fungi exist in the air and also whether there is a great difference between the species in different places. Very few investigations have been made into establishing the species of different fungi. In 1958 *P. J. van der Werff* published a work (43) in which he reported in detail on the various species of fungi and their seasonal variations in different places indoors and outdoors in Holland.

The object of this paper, which is the first part in a study of mould allergy in Sweden, is to establish:

1. The frequency and seasonal variation of airborne fungi in Stockholm, Sweden, including the effects of temperature, humidity and weather conditions on the spore concentration.
2. The most common species of the different genera of the airborne fungi in Stockholm indoors and outdoors.
3. Whether there is any great difference in fungus spore content between different places.

METHODS

There are various methods for establishing the frequency and species of airborne fungal spores. Since it was desirable to identify as many species as possible of the fungi, the Petri dish method was chosen. In this method uncovered Petri dishes containing suitable media for fungi are exposed to the air for

a certain time. They are then covered and incubated for about one week at a temperature of 25–27° C. During this time the spores develop into colonies and can afterwards be specifically identified.

The ideal duration for the exposure of the Petri dishes was found to be half an hour in the investigation reported here.

Petri dishes 15 cm in diameter were exposed with tomato agar.¹ This was selected since it was desirable to use a medium relatively poor in nutriment. The sporulation starts quickly and the mycelium grows slowly, making it easy to count and identify the colonies. Certain fungi, i.e. Actinomycetes, which are close to the bacteria, prefer a more neutral medium than the one mentioned above, and in view of this, besides the tomato agar, Petri dishes with neutral malt agar were used.²

Petri dishes with tomato agar were exposed five days a week from 1st of February 1959 until the 1st of February 1960 between 11 a.m. and 11.30 a.m. at four different places indoors and two different places outdoors in Stockholm and its environs. Petri dishes with malt extract were exposed once a week in the same places and at the same time. The dishes were conveyed to the exposure points in sterilized paper wrappings. After exposure they were incubated for a week at 27° C. The colonies were identified microscopically and counted. Those colonies which had not developed spores on the medium after one week were transferred to other media such as oatmeal agar, Sabouraud agar, malt agar, Czapek agar and carrot, whereupon identification was carried out as soon as the fungi sporulated. Several of the fungi were sent to Centraalbureau voor Schimmelcultures in Baarn, Netherlands, for identification. No particular specification of Yeast fungi was carried out, since this would have required other techniques and equipment than those needed for ordinary mould fungi.

¹ Condensed tomato mash ...	100 g
Peptone	10 g
Agar	25 g
Aqua dest.	ad 1000 g
pH 4.5 adjusted with 1 n HCl	

² Malt extract	30 g
Agar	15 g
Aqua dest.	ad 1000 g
pH 7.0 adjusted with 1 n HCl	

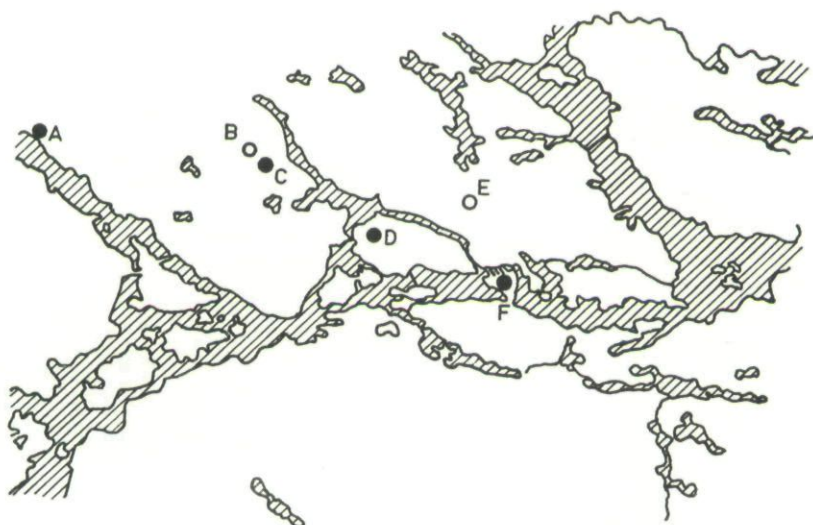


Fig. 1.

A map of Stockholm showing the six different exposure points.

● Exposure indoors.

○ Exposure outdoors.

The exposure points were selected so that three of them were in the centre of Stockholm and three were in the suburbs (Fig. 1). The dishes were exposed at the following places:

- A. *Indoors* in the home of a family in a new block of flats on Lake Mälaren.
- B. *Outdoors* on a balcony 50 feet up at the observatory at Bromma airport.
- C. *Indoors* in an industrial plant (500 m²) for the manufacture of steel constructions.
- D. *Indoors* in one of the offices at the St. Görans Hospital.
- E. *Outdoors* on Observatory Mount, a high point in the centre of Stockholm.
- F. *Indoors* in a flat with central heating in a 16th century building in the "Old Town" district of Stockholm.

A record was also kept of the weather, temperature and humidity conditions and also of any cleaning or repair work that might have been going on at the time of exposure.

*Total mould spore counts from 1st of Febr. 1959 to 1st of Febr. 1960
in relation to humidity, temperature, rain and snow.*

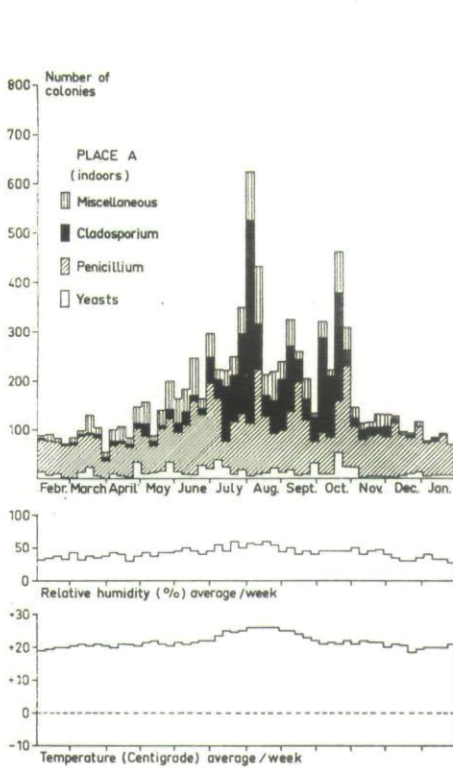


Fig. 2.

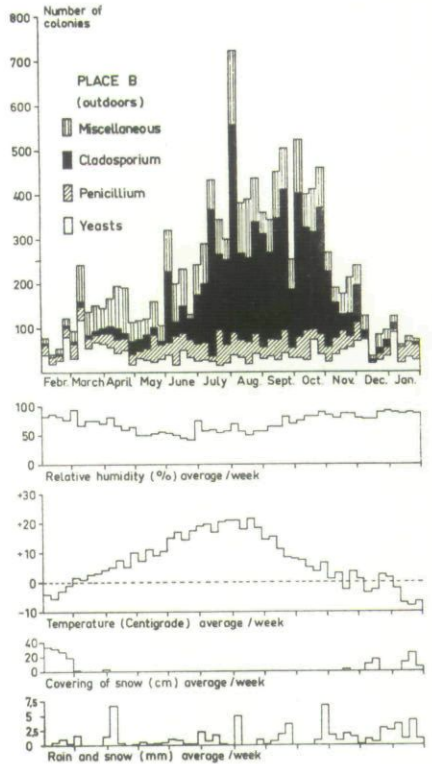


Fig. 3.

RESULTS

The variations in airborne fungal spores during the year in relation to weather, temperature and humidity conditions at six different exposure points are shown in Figures 2-7. It is evident that the number of spores varies greatly from day to day. In order to illustrate the general variations as clearly as possible the number of spores shown on the curves have been estimated on weekly basis, as has also the depth of snow and rain fall, the humidity and the temperature.

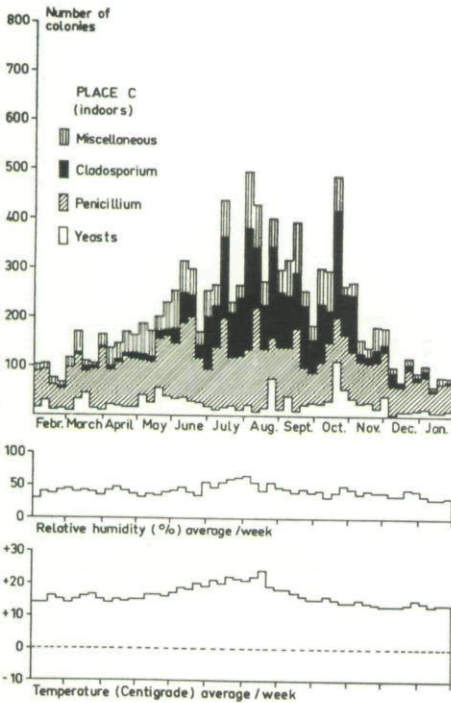


Fig. 4.

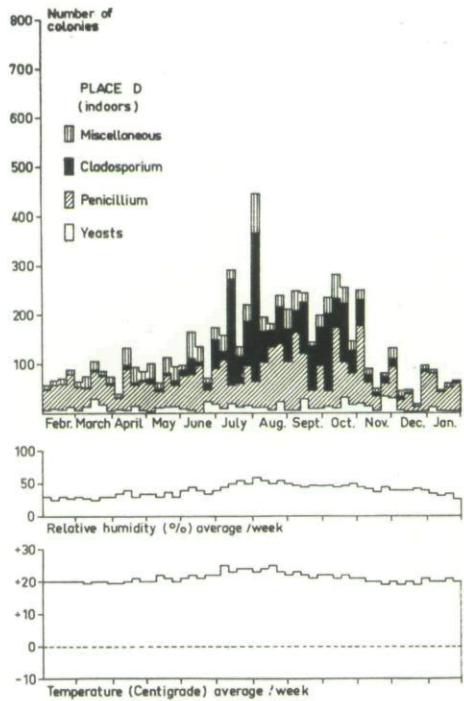


Fig. 5.

From Figures 2-7 it can be seen that there is a good correlation between the concentration peaks at the different exposure points. On the whole the spore concentration followed the changes in the weather throughout the year, both indoors and outdoors.

A comparison between the spore concentrations at the different points shows that the largest quantities were registered at the two points outside and at A and C, i.e. where there was most movements. At point F in the 16th century building there were very few spores in the air. This is probably because the flat is occupied by a quiet and orderly person.

The effect of weather, temperature, humidity, house cleaning and repair work on the mould spore concentration in the air is shown in Table 1.

*Total mould spore counts from 1st of Febr. 1959 to 1st of Febr. 1960
in relation to humidity, temperature, rain and snow.*

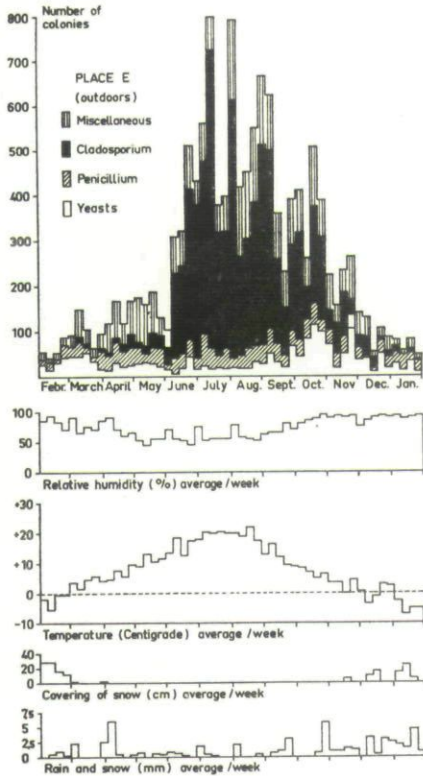


Fig. 6.

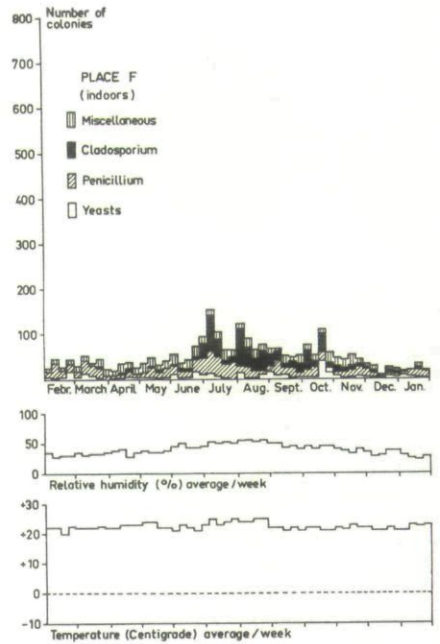


Fig. 7.

Cladosporium.

Cladosporium was the most common of the airborne fungi and appeared in great quantities outdoors (points B and E). In January and February when the ground was covered with snow only a few examples appeared on the plates, but at the beginning of March when the snow had melted and the temperature had begun to rise *Cladosporium* became more common. It was not until the beginning of June and a sudden increase in temperature, however, that *Cladosporium* began to appear in really large quantities. From now onwards until the

TABLE 1

The effect of weather, temperature, humidity, house cleaning and repair work on the mould spore concentration.

	Season	Mould spore concentration	
		(Indoors)	(Outdoors)
Cold weather	Winter	Decreased	Decreased
Warm weather	Summer	Increased	Increased
Dry weather	End of July	Decreased	Decreased
Snow	Feb. Dec. Jan.	Decreased	Decreased
Rain	April, end of June, first days of August,		
	November	Decreased	Decreased
Immediately after rain	Beginning of July, Beginning of August	Increased	Increased
Fall of the leaves	October	Increased	Increased
House cleaning		Increased	
Repair work	February (place F) June (place A)	Increased	
Humidity		No correlation	

beginning of November *Cladosporium* was predominant, particularly outdoors. The largest concentration could be registered during July and August but also during October when the leaves fell there was a high concentration. The *Cladosporium* concentration followed the weather changes closely both indoors and outdoors.

Cladosporium appeared almost exclusively as *Cladosporium herbarum* Link. ex. Fr. Only old colonies of *Cladosporium cladosporioides* (Fres.), *Cladosporium cucumerinum* Ell. et Arth., *Cladosporium elatum* (Harz) Nannf. and *Cladosporium sphearospermum* Penzig were registered. *Cladosporium cladosporioides* (Fres.) and *Cladosporium elatum* (Harz) Nannf. could be registered in relatively great quantities on certain days during the summer. No example of *Cladosporium fulvum* Cke. was registered.

Penicillium.

Penicillium was the second most common of the airborne fungi. Unlike *Cladosporium*, *Penicillium* was registered more

Monthly counts of *Cladosporium*, *Penicillium* and Yeasts
from 1st of Febr. 1959 to 1st of Febr. 1960.

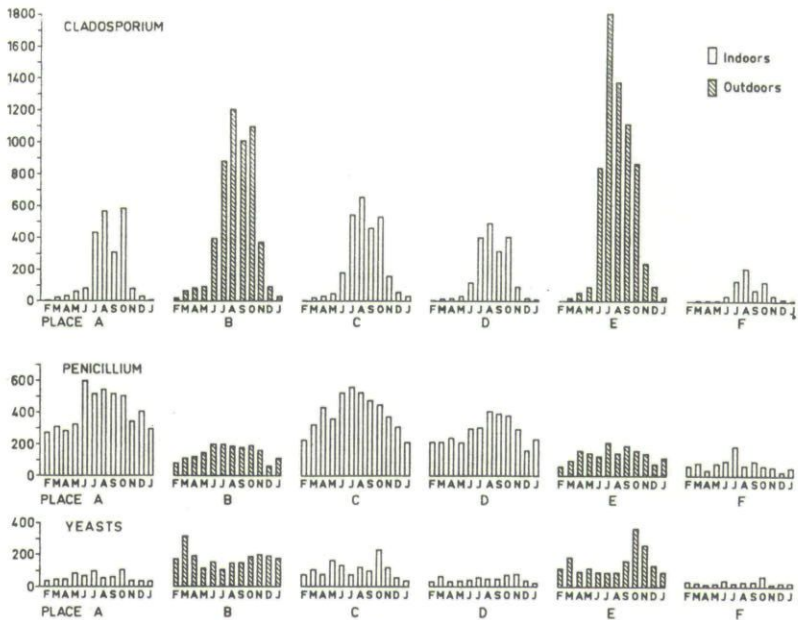


Fig. 8.

often indoors than outdoors. It was not subject to such a great seasonal variation as *Cladosporium*, though the concentration did increase somewhat during the warm periods. It was not dependent upon changes in the weather to the same extent as *Cladosporium*, neither was it possible to note any correlation between the variations in concentration at the different points. The number of *Penicillium* spores increased manifestly in connection with house cleaning and repair work. (place F: February, place A: June).

There were a great many *Penicillium* species at the different points, but some of these were particularly dominant. Several of the most common species at one point could often be found at the other points. *Penicillium waksmani* Zaleski, *Penicillium frequentans* Westl., *Penicillium notatum* Westl. and *Penicillium brevi-compactum* Dierckx were found at the same points in different concentrations. Certain *Penicillium* species domi-

Monthly counts of *Aspergillus*, *Botrytis* and *Mucorales*
from 1st of Febr. 1959 to 1st of Febr. 1960.

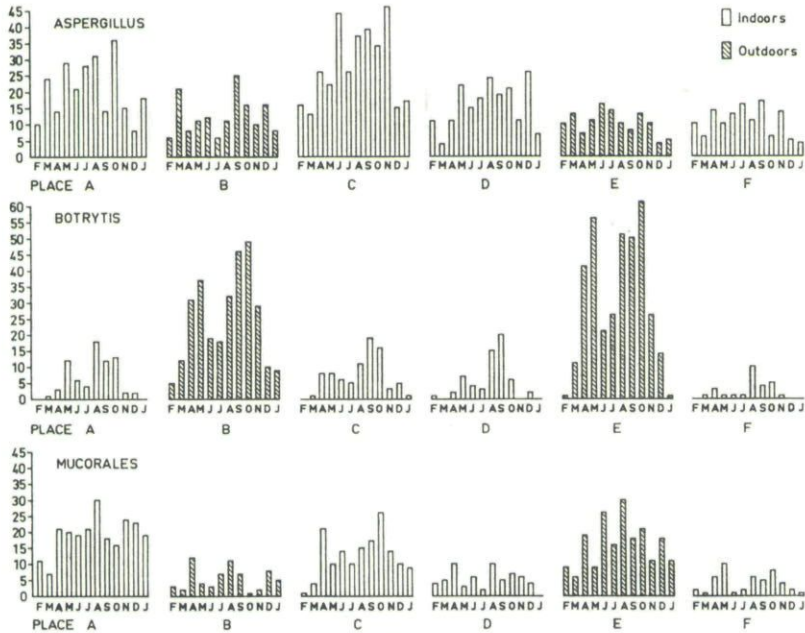


Fig. 9.

nated the others entirely. *Penicillium waksmani* Zaleski was found to the extent of about 40 per cent at point A and *Penicillium variable* Sopp to about the same extent at point C. Often the different *Penicillium* species appeared periodically. One species might appear in large quantities for one week, disappear almost entirely the following week and then after some days rest reappear in large quantities. This periodical occurrence was also characteristic for other fungi, such as *Monilia* and *Mucor*, which would appear in large quantities on certain days and then disappear from the plates altogether for long periods.

Yeasts.

Next to *Cladosporium* and *Penicillium* the Yeast fungi were most common. They appeared both indoors and outdoors but were much more common outdoors. They appeared all the

year round even when there was snow on the ground. The concentration of Yeast spores in the air varied greatly from place to place. The concentration was higher in the spring and autumn and lower during the summer months. As in the case of many of the other fungi, the Yeast fungi concentration decreased during rainy weather and then rose directly afterwards. The weather affected the Yeast fungi indoors too, although the variations in the weather were not as noticeable indoors as outdoors. The Yeast fungi appeared chiefly as *Cryptococcoideae* and *Rhodotoruloideae*. *Rhodotorula spec.* appeared at point A as 26 per cent of the Yeast fungi, B as 41 per cent, C as 33 per cent, D as 20 per cent, E as 28 per cent and F as 17 per cent of the Yeast fungi. No detailed determination of the Yeast fungi species has been undertaken.

Aspergillus.

Aspergillus appeared all the year round and relatively sporadically on the plates. Like *Penicillium*, *Aspergillus* was more common indoors than outdoors, but was much more rare than *Penicillium*. There were manifestly large variations in concentration from place to place and no real seasonable variations were observable.

Many different species of *Aspergillus* were found, but, as in the case of *Penicillium*, quite often the same species recurred at respective points. *Aspergillus repens* (Corda) de Bary, *Aspergillus versicolor* (Vuillemin) Tiraboschi, *Aspergillus terreus* Thom, *Aspergillus flavus* Link and *Aspergillus fumigatus* Fres. were common both indoors and outdoors.

Botrytis.

Botrytis was visible all the year round with a pronounced increase in concentration in spring and autumn. The concentration was particularly high in August, September and October. *Botrytis* was most common outdoors. On certain days it appeared in relatively large quantities, particularly after rain or during damp and cloudy weather. *Botrytis* appeared almost exclusively as *Botrytis cinerea* Pers.

Monthly counts of *Alternaria*, *Stemphylium* and *Fusarium*
from 1st of Febr. 1959 to 1st of Febr. 1960.

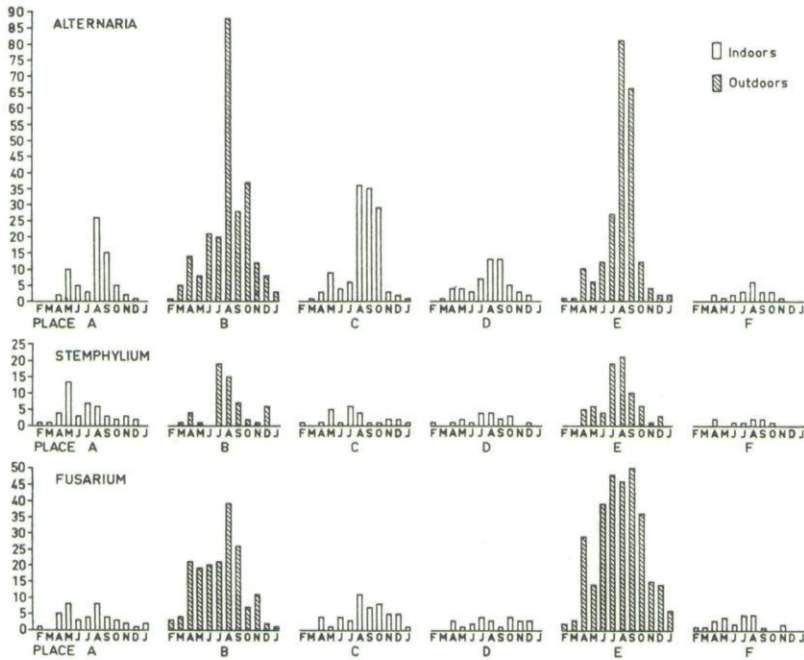


Fig. 10.

Mucorales.

Mucorales were to be seen all the year round. No special seasonal variations were visible, although there was a certain tendency to higher concentrations during the early and late summer. It was not possible to register any difference between the concentration of *Mucorales* indoors and outdoors. These fungi appeared most inside at point A, but were also common outside at point E. In the middle of August the *Mucorales* concentration increased visibly at all points following the heavy rain at the beginning of the month.

Mucorales appeared most as *Mucor* spec. and, as in the case of *Aspergillus* and *Penicillium*, the same species could be seen from time to time. The most usual of these were *Mucor hiemalis* Wehmer, *Mucor racemosus* Fres., *Mucor spinosus* van

*Monthly counts of Aleurisma, Epicoccum and Pullularia pullulans
from 1st of Febr. 1959 to 1st of Febr. 1960.*

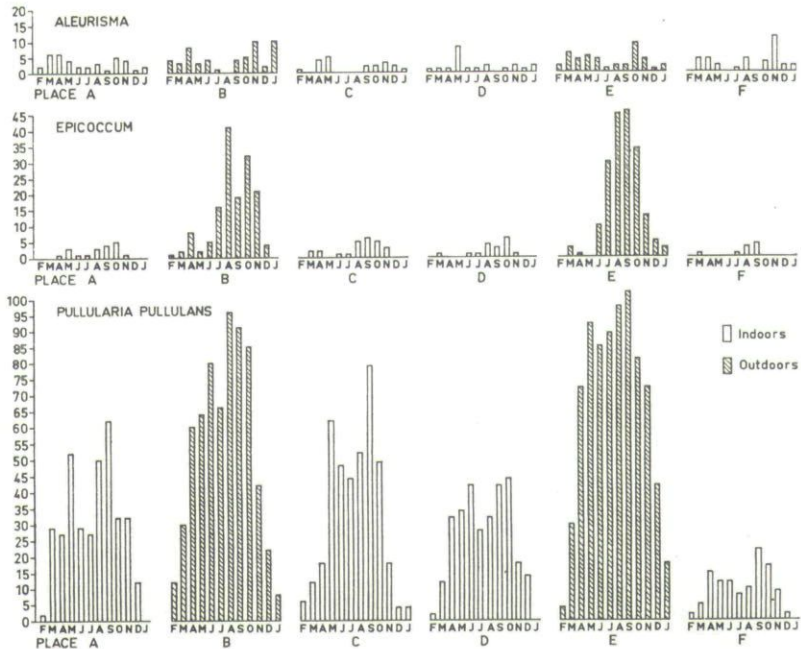


Fig. II.

Tieghem, *Mucor mucedo* (Linne) Brefeld. At point E there were relatively large quantities of *Syncephalastrum racemosum* (Cohn) Schroeter, *Rhizopus nigricans* Ehrenberg and *Mucor varians* Povah. Outdoors at both B and E there were a few colonies of Saprolegniales and Peronosporales.

Alternaria.

Alternaria varied distinctly according to the seasons and appeared more often outdoors than indoors. During the winter-time practically no *Alternaria* colonies were registered, but in April and May numerous colonies began to appear on the plates. In the middle of the summer the concentrations decreased somewhat, especially indoors. Suddenly in August and September numerous showers of *Alternaria* spores appeared

outdoors and on certain days the concentration of this fungus was greater than that of *Pullularia pullulans*. In November the concentration decreased rapidly.

Alternaria appeared almost exclusively as *Alternaria tenuis* Nees. A few colonies of *Alternaria geophila* Daszewska, *Alternaria humicola* Oud. and *Alternaria* (*Macrosporium*) *solani* J. et Gr. were registered.

Stemphylium.

Stemphylium appeared parallel with *Alternaria*. It was perhaps more widely distributed during the year, but was not so generally frequent. It appeared both indoors and outdoors, but like *Alternaria* it was more common outdoors.

The most common species were *Stemphylium consortiale* (Thüm.) Groves et Skolko (*Alternaria consortiale* (Thüm.) Groves et Hughes) and *Stemphylium piriforme* Bonorden.

Fusarium.

Fusarium, like most of the fungi, appeared chiefly during the warm months. The concentration increased in April and decreased again in November. In January, February, March and December only a few colonies were found. *Fusarium* spores were more common outdoors than indoors and were very common at point E, constituting 2.3 per cent of all the fungi there.

The most common was *Fusarium moniliforme* Sheld var. *subglutinans* Edw. which appeared at most points in various quantities.

Aleurisma.

Aleurisma appeared all the year round and in fairly large quantities even during the winter. There was no marked difference between the indoor and outdoor concentrations. At point F there were remarkably large quantities in comparison with other fungi.

Aleurisma appeared chiefly as *Aleurisma carnis* (Brooks and Hansford) Bisby.

Monthly counts of *Sphaeropsidales* and *Actinomycetes*
from 1st of Febr. 1959 to 1st of Febr. 1960.

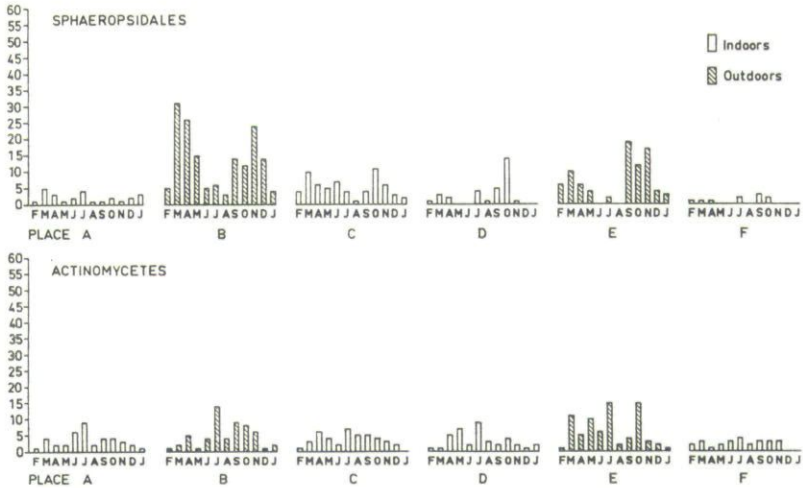


Fig. 12.

Epicoccum.

Epicoccum appeared in relatively high concentration outdoors during the late summer and autumn. Only occasional colonies were registered indoors.

Epicoccum appeared almost exclusively as *Epicoccum nigrum* Link.

Pullularia pullulans (= *Aureobasidium pullulans*
(de Bary) Arnaud).

Pullularia pullulans appeared profusely on the plates and was somewhat more common outdoors than indoors. The concentration increased during the warm part of the year and was highest at the beginning and end of the summer. In the middle of the summer, especially during the long dry period in July the concentration decreased slightly. Rain and sunshine seemed to be favorable growing conditions and the *Pullularia* concentration was particularly high during August and September when this type of weather was predominant.

Sphaeropsidales.

Sphaeropsidales appeared all the year round, but the concentration was particularly high during late winter and late autumn. Sphaeropsidales appeared particularly after rain or during damp and cloudy weather. There was a considerable parallel between the frequency of Yeast fungi and Sphaeropsidales. Sphaeropsidales was more common outdoors than indoors. It was particularly common at point B where it appeared in relatively large quantities during March and April.

Sphaeropsidales appeared chiefly as *Phoma* spec.

TABLE 2

Per cent of total number of colonies of airborne fungi found at six different places in Stockholm.

	In- doors A	Out- doors B	In- doors C	In- doors D	Out- doors E	In- doors F
<i>Cladosporium</i>	23.8	44.7	25.2	27.9	49.2	26.8
<i>Penicillium</i>	51.9	14.5	45.1	49.2	12.3	38.0
Yeasts	7.3	17.2	12.0	8.5	13.2	12.8
<i>Aspergillus</i>	2.7	1.2	3.1	2.8	0.9	5.3
<i>Botrytis</i>	0.8	2.5	0.8	0.9	2.7	1.2
Mucorales	2.5	0.5	1.4	0.9	1.5	1.6
<i>Alternaria</i>	0.8	2.0	1.2	0.8	1.7	0.9
<i>Stemphylium</i>	0.5	0.5	0.3	0.3	0.6	0.4
<i>Fusarium</i>	0.5	1.4	0.5	0.4	2.3	1.0
<i>Aleurisma</i>	0.4	0.5	0.2	0.3	0.3	1.4
<i>Epicoccum</i>	0.2	1.4	0.3	0.3	1.5	0.4
<i>Pullularia pullulans</i>	3.9	5.5	3.7	4.4	5.9	4.9
Sphaeropsidales	0.3	1.4	0.6	0.4	0.7	0.4
Other fungi	4.4	6.7	5.6	3.0	7.2	4.9

Actinomycetes.

As mentioned earlier, Actinomycetes were registered through the exposing of Petri dishes with neutral malt agar once a week. Actinomycetes developed very slowly into colonies and thus no readings were taken from the plates until after 12-14 days. Actinomycetes appeared to a fair degree throughout the year and was possibly somewhat commoner outdoors. But as

in the case of the other fungi the Actinomycetes concentration diminished during the winter months. Remarkably high concentrations were registered, however, indoors at point D. No detailed determination of Actinomycetes has been undertaken.

Other fungi.

These include numerous less common fungi. It also includes Basidiomycetes, Mycelia sterilia and others that are undetermined. The term undetermined in fact includes Mycelia sterilia since it is possible that certain of these fungi belong to Phycomycetes, Fungi imperfecti or Basidiomycetes, even though they did not sporulate in different media during the time of observation. Mycelia sterilia and undetermined made up 3.5 per cent at point A, 5.8 per cent at point B, 4.3 per cent at point C, 2.8 per cent at Point D, 6.3 per cent at point E, 2.9 per cent at point F.

CONCLUSIONS AND DISCUSSION

A. The spore concentration

- I. rose both outdoors and indoors
 - a) during warm and sunny but not too dry weather
 - b) after rain during the warm season
 - c) during the fall of the leaves
- II. sank both outdoors and indoors
 - a) during the winter
 - b) during rain and snow
 - c) during too dry weather
- III. was largest outdoors and next where there was most movements
- IV. was not correlated to the humidity
- V. rose during house cleaning and repair work
- VI. followed the weather variations especially outdoors but also indoors.

B. The seasonal variation of the fungal spores showed a good agreement as between the different exposure points

- I. Cladosporium, Alternaria, Stemphylium, Fusarium and Epicoccum rose in the summer

- II. *Botrytis*, *Pullularia pullulans* and *Sphaeropsidales* had two concentration peaks, one in the spring and one in the autumn
- III. *Penicillium*, *Aspergillus*, *Mucorales*, *Aleurisma*, Yeast fungus and *Actinomycetes* were not subject to any seasonal variation.
- C. Each place of exposure had its own typical fungus flora, but those fungi which were very common at one place could often be found at the other exposure points.

It was found that the most common fungi outdoors were *Cladosporium*, *Penicillium*, Yeast fungi and *Pullularia pullulans*, in this order. These fungi were also the most common indoors, but here *Penicillium* appeared in greater concentration than *Cladosporium* and *Pullularia pullulans* and Yeast fungi were less plentiful than they were outdoors. The results of these investigations are in accordance with the results from other places in Europe (26, 32, 34, 35, 43, 44). From *Durham's* (28), *Bernstein & Feinberg's* (29) and *Targow & Plunkett's* (45) investigations from America it would seem that *Alternaria* does not appear in such high concentration here as it does in America.

In the matter of seasonal variations of the fungal spores there has been found to be a fair degree of similarity at different places in Europe and America but the concentration peaks are, nevertheless, dependent upon climatic factors and they thus vary from country to country.

A comparison between the most common fungi species in Sweden, Holland and America (43, 46, 47) shows that several of the most common species in Stockholm are often relatively common also in these places, but there are also differences i.e. *Penicillium expansum* (Link) Thom and *Aspergillus ochraceus* Wilhelm was not so common in Stockholm as in Holland.

TABLE 3
Numbers and names of the colonies of the airborne fungi found at six different places in Stockholm from the 1st of February 1959 to the 1st of February 1960.

	A		B		C		D		E		F	
	Indoors	Number	Outdoors	Number	Indoors	Number	Indoors	Number	Outdoors	Number	Indoors	Number
<i>Phycomycetes</i>												
A. Mucorales												
1. Mucoraceae												
Absidia glauca Hagem					2				4			
Absidia lichtheimi (Luc. and Cost. Lendner)	7				4		2			2		4
Circinella spec.												
Mucor spec.	171		45		106		36		93			23
The most common are:												
Mucor dispersus Hagem											IV	
Mucor fragilis Bainer			III									
Mucor hiemalis Wehmer	I		I		II						III	
Mucor mucedo (Linne) Brefeld	IV				I				IV			
Mucor racemosus Fres.			II		III		I		II		II	
Mucor spheerosporus Hagem	III				IV		II		III		I	
Mucor spinosus van Tieghem	II											
Mucor varians Povah							III		I			
Rhizopus arrhizus Fischer												I
Rhizopus nigricans Ehrenberg	18			6	39		14		19			8
Zygorhynchus heterogamus Vuillemin									2			
Zygorhynchus moelleri Vuillemin	5								2			

TABLE 3 (cont.)

	A		B		C		D		E		F	
	Indoors	Order	Indoors	Order	Indoors	Order	Indoors	Order	Indoors	Order	Indoors	Order
B. Melanconiales												
i. Melanconiaceae												
<i>Pestalotiopsis westerdijkii</i> Steyert												
C. Mucedinales												
i. Mucedinaceae												
<i>Aleurisma carnis</i> (Brooks and Hansford Bisby)	38		54		20		21		41		33	
<i>Aspergillus</i> spec.	248		150		335		189		121		125	
The most common are:												
<i>Aspergillus candidus</i> Link.					IV						V	
<i>Aspergillus clavatus</i> Desm.											III	
<i>Aspergillus flavus</i> Link.	IV					III		I				
<i>Aspergillus fumigatus</i> Fres.	V				III	VI						
<i>Aspergillus nidulans</i> (Eidam) Winter						V						
<i>Aspergillus niger</i> van Tieghem												
<i>Aspergillus ochraceus</i> Wilhelm			III					II			I	
<i>Aspergillus repens</i> (Corda) de Bary	II		IV		I	IV		IV			II	
<i>Aspergillus terreus</i> Thom	I		V			I		III			IV	
<i>Aspergillus versicolor</i> (Vuillemin)												
<i>Tiraboschi</i>	III		II		II	II		V				
<i>Botrytis</i> spec.	73		297		83		60		359		27	
The most common are:												
<i>Botrytis cinerea</i> Pers.	Ia		Ia		Ia	Ia	Ia	Ia	Ia		Ia	

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TABLE 3 (cont.)

	A Indoors		B Outdoors		C Indoors		D Indoors		E Outdoors		F Indoors	
	Order	Num- ber	Order	Num- ber	Order	Num- ber	Order	Num- ber	Order	Num- ber	Order	Num- ber
The most common are:												
Alternaria tenuis Nees	Ia	2191	Ia	5391	Ia	2679	Ia	1897	Ia	6577	Ia	632
Alternaria geophila Daszewska	II		II		II		II		III		II	
Alternaria humicola Oud.			IV		IV		II		II		III	
Alternaria solani J. et Gr.			III						IV			
Cladosporium spec.												
The most common are:												
Cladosporium herbarum Link ex. Fr.	Ia		Ia		Ia		Ia		Ia		Ia	
Cladosporium cladosporioides Fres.	II		II		II		II		II		II	
Cladosporium cucumerinum Ell. et Arth.			IV		IV		IV		IV		II	
Cladosporium elatum (Harz) Nannf.	III		III		III		III		III			
Cladosporium sphaerospermum			V		V				V			
Penzig.												
Curvularia lunata (Walker) Boedijn				10		6				8		3
Dicoccum asperum (Cda.) Lindau				8		3						2
Gliomastix convoluta (Harz) Mason				12		11						2
Helminthosporium spec.												11
Nigrospora sphaerica (Saccardo) Mason		8										2
Papularia sphaerosperma (Pers) v. Höhn				24				7		21		3
Phialophora spec.						5						10
Polythrincium trifolii Schm. et Kze.				5		2						784
Pullularia pullulans (de Bary) Berkh.		354		656		396		300				114

SUMMARY

Methods for collection, identification and frequency determination of fungal spores in the air in Stockholm and environs between 1st of February 1959 and 1st of February 1960 are described.

Effects on the airborne fungi of weather, temperature, humidity, repair work and house cleaning were studied and it was found:

- 1) that the frequency of certain airborne fungi varies according to the season
- 2) that the concentration of airborne fungi depend on temperature and weather conditions both indoors and outdoors
- 3) that there is no correlation between the concentration of airborne fungi and humidity
- 4) that the concentration of airborne fungi is largest outdoors and where there is most movements
- 5) that the concentration of airborne fungi depends on repair work and house cleaning
- 6) that certain fungi are more usual indoors, others more usual outdoors
- 7) that each exposure point has its own typical fungus flora but that those fungi which are very common at one place are often to be found at others.

This investigation has been supported by very generous grants from the Swedish National Association against Heart and Chest Diseases.

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