

From the Nasal Allergy Clinic, Kings College Hospital, London

THE SEASONAL VARIATIONS OF ALLERGIC
BRONCHIAL ASTHMA IN RELATION TO THE
CONCENTRATION OF POLLEN AND FUNGAL
SPORES IN THE AIR IN 1954, 1955 AND 1956

A Report to the Geoffrey E. Duveen Trust

By

KATE MAUNSELL M.D. (KIEL) L.R.C.P., M.R.C.S.

INTRODUCTION

During the last decade a great number of surveys of air-borne particles have been published. In England systematic work on pollen and fungal spores has been carried out by Hyde (1949, 1950, 1952, 1955 and 1956), Hyde and Williams (1945, 1946, 1949), Hyde, Richards and Williams (1956), and Richards (1954, 1956). The relation of respiratory allergy to pollen has been established and attention has been drawn to the influence of air-borne fungal spores. Further information was needed on a controlled comparison of the seasonal fluctuations of respiratory allergy and fungal spores. Such an approach seemed reasonable since the development of the "Hirst spore trap" (Hirst 1952) allowed for the first time quantitative sampling of air-borne particles over prolonged periods. Consequently a survey was started in 1954 in collaboration with Professor P. H. Gregory, and Dr. E. Hamilton. It was intended to see whether peak periods of allergic respiratory attacks coincided with peak concentrations of air-borne particles and special attention was given to the causes of asth-

ma in July and August. All aerobiological data for 1954 and 1955 are based on E. Hamilton (1957).

CLINICAL MATERIAL

The patients included in this survey came from South London and the southern suburban areas and suffered from allergic bronchial asthma. They gave positive skin reactions to one or more inhalants of the main groups of allergens, pollens, moulds, house dust and related substances. Patients with negative skin tests although they might have been allergic cases were excluded from the survey. All patients were tested for pollen sensitivity and a sub-group of pollen positive cases was formed. The patients were also tested for mould allergy but further sub-division of these cases did not seem practical.

The observation period for each patient was from 16th May to 25th September, 19 weeks, during 1954, 1955 and 1956. This period covered the main seasons of grass and weed pollination and dispersal of fungal spores.

The patients kept diaries recording daily whether or not they had attacks, the severity of the attacks, mild, medium or strong, and the duration of the attacks. They were allowed to take Ephedrine $\frac{1}{2}$ gr. 1-4 tablets daily when needed and to use a spray with vasodilating drugs. The number of tablets and/or inhalations were recorded. From this information a key was worked out to weight the attacks. One point was given for a mild attack, two points for a medium attack and three points for a strong attack. Unweighted and weighted attacks were recorded per week.

AEROBIOLOGICAL METHODS AND MATERIAL

The "Automatic Volumetric Hirst Spore Trap" sampled air-borne particles by suction of air onto slides which were coated with vaseline and a resin, polyvinylacetate ('Solvar') and changed daily. Air was sucked at a rate of 10 litre per minute through an orifice 14×2 mm., the inner end of which

was approximately 0.5 mm. from the sticky surface of the slide. In order to separate the spores caught at different times the slide was moving past the orifice at a constant rate of 2 mm. per hour. Spores and other particles caught during a 24 hours exposure were deposited on a trace measuring approximately 48×14 mm. After exposure the slide was covered with a cover glass coated with polyvinylacetate and lactic acid. The particles were identified and counted. The figures were converted to the contents of particles per m^3 of air. Thus an average count per m^3 of air at any time of the day of the week or of the whole observation period was recorded.

The stations in 1954 and 1955 were on the roof of the Imperial College of Science, South Kensington, London and in 1956 in the grounds of Thames Ditton Hospital where the trap was placed two metres above the ground.

AIR SPORA

Organic particles must conform to the following criteria to act as allergens. First, they must contain those polypeptide polysaccharide molecules which are responsible for the allergic attacks. Secondly, they must be present in vast numbers in the air. Thirdly, they must be of 3–40 microns in diameter, a size enabling them to be inhaled and not exhaled again, but deposited on the respiratory tract where they exert their sensitising action. Such criteria apply to pollen, spores of fungi, and organic dust particles to which bacteria may or may not be attached. This research is directed to the influence of pollen and spores.

In one cubic metre of air which represents roughly the amount we inhale in the course of an hour, there may be a thousand grains of various pollen and sixteen thousand of identifiable fungal spores or even more.

Pollen

Pollen can be disseminated by wind, insects and a few by water and some plants are self pollinated. Respiratory allergy

is caused by those pollen disseminated by wind. Only one tenth of the flowering plants are wind pollinated and these include many trees and shrubs, grasses and dycotyledonous herbs (weeds).

Trees shed their pollen mainly in May and the counts of pollen of the London plane can be very high indeed (Hyde, 1956). However they are uncommonly offenders. Grass pollen are disseminated in great quantities from the first week of June until the third week of July and are the major cause of hayfever and pollen asthma in Great Britain. The time of their pollination is consistent. Cultivated grasses, cereals, however, are of less importance because their larger pollen grains are less buoyant and many cereals are self pollinated. Rushes and sedges shed many pollen but do not cause much trouble. Weeds are of great importance in America, especially the ragweed, which fortunately has not gained a foothold here. Our weeds are weaker allergens than grasses. Their pollination commences earlier than grass pollination and only some weeds have constant times of pollination e.g. artemesia, plantago and rumex (E. Hamilton, 1957). The pollen types which were recognised on slides are shown in Table I.

TABLE I

Pollen

1. Gramineae (grasses)
2. Artemisia (mugwort)
3. Other Compositae
4. Chenopodium (fat hen)
5. Plantago (plantain)
6. Rumex (sorrels and dock)
7. Urtica (nettle)
8. Total others.

Nos. 2-8 were listed as "weeds".

Fungal Spores

Air carries not only the buoyant pollen grains but a great part of the floating organic matter consists of fungal spores which are discharged by various mechanisms (Gregory 1945). The numbers floating in the air reach very high figures indeed

and *Cladosporium* spores can outnumber pollen grains by 1000:1.

According to Gregory (1955) the fungal spores are not discharged in large quantities into the air from the soil but from sources above the soil. The sources are dead and dying vegetation, leaves, stems, stubbles, where vast numbers of *Cladosporium* and *Alternaria* and many others can be discharged. Second, foliage and branches of living plants, herbs, crop plants and other vegetation. Here a vast population of saprophytic yeasts (*Ascomycetes*) and *Sporobolomyces* are found, but they can also be affected by pathogenic fungi, rusts, smuts, powdery mildew (*Erysiphe*) and others. A third source are the macroscopic fungi, mushrooms, and toadstools and bracket fungi found on trees (*Basidiospores*). Evidence for allergic properties of fungal spores of some genera and species has been produced by skin and inhalation tests. To this should be added evidence for the simultaneous occurrence of peak weeks in the concentration of fungal spores and clinical peak weeks.

The ten most common spore categories which have been identified on slides are listed in Table II.

RESULTS

1954 - total group

The total group comprised 37 cases. The average weekly ratio of attack days per diary days was 21 % and the average weekly ratio of weighted attack days per diary days was 32 %. The range of the attack rate was 7-32 and of the weighted attack rate 11-55. (Graph I).

1955 - total group

The total group comprised 35 cases. The average weekly ratio of attack days per diary days was 19 and the average weekly ratio of weighted attack days per diary days was 24, thus lower than in 1954. The range of the attack rate was 9-31 and of the weighted attack rate 15-40. (Graph II).

TABLE II

*Most common spore categories (E. Hamilton 1957).**Basidiomycetes*

Sporobolomyces

Tilletiopsis

Ustilago

Total Basidiospores - Brown basidiospores
 yellow
 hyaline
 ganoderma
 nolanea
 thelephora
 psilocybe
 uredospores
 coniophora
 tilletia
 lactarius russula

Ascomycetes

Total Ascospores - Unknown
 fusiform septate (thin)
 filiform
 nectria type
 leptosphaeria
 fusiform 3-septate fat
 sordaria
 venturia
 chaetomium
 pleospora

Fungi imperfecti

Cladosporium

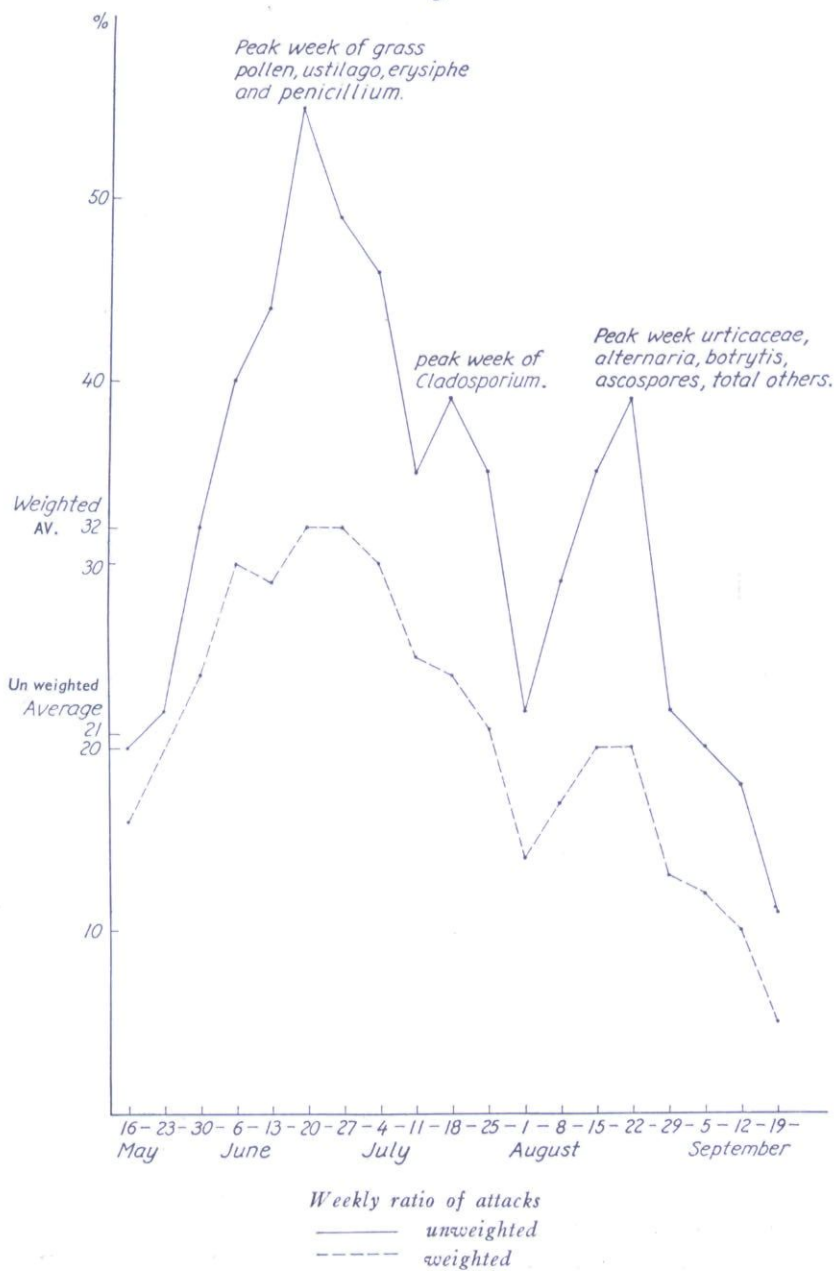
Botrytis

Penicillium type

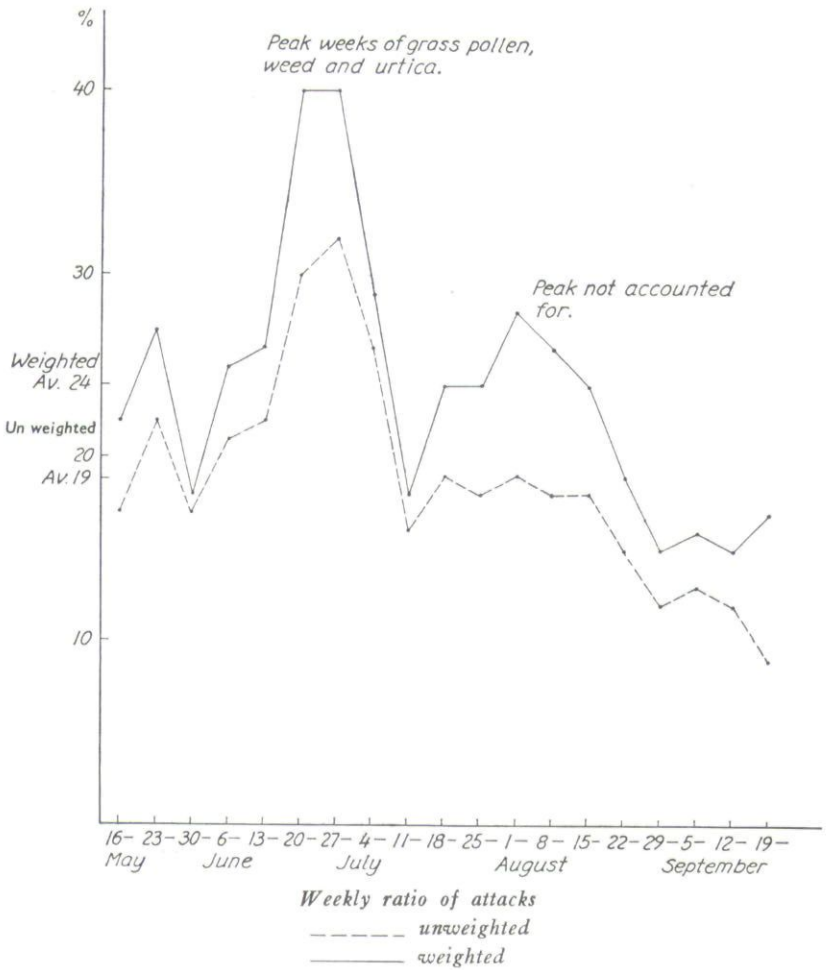
Erysiphe

Alternaria

Total others - epicoccum
 pullularia
 torula
 polythrincium
 dicoccum
 helicomyces
 helminthosporium
 periconia
 macrosporium
 stemphylium
 total unknown



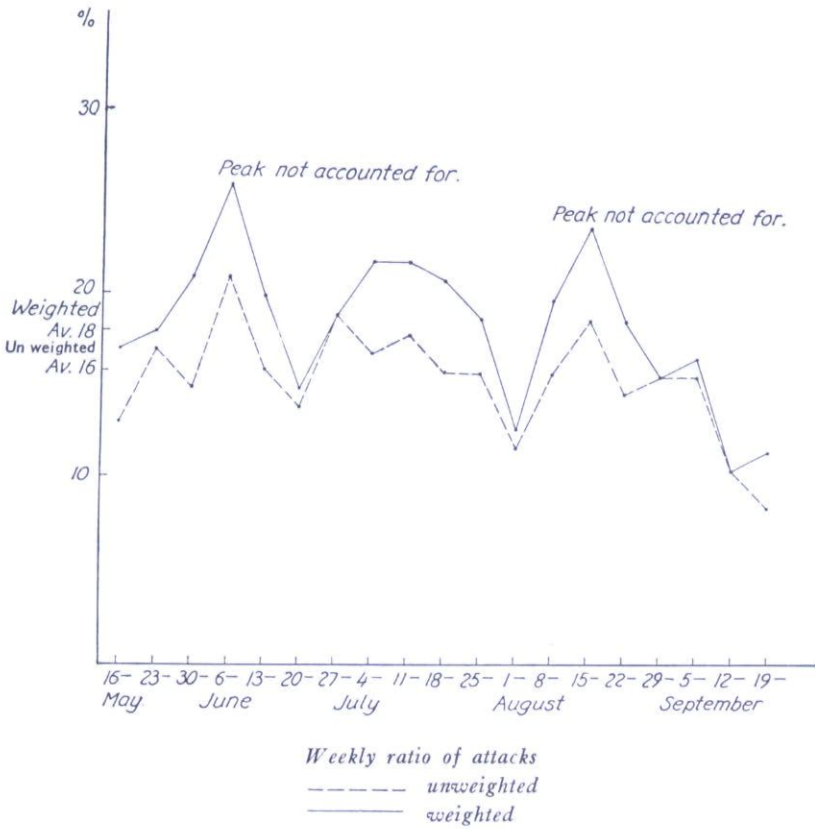
Graph I
1954 - Total group - 37 cases



Graph II
1955 - Total group - 35 cases

1956 - total group

The total group comprised 31 cases. The average weekly ratio of attack days per diary days was 16 and the average weekly ratio of weighted attack days per diary days 18, thus considerably lower than in 1954 and 1955. The range of at-



Graph III
1956 - Total group - 31 cases

tack rate and weighted attack rate was 9-21 and 11-26 respectively. (Graph III).

Fluctuation of Asthma attacks

Fluctuations were apparent in the charts of the weekly rates. They were more pronounced in the weighted attack rates which took into account not only the number of attacks but also the severity. Frequently a rise in the number of attacks was accompanied by an increase in the severity. In 1954, the year with the highest weekly incidence of asthma (Table III),

TABLE III

	Total group			Pollen group		
	1954	1955	1956	1954	1955	1956
Number of cases	37	35	31	25	25	23
average weekly ratio asthma days/diary days	21	19	16	25	24	16
average weekly ratio weighted asthma days/diary days	32	24	18	38	29	18
Range asthma days	7-32	9-31	9-21	6-42	13-42	11-23
Range weighted asthma days	11-55	15-40	11-26	6-73	15-55	11-25

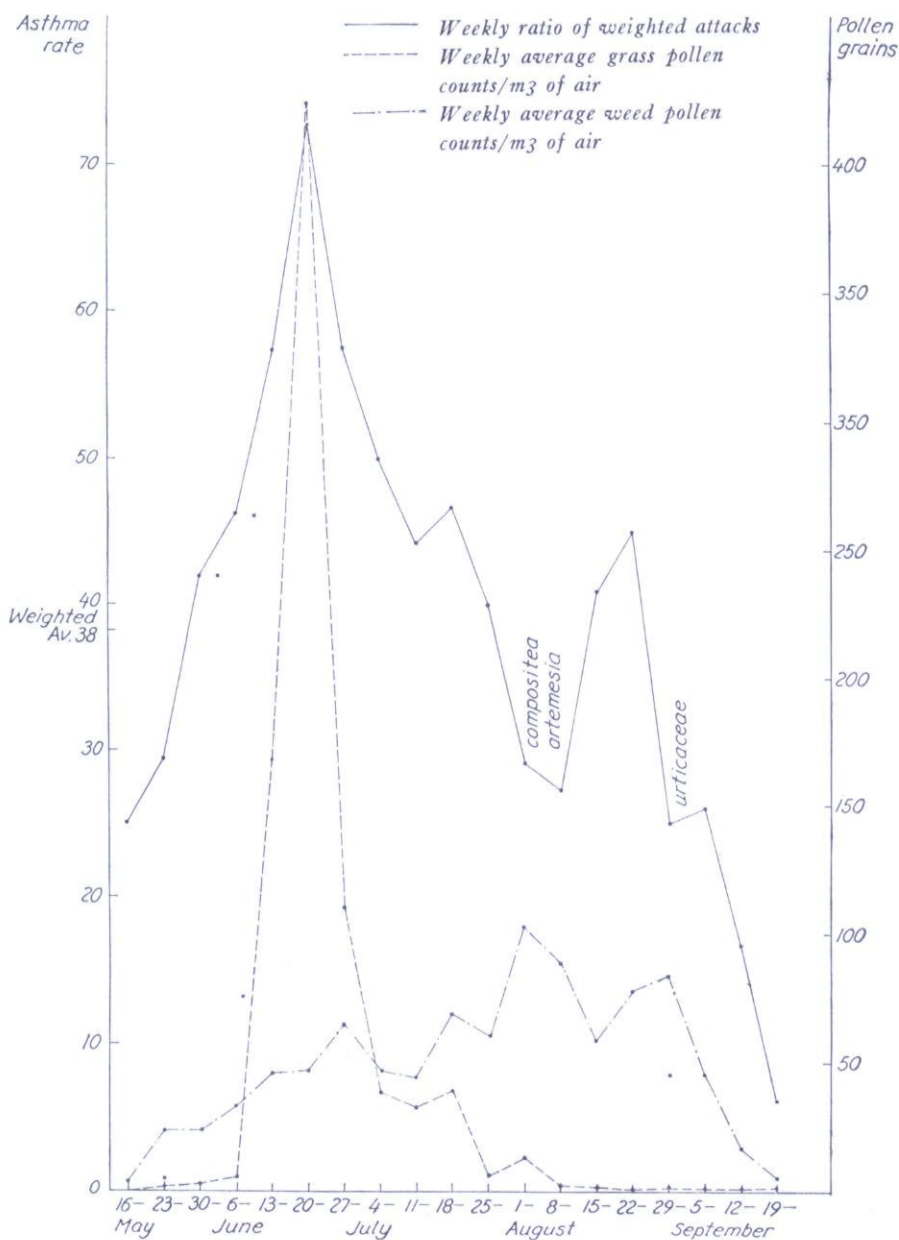
TABLE IV

	Weekly average Pollen grains/m ³ during peak weeks		
	1954	1955	1956
<i>Grass pollen</i>	407 20-26 June	352 20-26 June	150 20-26 June
<i>Weed pollen</i>	102 1-7 August	140 20-26 June	95 13-19 July
<i>Urticaceae</i>	65 1-7 August	115 27 June-3 July	23 18-24 July

three peaks were observed and in 1955 a similar pattern occurred though the curve was flatter. In 1956 the curve did not show marked rises (Graph I, II and III).

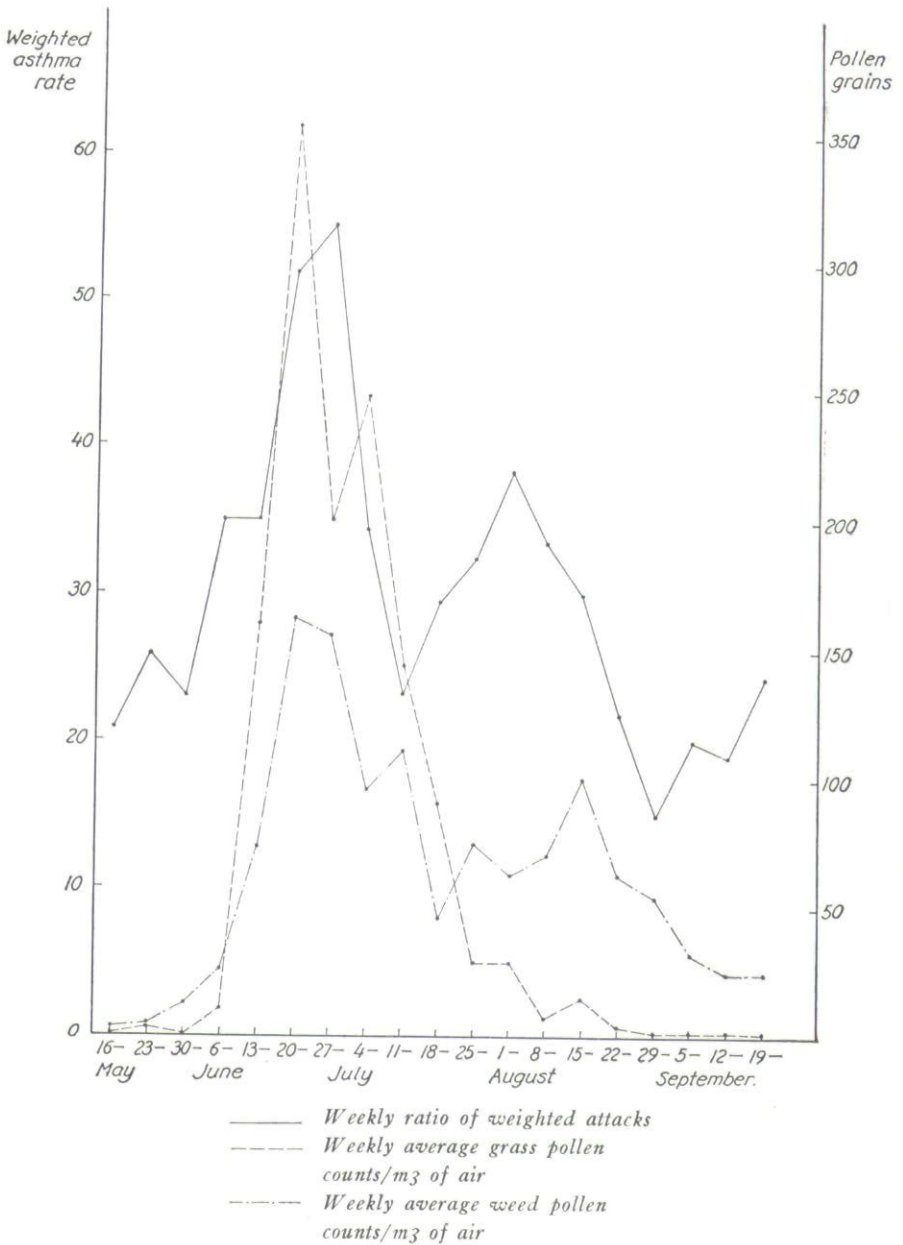
Clinical results in Relation to Pollen

The first sharp clinical rise in 1954 and 1955 coincided closely with the rise of grass pollen. Weed pollen, with smaller numbers, may have contributed to an allergic stimulus. The second rise in 1954 beginning of August coincided with a peak of artemesia but the total numbers of artemesia are small and it is not likely that they aggravate asthma in many cases. In 1956 the lack of a clinical rise coincided with low pollen figures (Table IV and Graphs IV, V and VI). It seems that du-



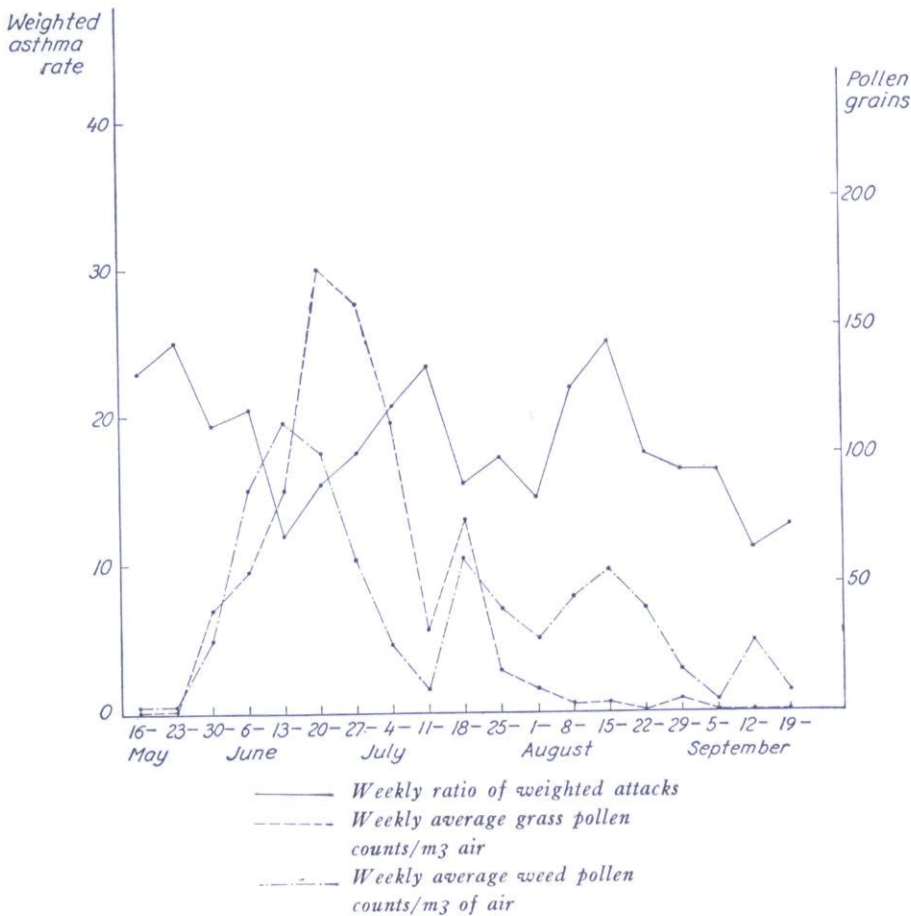
Graph IV

1954 - Pollen group - 25 cases - in relation to Pollen counts



Graph V

1955 - Pollen group - 25 cases - in relation to Pollen counts



Graph VI

1956 - Pollen group, 23 cases - in relation to pollen counts

ring 1956 the pollen did not reach the threshold which evokes attacks in the many pollen asthmatics.

Clinical results in Relation to Moulds

A relation of the fluctuation of asthma to moulds is more difficult to trace. First, they are weaker allergens in the majority of cases. Secondly, the period of occurrence is less constant

TABLE V

Peak weeks		Weekly average of whole period	
Weekly average of particles/m3			
<i>1954</i>			
20-26th June	Grass pollen	407	40
	Ustilago	2399	419
	Erysiphe	112	28
	Penicillium	274	142
11-17 July	Sporobolomyces	2135	903
18-24 July	Cladosporium	8668	2340
1-7 August	Weed pollen	102	45
	Urtica	56	24
22-28 August	Alternaria	55	19
	Botrytis	389	166
	Ascospores	3003	1399
	Total others	1344	510
29-4 Sept.	Basidiospores	1235	513
5-11 Sept.	Tilletiopsis	680	189
<i>1955</i>			
20-26 June	Grass pollen	352	63
	Weed pollen	146	58
27-3 July	Grass pollen	200	63
	Urtica	115	33
4-10 July	Ustilago	3149	687
	Erysiphe	127	32
8-14 August	Sporobolomyces	3775	905
	Tilletiopsis	1074	197
15-21 August	Cladosporium	17574	6375
22-28 August	Alternaria	244	47
	Botrytis	533	158
	Basidiospores	548	422
	Total others	930	385
	Ascospores	911	112
5-11 Sept.	Ascospores	911	112
12-18 Sept.	Penicillium	1965	340
<i>1956</i>			
13-19 June	Weed pollen	95	39
20-26 June	Grass pollen	150	41
	Ustilago	1274	191
	Sporobolomyces	2652	993
	Gladosporium	6468	2434
11-17 July	Urticaceae	23	6
18-24 July	Erysiphe	100	15
	Penicillium	448	114
	Tilletiopsis	1633	657
8-14 August	Alternaria	71	15
5-11 Sept.	Basidiospores	2757	891
	Botrytis	515	141
	Ascospores	1971	410

TABLE V

Total group	
Weekly weighted asthma attack rate	
16th may to 25th september — 19 weeks	
	Average 32
	55
	35
	39
	22
	39
	22
	20
	Average 24
	40
	40
	28
	26
	24
	19
	15
	15
	Average 18
	20
	15
	21
	19
	13
	20
	17

than that of grass pollen. Thirdly, most mould sensitive patients react, by skin tests, to a variety of moulds and the combinations change. Equally, a variety of moulds are present in the air at the same time but again their combination changes from week to week in type and frequency and from year to year. Faced with these difficulties which became more apparent each year, it appeared best to trace the peak weeks of moulds and pollen and to see whether or not a rise of asthma occurred at these times. Table V shows the peak weeks of pollen and moulds with the corresponding rise or decline of asthma. Only the rise of asthma during the grass pollen season may be of clinical significance. In 1954 the weighted asthma rate increased from an average of 32 to 55, in 1955 from an average of 24 to 40 but in 1956, with low pollen figures, only from an average of 18 to 20.

The other clinical rises may be of less significance, but it should be noted that a rise in the weighted asthma rate from 32 to 39 occurred in 1954, 18th to 24th July, during the *Cladosporium* peak week. This, however, was not repeated in 1955 or 1956 although *Cladosporium* figures were as high or even higher. Another clinical rise of weighted attack rate from 32 to 39 was noted 22nd to 28th August, 1954, and this coincided with peak weeks of a number of moulds, the highest figures being reached by *Ascospores*, mainly the thin fusi-form types. Such conditions were not repeated in 1955 or 1956.

Individual cases

The strongest skin reactions to moulds occurred in patients who were also sensitive to pollens. Two cases showed strong reactions to pollen and *alternaria* and whereas these patients selected the grass pollen peak week for their major attacks they did not report bad attacks during the *alternaria* peak weeks.

Three cases showed strong reactions to pollen and *Cladosporium*. Again, severe attacks occurred during the pollen

season but only one was clinically bad during the *Cladosporium* peak week.

Two cases showed strong reactions to pollen and *Sporobolomyces*. One case responded to the pollen peak week and the *Sporobolomyces* peak week; the other case to the pollen peak week only.

No further definite clinical rises were seen at peak periods of moulds.

DISCUSSION

The pollen and spore figures were based on identification from slides. Many fungi imperfecti are better identified on culture plates. On the other hand, the latter method misses a number of species which cannot be cultured on routine media.

A comparison of the fluctuation of asthma and of the concentration of grass pollen is helped by the fact that the time of flowering of grasses is constant in Great Britain. It is determined by the hours of daylight, consequently occurring each year at the same time (Peterson et al., 1958). The flowering of some trees and of most weeds is less constant.

The time of dispersal of most fungi varies from year to year. *Ustilago* (smuts) believed to be a major cause of respiratory allergy (Waldbott et al, 1940), and *Erysiphe* (powdery mildew) occurred at the time of grass pollination which masks the assessment of their influence on the allergic patients. But skin tests to *Ustilago* and *Erysiphe* are rare and weak.

The number of spores at peak periods may be 50 times as high than the number of pollen at peak periods. It is fortunate for the allergic population that the allergenic properties of moulds are weaker than those of pollen.

Pollen are discharged in higher numbers in dry weather, and so are some of the fungal spores, i.e. *Cladosporium* and *Ustilago*. This explains why pollen sensitive patients become worse during dry spells. The rise of pollen asthma occurred during dry spells in 1954, 1955 and 1956. Fusiform Asco-

spores and some other fungal spores are discharged in higher numbers in damp weather. This may explain why sensitive mould patients break down in periods of high relative humidity. The increase of asthma during August 1954 which was probably mould asthma occurred during a phase of very high relative humidity.

The comparison of this study was based on the concentration of airborne particles in the atmosphere of the air out of door. It did not take into consideration local variations of the out door air which may be very great indeed, nor the influence of in-door atmospheric conditions (Richards 1954). Basidiospores out-of door did not seem to have a great affect on the allergic patient, whereas one species of basidiospores, *Merulius lacrymans*, dry rot, causes asthma in many patients (Frankland 1951). Their concentration can be much higher than the number of basidiospores out-of door (Gregory et al, 1953).

CONCLUSIONS

Reliable aerobiological data on the composition of the airspora, its change with season, weeks within the season and relative humidity allow a better understanding of the role of the airspora as one of the factors precipitating attacks of respiratory allergy.

The numbers of airborne particles present in the air vary for each category from day to day, week to week, and season to season. Some categories produce particles in very high numbers but it does not follow that the most common particles are the major causes of attacks. Tree pollen, much higher in numbers than grass pollen during some years and in some areas, and *Cladosporium* which reaches peak counts 50 times as high as grass pollen, causes less respiratory allergy than grass pollen.

Peak weeks of airborne particles, showed the relation of grass pollen to an increase of asthma, but a relation of spores was less obvious. Some indication was obtained to *Cladospo-*

rium as a contributory factor and attention was drawn to Asco-spores.

Five out of seven patients with strong reactions to *Cladosporium*, *Alternaria*, or *Sporobolomyces*, did not select the respective peak weeks of those moulds for their major attacks.

The critical period of pollen asthmatics could be predicted. The danger period of mould asthmatics could not be stated in advance.

ACKNOWLEDGEMENTS

I wish to express my gratitude to the Geoffrey E. Duveen Trust for a personal grant and to the Asthma Research Council for the purchase and maintenance of a Hirst Spore Trap, to Kings College Hospital and the Asthma Research Council for grants.

I am indebted to Professor P. H. Gregory, Director of the Department of Botany, Imperial College of Science for many, discussions, continuous help, suggestions and encouragement, and to Dr. E. Hamilton. All aerobiological figures for 1954 and 1955 are based on the results of Dr. E. Hamilton.

My thanks are due to Mr. R. R. Davies, St. Thomas Hospital, for providing material for skin testing and for counting slides, and to Mrs. A. Scillag for counts of the 1956 series.

I wish to thank Mr. W. Daggett, Dr. Bruce Pearson, Dr. Bernard Freedman, Dr. A. W. Frankland and Mr. Zwiefach for clinical records and Dr. Tickler and the staff of Thames Ditton Hospital for running the trap in the grounds of the hospital.

My thanks also to Dr. D. A. Williams, Dr. H. A. Hyde and Dr. K. Taylor for personal discussions.

The help of Miss R. Hobling and Mrs. A. M. Chippindale is appreciated with thanks.

REFERENCES

- Frankland, A. W. & Hay, M. J.*: Dry rot as a cause of allergic complaints. *Acta. Allerg. IV*, 168, 1951.
- Gregory, P. H.*: The dispersion of airborne spores. *Trans. Brit. Mycol. Soc.*, 28, 26, 1945.
- Gregory, P. H.*: Problems of aerobiology in relation to allergy. *Brit. Assoc. of Allergists Meeting Oct.* 1955.
- Gregory, P. H., Hirst, I. M. & Last, I.*: Concentrations of Basidiospores of the dry rot fungus *Merulius lacrymans* in the air of buildings. *Acta Allergol.*, 6, 168, 1953.
- Hamilton, E. D.*: A comparison of the pollen and fungus content of the air in two localities as a contribution to the study of respiratory allergy. Thesis 1957.
- Hirst, J. M.*: An Automatic volumetric spore trap. *Ann. Appl. Biol.* 39, 257, 1952.
- Hyde, H. A.*: Phenology of British hayfever plants and the significance to allergists. *Brit. Med. J.* 897, 1949.
- : Studies in atmospheric pollen IV. Pollen deposition in Great Britain, 1943. Part 2. The composition of the pollen catch. *New Phytol.* 49, 407, 1950.
 - Grass pollen in Great Britain. *Acta. Allerg. Kbh.* 5, 98, 1952.
 - A census of atmospheric pollen and its possible applications. *Proc. Linn. Soc. Lond.* 165, 107, See Hyde 1956.
- Hyde, H. A. & Williams, D. A.*: Studies in atmospheric pollen. II Diurnal variation in the incidence of grass pollen. *New Phytol.* 44, 83, 1945.
- Studies in atmospheric pollen, III, 1946.
 - A census of mould spores in the atmosphere. *Nature, Lond.* 164, 668, 1949.
- Hyde, H. A.*: Tree Pollen in Great Britain. *Acta. Allerg. Kbh.* 10, 224, 1956.
- Hyde, H. A., Richards M. & Williams, D. A.*: Allergy to mould spores in Britain. *Brit. Med. J.* Vol. I, 886, 1956.
- Peterson, M. L., Cooper, J. P. & Vosc. P. B.*: Non-flowering strains of herbage grasses. *Nature*, 181, 591, 1958.
- Richards, M.*: Atmospheric mould spores in and out of doors. *Allergy*, 25, 429, 1954.
- A census of mould spores in the air over Britain in 1952. *Trans. Brit. Mycol Soc.*, 39, 431, 1956.
- Waldbott, G. L. & Ascher, M. S.*: Rust and smut, major causes of respiratory allergy. *Ann. intern. med.* I, 14, 213, 1940.

This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.