

Aerobiological studies based in Derby

II. Simultaneous pollen and spore sampling at eight sites within a 60 km radius

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Summary

In order to determine whether a sampling site in the centre of Derby, where air sampling had been carried out for five summers, really provided valid aerobiological data for the surrounding area, eight identical volumetric spore traps were operated simultaneously during the summer of 1969 at various sites up to 56 km from Derby. For most pollen and spore types, total numbers and seasonal pattern at all the sampling sites were found to be similar, although a few extreme and unexpected variations were noted. Figures varied somewhat in different types of site, and local effects are emphasized.

Introduction

In order to give the clinician more knowledge of the local air spora, continuous air sampling has been carried out on the roof of the Derby Chest and Allergy Clinic between late February and early December for the past 9 years. The daily counts per m³ for the major allergenic pollens and spores are directed towards indicating the seasonal allergens causing symptoms in patients attending the Clinic, who keep daily symptom and treatment charts, and some who are also recording their peak expiratory flow rates three or four times daily.

The many comparative aerobiological surveys carried out in Britain using the Hirst automatic volumetric spore trap (Hirst, 1952), both across the country (Davies, Denny & Newton, 1963) and more localized investigations (Hamilton, 1959; Adams, Hyde & Williams, 1968; Harvey & Mullins, 1975), have shown the same general picture of the air spora with considerable quantitative differences between rural and urban sites, inland as compared with coastal sites, and between mountain and lowland areas. The same spore and pollen types dominate the catch, and their phenology seems similar throughout southern Britain. Earlier work using the 'gravity' slide technique (Hyde, 1952, 1956, 1959) also indicated a variation in pollen incidence over Britain.

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Considerable differences have also been found between closely adjacent sites, very local conditions exerting a marked effect on the air spora (Lacey, 1962).

An urban sampling site has certain advantages for the study of airborne allergens, as it is isolated from most local sources and provides a reasonably representative picture of the air spora over a wide area. If the trapping site is at roof-top level counts are less affected by local turbulence, sedimentation and convection within a city (Davies, 1969, Gregory, 1967).

The previous investigations quoted above suggest that the pollen and spore counts obtained from a single spore trap on a roof in the city centre might be an unreliable guide to aerobiological conditions in the surrounding countryside, in which many of our patients live. The only way to define the extent of local variation is to operate a number of identical spore traps simultaneously, and eight were set up within 60 km of Derby.

Materials and methods

'Morrow Brown' spore traps were installed at each of the eight sampling stations, four using slides coated with petroleum jelly, the other four being fitted with rotating drums, which would run unattended for 7 days. The important constructional details of all traps were identical (Brown & Jackson, 1978). Where the trap could be attended to daily, the slide-type trap was used, and the slides posted back to the laboratory. The drum-type traps were visited once a week in order to replace the drums. The strips of plastic, coated with petroleum jelly, were removed from the exposed drums, cut into lengths corresponding to 24 hr periods, placed on slides and mounted. Slides were mounted and stained as previously described: the use of cotton blue stain helping greatly in counting small spores. To estimate spore counts a single longitudinal scan 200 μm wide was counted using a $\times 50$ Fluorite oil immersion objective, with a $\times 10$ eye piece giving a total magnification of $\times 500$. The count for each spore type multiplied by five gave the average spore concentration per cubic m^3 of air over the 24 hr period. For pollens $4 \times 250 \mu\text{m}$ strips were scanned, this figure giving directly the number of pollen grains per m^3 of air.

The sampling period was from June to October, but complete records were not obtained from all sites due to occasional pump breakdowns and other mishaps. Rain-fall information was obtained from the Meteorological Office weather stations nearest to the trapping sites; weather records were also kept at the Chest Clinic. The sampling rate of 10 l/min was checked and adjusted daily at all stations.

The trapping sites and distances from Derby are described in Table 1. These locations had to be determined by practical considerations rather than the ideal nature of the site, many being in the gardens of patients or medical practitioners. The locations are shown in Fig. 1.

Results

Examples of the daily counts per m^3 of air from midnight to midnight are presented as histograms in Figs 2 to 4, and similar histograms for other predominant pollen and spore types are available from the authors. Gaps in the record made close comparisons difficult in some cases, but for most spore types an overall similarity in seasonal pattern was shown. Similarity was evident between peak concentrations at different sampling sites, but while the correlation was remarkably good for some spores, peak concentrations occurring on the same day, there were very great differences in others.

Table 1. Sampling sites

Location	Distance from Derby (km) and direction	Height above sea level (m)	Nature of site	Sampling height above ground (m)	Nature of surrounding area
Derby	—	60	Roof of Chest Clinic	10	Town—open country with farmland 5.0 km from trapping site; 1.0–2.0 km to east is large area of grassland, wasteland and farmland
Ashby (Blackfordby, Leicestershire)	19 S	110	Garden in small village (nettle patch 3.0 m away over fence)	1.0	Rural, good agricultural land (arable and dairying); Ashby (small town) 2.0 km to SE, built up area of Swadlincote 3.0 km to NW
Birmingham	56 SW	60	Grounds of Dudley Road Hospital; little open space nearby	1.0	City. Small area of open country 3.0 km to NW (farm, golf courses). Otherwise surrounded by built up area for between 8.0 and 21 km
Church Broughton, Derbyshire	14 W	90	Garden in village	1.0	Rural, good deal of grassland; Dove valley about 4.0 km to S
Critch, Derbyshire	21 N	300	Garden in village, surrounded by new houses	1.0	Upland rural; mixed farmland and moorland. Derwent valley, wooded, about 2 km to W and SW
Hartington, Derbyshire	29 NW	300	Garden in village	0.5	Upland rural; rough grassland, moorland
Attenborough, Nottinghamshire	16 E	45	Garden surrounded by mature gardens with trees	0.5	Suburban/industrial; gravel pits and River Trent about 1.0 km to SE
Sutton Bonnington, Nottinghamshire	19 SE	60	Beside veterinary laboratory, School of Agriculture	1.0	Rural; mixed farmland. River Soar about 1.0 km to W

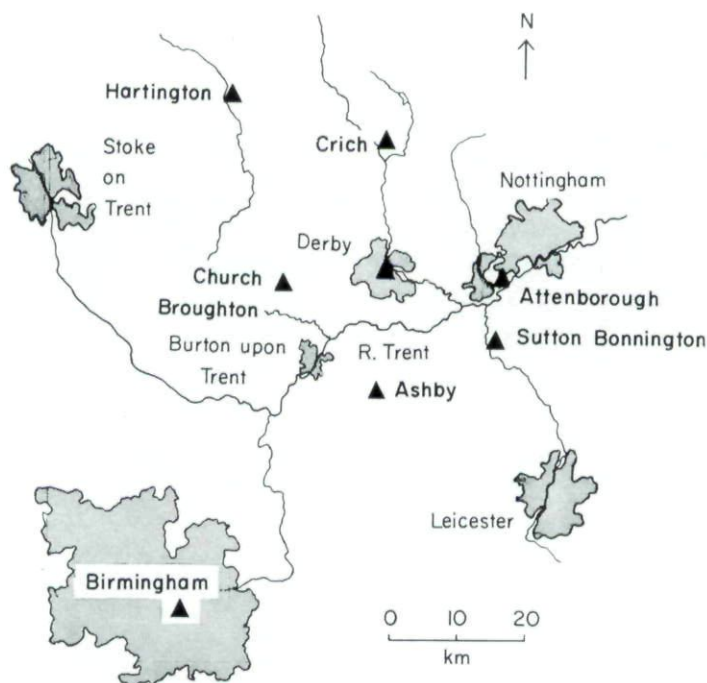


Fig. 1. Map showing location of spore traps in 1969. (▲) Sampling sites; shaded areas show urban areas.

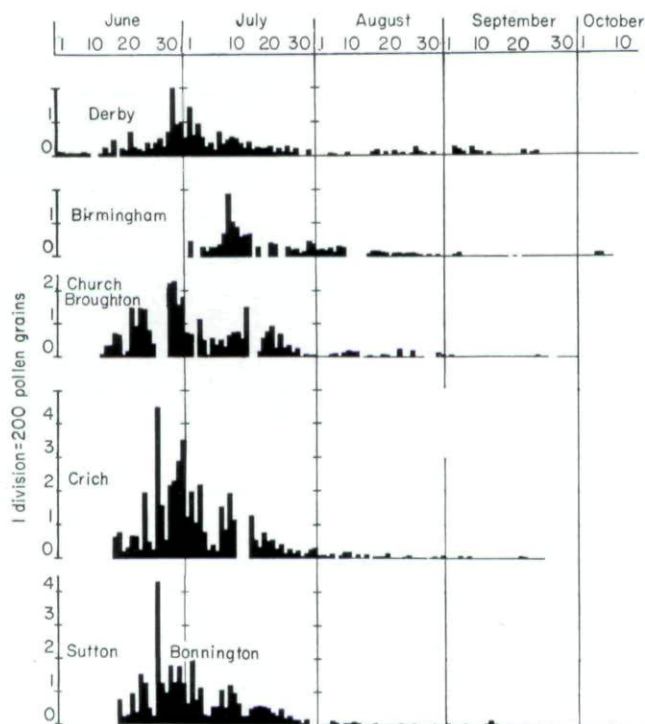


Fig. 2. Daily grass pollen counts (average concentration per m^3) from the eight sampling sites in 1969. No baseline denotes no observations made.

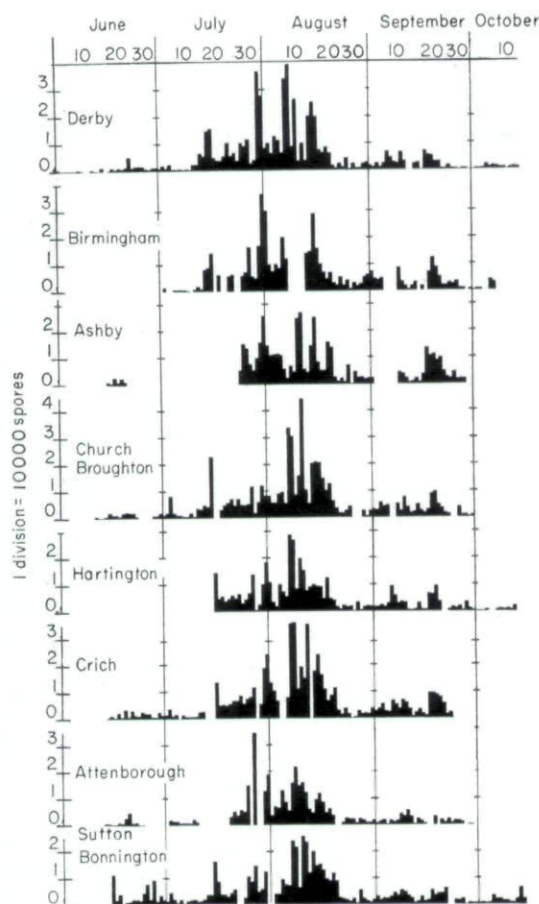


Fig. 3. Daily counts per m^3 of *Cladosporium* from the eight sampling sites in 1969. No baseline denotes no observations made.

Percentages in the following comments refer to comparison with counts at the Derby station.

Pollens

It was unfortunate that the traps at Ashby, Hartington and Attenborough were not operating during the peak period, and loss of record at other sites make a proper comparison of grass pollen counts (Fig. 2) possible only between three stations: Derby, Crich and Sutton Bonnington. A reasonable similarity is apparent between the catches at Crich and Sutton Bonnington (33 km apart), the daily average figures over the peak season at Crich and Sutton Bonnington being about 220% and 170% respectively of the Derby figure, but day to day correlation with Derby is poor at all stations.

Nettle pollen shows virtually no correlation between sites. In Derby there was no clear nettle pollen season in 1969, whereas in subsequent years numbers have been higher and a definite peak noticed, varying somewhat, but generally in June/July. Average numbers at Church Broughton and Crich (rural areas) were 300% and 320% respectively of the Derby average.

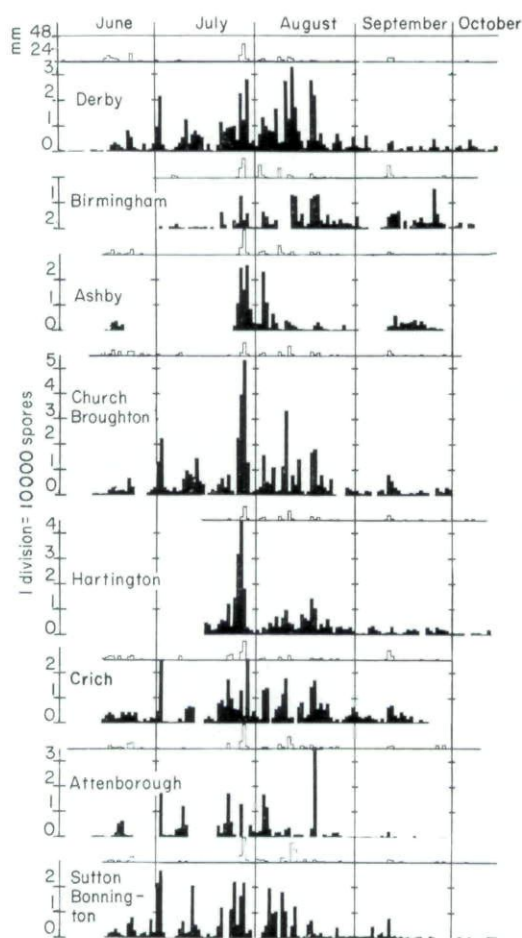


Fig. 4. Daily counts per m^3 of *Sporobolomyces* from the eight sampling sites, in 1969. White bars show rainfall. No baseline denotes no observations made.

Fungal spores

Cladosporium. Daily counts and incidence over the season were very similar at all stations (Fig. 3); both major and minor peaks being represented at most stations, ranging from 125% of the Derby figure (Crich) to 83% (Hartington).

Sporobolomyces. The seasonal incidence was similar at all stations (Fig. 4); this, and to a lesser extent the numbers, varying somewhat from station to station. Peak numbers occurred at most stations on July 27–29, correlated with heavy rain at all stations on July 28. Numbers were higher at Derby than at any of the other sites, although the average figure at Church Broughton approached this (95%). At Birmingham and Attenborough the figures were approximately half that at Derby (49% and 45% respectively).

Tilletiopsis. Highest numbers occurred at most stations in late July and August. Peak counts occurred at around August 10 and August 20 at Derby, Birmingham, Church Broughton and Hartington; at Crich the later peak only was represented. At the other stations the seasonal pattern was less clear-cut but smaller peaks in September were represented at most sites. The average daily figures over the peak season at

Attenborough was 2% of that at Derby. Counts at all other stations were lower than at Derby, e.g. 39% at Birmingham, 28% at Church Broughton and Sutton Bonnington, and 47% at Hartington and Crich.

Botrytis. Reasonably good correlation was obtained between all stations in numbers and seasonal incidence, a peak in mid-August occurring at all stations except Ashby, where a similar peak occurred a week later. High counts were also recorded at all stations during the third week in September. Maximum numbers occurred at most stations during this period. Average daily counts per m^3 varied between 85% (Hartington) and 25% (Ashby) of the Derby figure.

Alternaria. Similar numbers occurred at all sites and the seasonal incidence was similar. The period of peak counts was in August at all stations except Church Broughton, and further peaks in early and late September were represented at most sites. Highest counts generally occurred on August 7–8 and September 19–20. Average

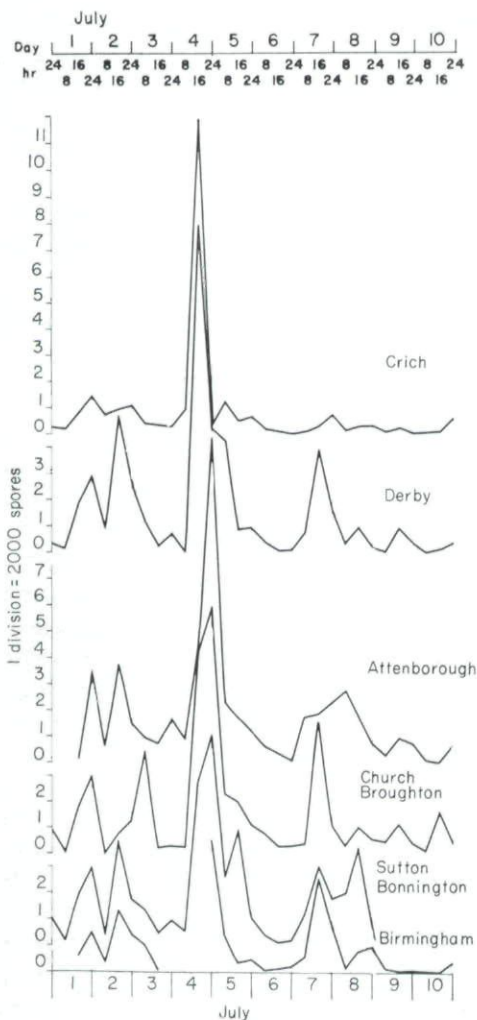


Fig. 5. 8 hourly concentrations per m^3 of *Ustilago* over the period July 1 to 10 for six of the sampling sites, in 1969.

numbers at Sutton Bonnington were about the same as at Derby (102%), with considerably lower numbers (54% and 60%) at Hartington and Attenborough.

Leptosphaeria. A similar pattern was found between sites in the incidence of this spore, maximum numbers being recorded in mid-August and mid-September. High counts occurred on isolated days, for instance on September 17 at Derby and August 13 and 18 and September 11 at Sutton Bonnington. The daily average at Sutton Bonnington was 135% of that at Derby; at Attenborough and Hartington it was around 60%.

Ustilago. Maximum concentrations occurred on July 4 at all six stations in operation. The peak season was the same at all stations, covering the period mid-June to Mid-July. Fig. 5 shows mean 8 hourly concentrations of *Ustilago* (00.00 to 08.00, 08.00 to 16.00, 16.00 to 24.00 hours) over the period July 1 to 10, indicating the similarity of timing of the peak counts between stations. The highest daily average figure for this spore was at Attenborough (about twice the Derby figure for the short period when the trap was operating). At Sutton Bonnington the average was 134% of the Derby figure and at Crich 68%.

Basidiospores. Coloured basidiospores, excluding *Ganoderma*, showed a broadly similar pattern at all stations, numbers increasing sharply in early August and high counts occurring at most stations during August and in late September. At Sutton Bonnington the September peak was absent.

Aspergillaceae. No seasonal pattern was exhibited by this group (*Aspergillus*, *Penicillium* and related genera) during this period studied, and no correlation between stations was observed. High counts occurred on isolated days at many stations.

Discussion

Pollen

The importance of the contribution of the local flora to the pollen count was shown by Hyde (1950, 1952, 1959), who concluded that the pollen catch at any site is mostly of local origin. For instance, he found the grass pollen catch in an uncut meadow near Chesterfield, Derbyshire, was 180% of the figure obtained in the centre of Cardiff, whereas that from a mountain site in Wales was only 15% of the Cardiff figure. Similar variations in numbers occurred with weed pollen. In our investigation, grass pollen concentrations were higher in the rural sites with a good deal of grassland close by. It would seem that for both grass and nettle pollen the timing of the release of pollen from sources within a few km is very important, as day to day correlation between sites is poor. Hay cutting in the immediate vicinity must also have an obvious effect, but we could not monitor agricultural activity.

Fungal spores

The spores of fungi characteristic of arable land and grassland—such as *Alternaria*, *Erysiphe*, *Leptosphaeria*, *Ustilago*, *Cladosporium* and *Sporobolomyces*—may be expected to occur in higher concentrations at rural sites close to farmland than in urban areas, but in this survey this was not always so. Counts of many types of spore were unexpectedly high in Derby, possibly explained by the fact that the central trapping site in Derby is surrounded by farmland at a distance of only about 5.0 km. Grassland tends to be dominant to the north of Derby, and arable farmland to the south. In Birmingham, counts of spores were mostly lower than in Derby, although

counts of *Botrytis* and basidiospores were higher. Spore numbers at Attenborough, a suburb at the edge of the large urban area of Nottingham, were unexpectedly low in view of the closeness of the site to the grassland, scrub and woodland alongside the River Trent and flooded gravel pits, yet in the case of *Ustilago*, numbers were about twice those in Derby.

At Hartington, a moorland site surrounded mostly by rough grazing land, spore numbers were again fairly low, although basidiospores were relatively abundant.

Our finding that *Cladosporium* numbers were very similar at all stations is not in agreement with other surveys. Richards (1956) showed by a culture plate survey that the numbers of *Cladosporium* were closely related to nearness to open country, particularly cereal crops. Harvey (1967) confirmed this, finding that annual totals of *Cladosporium* obtained in the centre of Cardiff were generally 30–55% of those at a more rural site 2 miles away. Harvey & Mullins (1975) obtained higher counts of *Cladosporium* from arable land than in central Cardiff. Possibly suitable substrates for the growth of *Cladosporium* were abundant near the two trapping sites. Davies *et al.* (1963) have shown that the parks of central London are an important source of this spore, possibly due to the colonization of moribund mown grass.

The high counts of *Sporobolomyces* and *Tilletiopsis* obtained in Derby are surprising in view of the fact that these fungi grow on the surface of leaves. Harvey & Mullins (1975) report lower numbers of *Sporobolomyces* and *Tilletiopsis* in central Cardiff than in arable land 14 km away. The very low counts of *Tilletiopsis* at Attenborough as compared with Derby are also unexpected. Further investigations would seem desirable because Pawsey (1964) obtained low counts of 'hyaline basidiospores', including *Sporobolomyces*, at Nottingham University, 4.0 km from the Attenborough site, in 1956. Counts of *Sporobolomyces* spores were fairly low in Birmingham, as might be expected, but *Tilletiopsis* figures were relatively high compared with the rural sites.

Counts of *Leptosphaeria* and *Ustilago* have tended in this survey to be determined by proximity to arable farmland, although the high peak of *Ustilago* concentration at Attenborough is unexpected. *Alternaria* did not show this tendency and at Sutton Bonnington, surrounded by cereal crops, the average number was about equal to that at Derby.

Spores of *Botrytis*, a common saprophyte and parasite found on a wide variety of plants, occurred at all sites in numbers higher than, or similar to, those of Derby.

No woodland site has been included in this survey. Woodland is in fact poorly represented in Derbyshire (5.5% of the county is wooded, the national average being 8%), but there are many trees in the city.

The site nearest to a large area of woodland was Crich, but no increase in basidio-spore numbers, as expected from the work of Adams *et al.* (1968) and Harvey & Mullins (1975) was noted here; the wooded area was possibly too far away to exert any noticeable effect.

The precise nature of the sampling site and its local flora is of great importance, as shown for instance by Lacey (1962) at Rothamsted, Herts, and Long & Kramer (1972) in Kansas (U.S.A.). Lacey compared the air spora in a valley near a stream with that of an exposed site 600 m away, and 2.5 times more spores were trapped at the site near the stream and the proportions of spore types differed at the two sites. More grass and 'weed' pollen were found at the lower site, a local area of nettles probably accounting for the much higher nettle pollen count. This work illustrates the difficulty,

or indeed impossibility, of choosing a site truly representative of the surrounding area, which would apply to all the sites used in the survey described by us.

This study has shown that counts taken on the roof of the Clinic in Derby can only provide a rough idea of the daily variations in spore numbers elsewhere in the area, so that the symptoms diary of a patient living out in the country can only give an approximate guide to the likeliest sensitivities. Our results do suggest, however, that for certain spores such as *Cladosporium*, *Ustilago* and *Alternaria*, the day to day fluctuations observed in the centre of Derby could be taken as representative of those throughout the area. In the case of most of the other spores and pollens, broad similarities have been shown throughout the area surveyed, together with some idea of the variations to be expected in different situations. Thus with certain exceptions comparison of patients' symptoms diaries with the central Derby figures should help in indicating the most likely allergens. However, diagnosis is complicated by many factors, including an individual patient's degree of sensitivity, daily activities, drugs taken and the fact that many different types of spore often show a rapid rise in numbers on the same day, in response to a sudden change in weather conditions.

Weekly average counts or running means have not been used, as we have found that patients' symptoms as recorded by them are closely related to sudden peaks of pollen or spore counts, especially at the beginning of a seasonal rise. Outbursts of fungal spores may occur on certain days providing a useful pointer to the correct allergens when symptoms peak on these key dates. Even if several spore types reach a peak on the same day the suspects can be narrowed down, and the number of confirmatory provocation tests limited.

The availability of aerobiological data at this clinic for the past 9 years has not only proved helpful in allergen diagnosis, but has enabled us to study our patients from a position of understanding and interest which would otherwise be impossible. Without this information the allergist is severely handicapped.

By running a number of spore traps in a relatively small area of the country, to our knowledge the first time so many volumetric spore traps have been simultaneously operated in this way, valuable information has been gained about the variations in spore and pollen content of the air over this area.

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