

National Museum of Wales and Asthma & Allergy Research Unit,
St. David's Hospital, Cardiff.

TREE POLLEN IN GREAT BRITAIN

By

H. A. HYDE

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I. INTRODUCTION

There appears to be a consensus of opinion that allergy to tree pollen is relatively unimportant in Great Britain, though there are few reliable data on its frequency (Frain-Bell, 1951; Frankland, 1956; Freeman, 1950). Furthermore no general assessment of the incidence of tree pollen has hitherto been

attempted: it is believed therefore that consideration of the existing data in relation to the known distribution of the various tree species may be of value. Such an enquiry may perhaps explain, if not entirely justify, the low rating given to tree pollens as causes of hayfever and asthma. The present contribution is based on a pollen census which was begun in 1942 and is still in operation.

2. TREES AND FORESTS IN GREAT BRITAIN CONSIDERED FROM THE POINT OF VIEW OF ALLERGY

Great Britain is one of the most poorly wooded countries in Europe: woodland covers only 6.5 per cent of the land surface (Forestry Commission, 1951) as compared with 26.8 per cent in Germany, with the 26.1 per cent average in Western Europe, and with the (probably) 30 per cent in Europe as a whole. In making this comparison, however, it should be borne in mind that in central and more especially in northern Europe (where the woodland area rises to 60 per cent) the forests are predominantly coniferous (and therefore to that extent negligible in relation to allergy), a situation which does not obtain in Great Britain.

Effective tree growth in Great Britain is confined to areas below 1250 ft alt. (c. 400 m.). Mountainous country predominates in Wales, the north of England and Scotland: here the forests are largely confined to the lower slopes and valley sides, while the valley bottoms are devoted to agriculture and the ridges and mountain tops are treeless. Elsewhere the woodlands are very unevenly scattered, and indeed the distribution of forest is very uneven throughout, ranging from 21.6 per cent in parts of Scotland down to 1 per cent in the east of England, e.g. Cambridgeshire (Forestry Commission, 1952). Here again some allowance must be made for the proportion of coniferous forest. The greater part of the country lies within the vegetation zone of deciduous summer forest¹, only

¹ Forest dominated by trees which shed their leaves in winter.

the north of Scotland coming into the coniferous zone but, as the result of artificial planting, coniferous plantations make up nearly one-third of the total woodland area, a figure which rises to 40 per cent in Wales and over one half in Scotland (woodlands felled or devastated during the last war are here neglected). On the other hand, in the south-east of England, which is relatively rich in woodlands (10–15 per cent of the area) these mainly comprise dicotyledonous (broadleaved) trees, the pollen of most of which has been regarded as antigenic. Moreover, quite apart from large woods and plantations which, as stated, cover only a relatively small total area, trees—particularly broadleaved trees in the form of small woods and hedgerow specimens—are very widely scattered throughout England (though this applies to a less extent to Wales and much less still to Scotland): the typical landscape pattern of England at least is a patchwork of enclosed fields and hedgerows, hedgerow trees and small woods. (Forestry Commission, 1953).

Two species of coniferous tree, viz. pine (*Pinus*) and yew (*Taxus*) only, are native to Great Britain and both pine and yew pollen are regularly present in quantity at all centres so far investigated. The pollen of both species is regarded as non-antigenic, as is that of almost all the many introduced species of conifers grown on a forest scale; certain coniferous species which are occasionally grown and whose pollen is known to be antigenic are referred to later (see *Coniferae*, p. 239).

The principal species of broadleaved tree in Great Britain, and the one which forms by far the largest proportion of pure (unmixed) woodland, is oak (*Quercus robur* and *Q. petraea*). Other, though on the average less important, social species are beech (*Fagus sylvatica*), ash (*Fraxinus excelsior*), alder (*Alnus glutinosa*) and birch (*Betula* spp.) all of which together with the (non-social) elms (*Ulmus* spp.) and the more or less shrubby hazel (*Corylus avellana*), willows (*Salix* spp.), hawthorn (*Crataegus* spp.), and elder (*Sambucus nigra*) are widespread, and all native. (These species of widespread

distribution, together with yew (*Taxus*), form group A in Figure 1). Other kinds of trees, which are planted mainly for ornament and are therefore very common in parks and also in towns as street trees, include lime (*Tilia* spp. chiefly *T. vulgaris*), horse-chestnut (*Aesculus hippocastanum*), plane (*Platanus acerifolia*, especially numerous in London), sweet chestnut (*Castanea sativa*, also locally abundant as a woodland tree especially in southern England), sycamore (*Acer pseudoplatanus*) and poplars (*Populus* spp.); hornbeam (*Carpinus betulus*) an important woodland species in parts of south-east England, is elsewhere a rarely planted tree. (These latter species together with pine (*Pinus*) form group B in Figure 1).

To sum up: sources of tree pollen are much more widespread than the small area of woodland would seem to suggest, and especially in England where, to judge from the distribution of trees alone, the risk of exposure to significant quantities of antigenic tree pollen must be distinctly greater than in most parts of Wales or Scotland; and such risk is by no means negligible in certain towns.

3. POLLEN-INCIDENCE (ESPECIALLY THAT OF TREES) IN RELATION TO GEOGRAPHICAL SITUATION

The pollen census referred to above has been carried out by daily pollen trapping throughout one or more seasons at the various stations listed in Table A. The gravity slide method has been used throughout¹; all exposed slides have been sent to Cardiff for analysis.

Despite the fact that at five of the stations listed trapping was confined to one year, it is believed that certain general conclusions can be drawn from the data so secured. Apart from observations made near ground level in grass fields, the

¹ Volumetric counts have been made at Cardiff in 1954-6 but they are not included in the figures presented here. A preliminary comparison between gravity and volumetric counts shows that the broad conclusions drawn here remain unaffected.

TABLE A
Tree pollen catches at 9 stations in Great Britain. (Grains caught on 5 sq.cm. of horizontal adhesive surface exposed continuously and changed 24-hourly throughout the year).

Station	Altitude O. D.	Surroundings	Height of apparatus above ground	Year(s)	Tree pollen catch (average to nearest hundred)	Tree pollen as % of total pollen catch
Cambridge	40 ft	Town with parks	60 ft	1943	10,000	51
Cardiff	45 ft	Town with parks and gardens	60 ft	1943-55	7,100	29
Paddington	90 ft	Central London	80 ft	1943	6,500	55
Bishop Rock, Isles of Scilly ¹	0 ft	Sea: 32 miles from Land's End	125 ft	1953-55	2,800	27
Edinburgh	250 ft	Betwixt suburb and cultiv- ated land	24 ft	1943	2,800	13
Aberystwyth	20 ft	Small town; beside sea	60 ft	1943	2,700	24
Brecknock Beacons, Breck ²	1440 ft	Open moorland with rough grazing	5 ft	1945-49	2,000	23
Aberdeen	25 ft	Large town; sea ¼ mile	15 ft	1943	2,000	24
Black Mountains, Breck ³ ...	1750 ft	Valley in mountains; upland vegetation	5 ft	1945-49	1,800	24

¹ I am indebted to the Elder Brethren of Trinity House for facilities for exposing slides and to Captain R. E. Goodman and the staff of Bishop Rock L. H. for their cooperation.

² I am indebted to the Cardiff Corporation Waterworks for facilities for exposing slides and to Mr G. Cover and his staff for their cooperation.

³ I am indebted to the Aberillery Water Board for facilities for exposing slides and to Mr Cory Goddard and his staff for their cooperation.

highest annual pollen catches (Fig. 1) were made on the rural outskirts of Edinburgh and at Cardiff, a city of trees, parks and open spaces¹. Cambridge, a town of population 86,200 surrounded by a purely rural area, produced a somewhat smaller total; Aberystwyth, a town of population 10,400 situated on the western seaboard, gave a smaller catch, comparable in magnitude with that in central London; and Aberdeen, a large treeless seaport (population 167,000), gave counts comparable with those obtained at two stations on the Breconshire mountains. The presence and kind of vegetation immediately around the stations produce a very considerable effect on the average pollen concentration: rural and suburban localities in the lowlands with their numerous populations of trees and grasses and other herbs have the highest pollen incidence, large towns a much lower one, and mountain areas a lower one still. Very significant quantities of pollen are carried from productive areas into non-productive ones, and indeed (as the observations on Bishop Rock have shown) to a distance of at least 30 miles out to sea.

A first rough analysis of the pollen catch into tree pollen and non-tree pollen brings out the influence of the vegetation immediately surrounding the station concerned (Fig. 1). Cambridge, with its many gardens and its abundance of planted trees, has the highest figure not only for tree pollens as a whole, but also for native trees (group A) and for the 'occasional' species (group B) so often planted in towns (see p. 230); central London runs Cambridge close for group B tree pollens but not for native trees. Conversely, Cardiff (apart from the centre, see footnote 1) has a rather smaller count of group A trees than Cambridge and a much lower count of

¹ Two stations have been operated at Cardiff (a) at Llandough Hospital on the rural outskirts, (b) at the National Museum of Wales near the city centre. In view of the very abnormally large number of elm trees situated in central Cardiff (300 were counted within a 1/2 mile radius) the elm (*Ulmus*) counts from that station have here been replaced by the corresponding figures from Llandough Hospital and the counts of total pollens have been adjusted accordingly.

TREE (AND OTHER) POLLENS CAUGHT IN BRITAIN

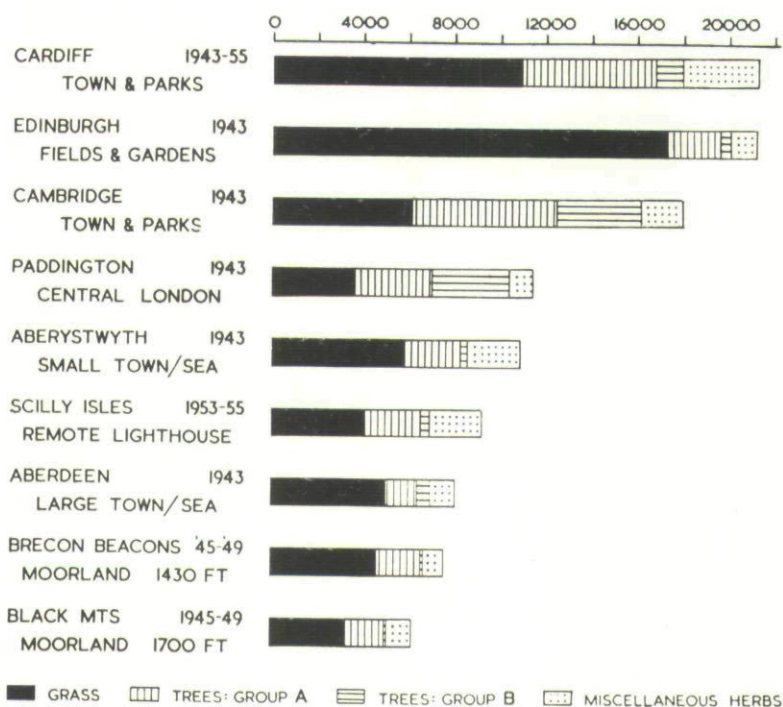


Fig. 1.

Tree (and other) pollens caught in Great Britain: showing the magnitude and general composition of the pollen catch at nine stations. Trees (group A) are widespread throughout and all native: trees (group B) are species of more or less restricted distribution, some native and some introduced. For further explanation see text.

group B. The smallest catches of group B tree-pollens, and the lowest relative to group A, came from two remote stations situated in the Welsh mountains.

4. BOTANICAL COMPOSITION OF TREE POLLEN IN BRITAIN

Tree pollen, unlike grass pollen, is derived from plants belonging to a wide range of families and cannot be regarded by

TREE POLLENS CAUGHT IN BRITAIN

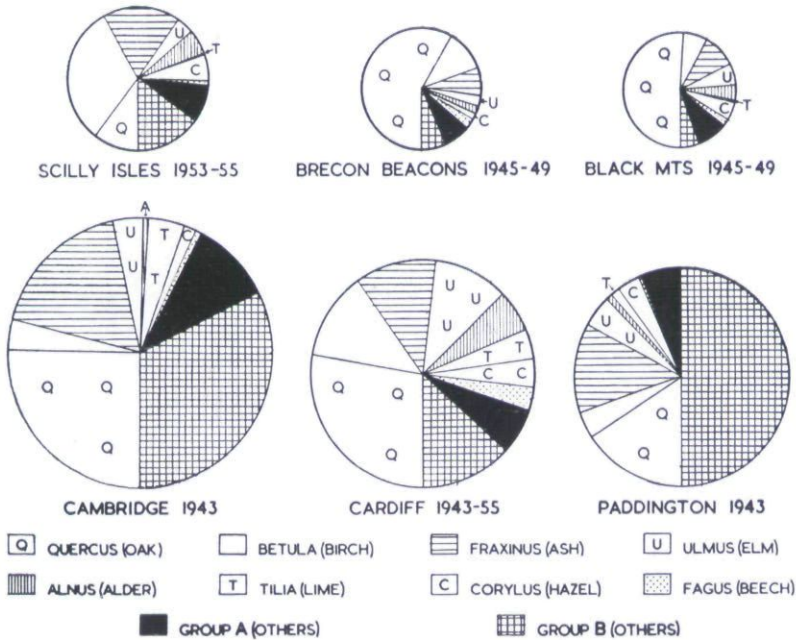


Fig. 2.

Various kinds of tree pollen caught in Great Britain: average annual catches at six centres. The areas of the circles are in proportion to the total tree pollen catch. The catches of the principal constituent pollens are indicated; of those mentioned by name all but *Tilia* (lime) belong to Group A (native and wide-spread). At Cambridge and Paddington, group B pollens (from trees of restricted distribution) are a major element, while in the Welsh mountains they are quite insignificant. For further explanation see text.

the allergists as a single entity. The differential incidence of pollen of the generally distributed trees (group A) and that of the occasional ones (group B) has already been indicated: the average incidence of the principal individual kinds of tree pollen at certain centres is illustrated in Fig. 2. The relatively high incidence of certain kinds of tree pollen, notably oak, ash and birch, is clearly shown: but average incidence, though suggestive of the probable importance of an allergen, is insufficient. In any evaluation not only of the probable prevalence

of tree pollen allergy but also of the likelihood of its being diagnosed it is necessary to consider not only average annual incidence but also other features of the occurrence of the various types.

5. VARIATION IN INCIDENCE FROM YEAR TO YEAR

The variation in the abundance of several principal types of tree pollen at Cardiff is shown in Fig. 3. This is the only station for which counts for so many years are available, but there are many reasons for supposing that similar wide variations occur over the whole country and often simultaneously year by year. Study of the diagram shows that each of the kinds of tree concerned produces bumper crops of pollen: perhaps the most notable contrast was shown by oak pollen in 1946 and 1947 respectively, but in all seven types there were years when the pollen counts were negligible in comparison with those of bumper years. With the single exception of hazel, these variations are much wider than those observed in the abundance of grass pollen (Hyde, 1952).

6. PHENOLOGICAL VARIATION

The course of events in the tree pollen year is summarised in Figure 4, in which the *average* dates between which the various kinds are present in the air, or abundant, or (in oak and birch) very abundant, are indicated. The order of these events is nearly fixed but, as shown in Figure 5, the actual dates of their occurrence vary widely from year to year. For most types there is a period during which pollen of any particular kind is present (though not necessarily abundant) in the air every year (abnormal seasons apart); this constant period at Cardiff may be as long as 75 days (elm, *Ulmus*) or as short as 10 days (beech). In all types pollen may be present for a considerable time before or after the constant period. Thus oak has been registered 20 days before the constant period; elm 46; ash 41; birch 34; beech 26; hazel 42; and alder 45;

TREE POLLENS: VARIATION YEAR TO YEAR
GRAINS DEPOSITED ON 5 SQ. CM. CARDIFF 1943-55

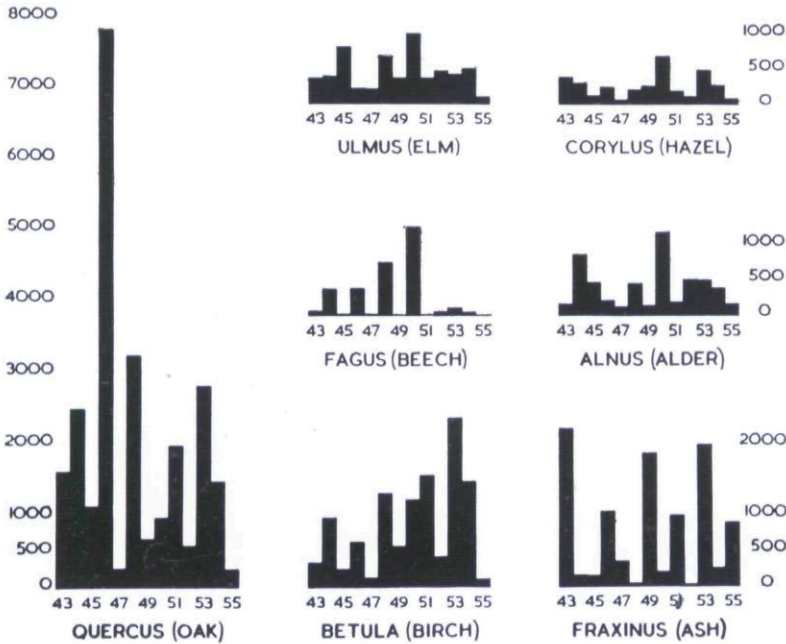


Fig. 3.

Variation in annual abundance of seven principal (native) types of tree pollen at Cardiff 1943-55. All counts are shown on the same scale. Except that in 1947 all types of tree pollen but ash (*Fraxinus*) gave a low count, the various trees do not rise and fall in unison. For further explanation see text.

and similarly oak has been caught 61 days after the constant period; elm 35; ash 29; birch 28; beech 25; hazel 34; and alder 28. Phenological variation is most marked in trees which flower in early spring and least so in those which flower at high summer. The wide time-variation in the incidence of most tree-pollens contrasts markedly with the constancy of grass pollen incidence in Britain (Hyde, 1952). The grass pollen season is closely tied to the calendar; not so those of the various trees.

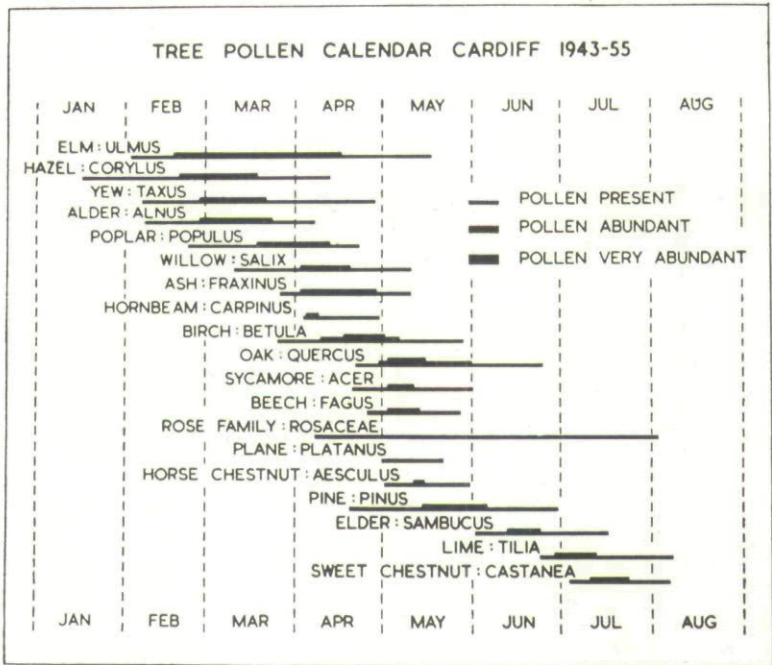


Fig. 4.

Tree pollen calendar for Cardiff based on the pollen census 1943-55. Average dates of occurrence are shown: the actual dates in particular years were often very different, though the sequence remained much the same. For further explanation see text.

7. DAY TO DAY VARIATION IN POLLEN INCIDENCE OF PARTICULAR TYPES

The general picture presented by the incidence of a particular kind of tree pollen during the whole of one season varies greatly from one pollen type to another. Two sorts of seasonal frequency diagrams have been recognized, viz. the compact and the diffuse (Hyde, 1950). The compact kind of frequency diagram is exemplified by ash (*Fraxinus*, Fig. 6): here each year shows a pattern of alternate rises and falls in which the rises increase up to a maximum toward the middle of the season and thereafter decrease. Every year it is possible to indi-

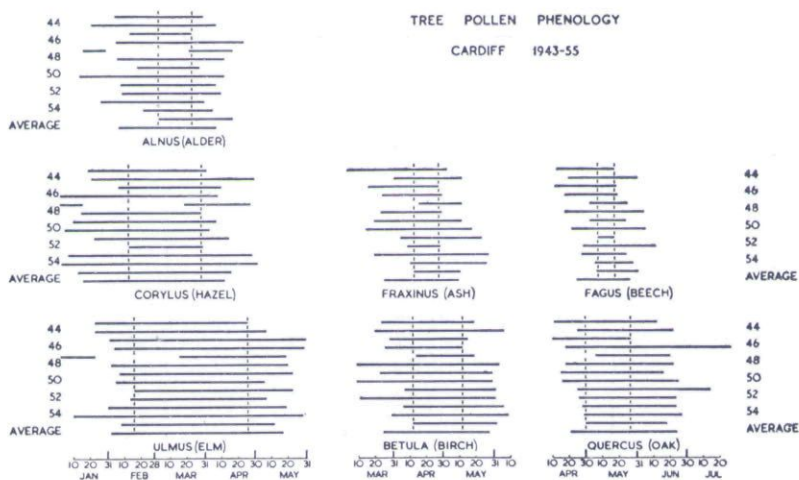


Fig. 5.

Tree pollen phenology at Cardiff 1943-55. The periods during which seven principal kinds of tree pollen were present in the air from year to year are indicated by horizontal lines. The constant period for each type is shown by broken vertical lines (the year 1947 was quite abnormal being marked by blizzards all over Britain between 25 January and 15 March and it has therefore been left out of the reckoning). For further explanation see text.

cate a peak period, though the actual intensity at this period varied greatly. Compact frequency diagrams (not shown here) have also been constructed from the data on elm (*Ulmus*), oak (*Quercus*), birch (*Betula*), beech (*Fagus*) and certain other pollen-types. In all of these except elm the flowering season is relatively short and the numbers of individuals in flower rapidly increase up to the peak, after which flowering diminishes generally. (In elm (*Ulmus*) the length of the season is in part to be accounted for by the fact that several species are concerned and that their flowering seasons do not coincide). The peak date usually but not always falls inside the constant period.

The diffuse kind of pollen diagram is exemplified by hazel (*Corylus*, Fig. 7). Here there is no single maximum phase or peak period: rises and falls of no great amplitude occupy the whole of the season concerned. Field observation shows that,

ASH POLLEN AT CARDIFF 1943-8.

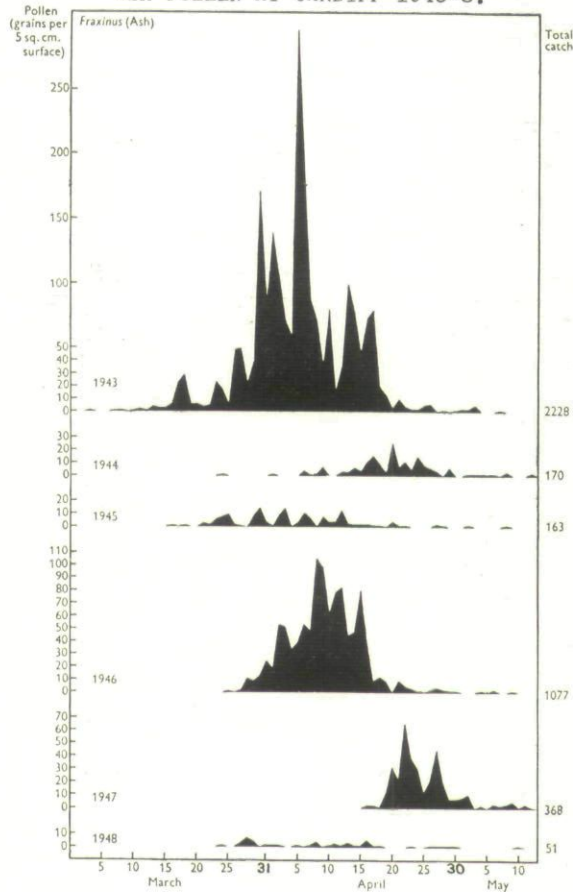


Fig. 6.

Daily frequency diagrams for ash (*Fraxinus*) pollen, 1943-8: an example of the compact type of incidence. The total incidence varies widely from year to year but the pattern based on simultaneous flowering remains the same. For further explanation see text. (Hyde (1952): *New Phytologist* 51. 287. Reproduced by permission of the Editors).

in a given district, hazel trees unlike ash trees, oak trees etc. flower not simultaneously but successively. Consequently the pollen season, though long, is never intense. Alder also gives diffuse frequency diagrams, and for similar reasons.

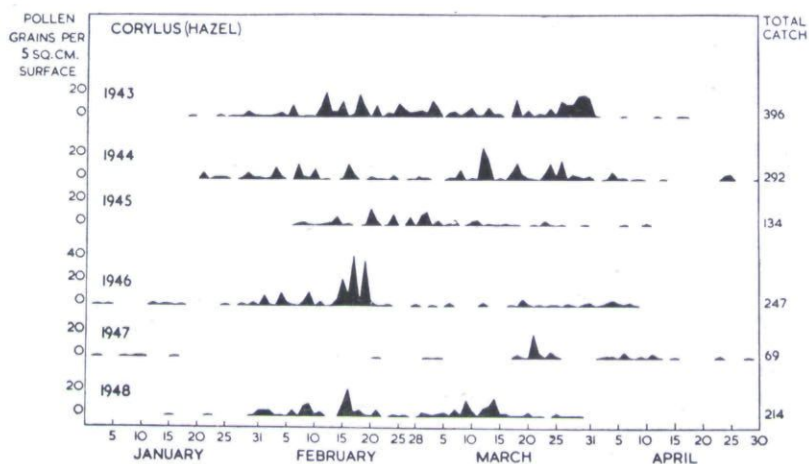


Fig. 7.

Daily frequency diagrams for hazel (*Corylus*) pollen 1943-8: an example of the diffuse type of incidence. Flowering is successive and there is no constant pattern of incidence. For further explanation see text.

8. ANNOTATED LIST OF TREE AND SHRUB POLLENS CAUGHT FROM THE AIR IN GREAT BRITAIN AND KNOWN OR PRESUMED TO BE ANTIGENIC

The following information is given here in regard to the various pollen types recognised:

(a) the names of the source plants and their status in Great Britain, i.e. whether native or introduced;

(b) the type of pollination if not purely by the wind;

(c) the type of pollen season (as deduced from frequency diagrams), i.e. whether compact, diffuse, or in this respect indeterminate.

(d) the earliest and latest observed dates when pollen is caught from the air; the constant period of occurrence, if any, is in *italics*;

(e) numerical indices of incidence (all stated as percentages of grass pollen incidence, in order to facilitate comparison with data already published (Hyde, 1952), viz., average annual

incidence (A.A.I.) at Cardiff, as a percentage of the A.A.I. of grass pollen at Cardiff (c. 11,000 grains/5 cm.²), highest annual incidence (H.A.I.) at any station, as a percentage of the H.A.I. of grass pollen at any station (c. 17,250 grains/5 cm.² at Edinburgh, 1943; catches made near ground level in grass fields being excluded as not comparable) and highest daily incidence (H.D.I.) at any station as a percentage of the H.D.I. of grass pollen recorded at any station (1679 grains/5 cm.² on Bishop Rock, 29 June 1953; catches in grass fields excluded as above): where the highest counts have been obtained outside Cardiff the name of the station is stated;

(f) reference to antigenicity as observed in Great Britain or, only in default of this, in North America.

Acer (Maple, sycamore). Sources: *Acer pseudoplatanus* (introduced, naturalised), *A. campestre* (native and common in England and Wales, not Scotland), and other introduced spp. Pollination chiefly by insects. Season compact: (30 March-) 6-8 May (-14 June). A.A.I. 0.8 %; H.A.I. 1.4 %; H.D.I. 5.3 %. Antigenic?

Aesculus (Horse-chestnut). Source: *Aesculus hippocastanum* (introduced, common as an ornamental tree). Pollination in part (? largely) by insects. Season compact: 18 April-19 June. A.A.I. 0.5 %; H.A.I. 2.1 % (Cambridge, 1943); H.D.I. 3.7 %. Antigenic?

Alnus (Alder). Source: *Alnus glutinosa* (native throughout). Season diffuse: (14 Jan.-) 3-23 March (-24 April). A.A.I. 3.8 %; H.A.I. 6.9 %; H.D.I. 11.5 %. Antigenic (Freeman, 1950); typical hayfever symptoms in January or February nearly always due to this or *Corylus* (Frankland, 1956).

Betula (Birch). Source: *Betula pubescens* and *B. verrucosa* (both native throughout). Season compact: (9 March-) 12 April-12 May (-9 June). A.A.I. 8.1 %; H.A.I. 13.2 %; H.D.I. 43.2 % (Bishop Rock, 1953). Antigenic: out of 59 hayfever patients interrogated by Frain-Bell (1951) one only experienced symptoms during the birch season and gave a positive skin reaction to birch pollen; he also reacted to hazel.

Frankland (1956) reports season heavy enough to produce asthma (2-3 weeks) in some patients.

Carpinus (Hornbeam). Source: *Carpinus betulus* (native in SE England, elsewhere rarely planted). Season compact: 20 March-23 May. A.A.I. 0.4 %; H.A.I. 2.4 % (Bishop Rock, 1953); H.D.I. 13.1 % (Bishop Rock, 1953). Antigenic in England (Frankland, 1956 a).

Castanea (Sweet Chestnut). Source: *Castanea sativa* (introduced; planted commonly in SE England, occasionally elsewhere). Season compact: (24 June-) 13-19 July (-21 August). A.A.I. 1.4 %; H.A.I. 2.2 %; H.D.I. 11.8 %. Antigenic?

Coniferae. 'Taxoid' pollen as recorded by us includes all grains similar to those of *Taxus baccata* (common yew), but exceeding 30 μ in diameter. Sources: mainly cypresses (*Cupressus* spp.) and false cypresses (*Chamaecyparis* spp.) which are occasionally planted, one of them (*Chamaecyparis lawsoniana*, Lawson Cypress) sometimes on a commercial scale. Season indeterminate: 2 March-7 May. A.A.I. 0.2 %; H.A.I. 0.5 % (Paddington, 1943); H.D.I. 1.1 % (Paddington, 1943). The pollen of *C. lawsoniana* is antigenic (Wodehouse, 1945).

Junipers (*Juniperus* spp.) are occasionally planted and one (*J. communis*) is native though rare; their pollen is probably antigenic (Wodehouse, 1945), it is certainly rare in Great Britain except near the source trees; it is distinguishable only with much difficulty from that of *Taxus* and no data on its incidence are available.

Corylus (Hazel). Source: *Corylus avellana* (native and common almost throughout). Season diffuse: (2 Jan.-) 13 February-29 March (-2 May). A.A.I. 2.5 %; H.A.I. 4.4 %; H.D.I. 7.6 %. Antigenic (Freeman, 1950). See also under *Alnus* and *Betula*.

Ericaceae (Heather Family). Source: principally Ling, *Calluna vulgaris* (native throughout, locally abundant). Pollination partly by insects, partly by wind. Season diffuse: (7 July-) 31 August-3 September (-28 September). A.A.I. 0.2 %;

H.A.I. 2.2 % (Black Mountains, 1947); H.D.I. 5.8 % (Edinburgh, 1943). Antigenic (Freeman, 1943).

Fagus (Beech). Source: *Fagus sylvatica* (native to southern Britain and locally abundant; very commonly planted elsewhere—the principal dicotyledonous tree in Scotland). Season compact: (12 April–) 8–18 May (–12 June). A.A.I. 2.2 %; H.A.I. 7.3 %; H.D.I. 11.8 %. Antigenic (Frankland, 1956a).

Fraxinus (Ash). Source: *Fraxinus excelsior* (native and common throughout, locally very abundant). Season compact: (3 March–) 13–28 April (–28 May). A.A.I. 7.5 %; H.A.I. 14.6 %; H.D.I. 25.5 % (Rothamsted¹, 1955). Antigenic (Freeman, 1950); Williams (1956) has observed clinical sensitivity at Cardiff.

Juglans (Walnut). Source: *Juglans regia* (introduced, planted here and there, usually as specimen tree). Season indeterminate: 1 May–7 June. A.A.I. 0.06 %; H.A.I. 0.6 % (Cambridge, 1943); H.D.I. 1.3 % (Rothamsted, 1952). Pollen of *Juglans* spp. is antigenic in N. America; an occasional cause (Wodehouse, 1935) but *J. regia* apparently harmless (Wodehouse, 1945).

Ligustrum (Privet). Source: *Ligustrum vulgare* (native and as such rare) and also *L. ovalifolium* and other introduced spp. common as hedge plants and flowering abundantly if neglected. Season indeterminate: 26 June–10 September. A.A.I. 0.4 %; H.A.I. 1.0 %; H.D.I. 7.3 %. Pollen of these and other species of *Ligustrum* is regarded as antigenic and locally important in N. America (Wodehouse, 1945).

Platanus (Plane). Source: chiefly London Plane, *P. acerifolia* (originated in cultivation and planted by thousands in London (over 3,000 in Royal Parks alone; the Bailiff, 1946)). Season compact: 16 April–5 June. A.A.I. 0.3 %; H.A.I. 110.8 % (Paddington, 1945); H.D.I. 294.4 % (Paddington, 1945). Antigenic (Freeman, 1950) but in spite of its

¹ I am indebted to the authorities of Rothamsted Experimental Station, Harpenden, Herts., for facilities for exposing slides and to Dr. (now Professor) P. H. Gregory and Dr. J. M. Hirst for their cooperation.

high abundance in a densely populated area, very few people are affected (Frankland, 1956).

Populus (Poplar). Source: *Populus serotina* and various other spp. planted here and there. Season indeterminate or diffuse as a whole. (7 February–) 27 March–3 April (–8 May). A.A.I. 0.9 %; H.A.I. 3.8 % (Cambridge, 1943); H.D.I. 18.5 % (Cambridge, 1943). Antigenic (Freeman, 1950).

Quercus (Oak). Source: *Quercus robur* and *Q. petraea* (both native and locally very abundant throughout). *Q. cerris*, *Q. ilex* and other introduced spp. occasionally planted. Season compact: sometimes with late extensions due to *Q. ilex*. (10 April–) 30 April–27 May (–27 July). A.A.I. 17.7 %; H.A.I. 63.9 % (Rothamsted, 1953); H.D.I. 235.2 % (Rothamsted, 1953). Antigenic (Freeman, 1950).

Rosaceae (arboreal). Source: Rose Family, chiefly Hawthorn, *Crataegus monogyna* (native and common throughout) but also fruit trees including apple (*Malus pumila*), plum (*Prunus domestica*) etc. Season indeterminate: (10 February–) 5–16 May (–28 September). A.A.I. 0.5 %; H.A.I. 0.6 %; H.D.I. 2.5 % (Paddington, 1943).

Salix (Willow). Source: *Salix* spp. especially *S. caprea* (native, probably common throughout). Pollination chiefly by insects. Season diffuse or indeterminate: (18 February–) 29 March–19 April (–30 May). A.A.I. 0.8 %; H.A.I. 1.9 % (Chesterfield, 1943); H.D.I. 4.7 % (Cambridge, 1943). Pollen of *Salix* spp. is antigenic in N. America but of minor importance (Wodehouse, 1945).

Sambucus (Elder). Source: *Sambucus nigra* (native and common probably throughout). Season compact: (24 May–) 13–28 June (–1 August). A.A.I. 1.2 %; H.A.I. 1.7 % (Chesterfield, 1943); H.D.I. 6.3 % (Chesterfield, 1943). Antigenic?

Tilia (Lime). Source: chiefly *Tilia europaea* (hybrid which originated in cultivation; very commonly planted, often in large numbers in avenues) and other species similarly employed. Pollination chiefly by insects. Season compact: (13

June-) 6-19 July (-22 August). A.A.I. 2.8 %; H.A.I. 3.7 %; H.D.I. 8.7 %. Pollen of *Tilia* spp. is antigenic in N. America; cases reported (Wodehouse, 1945).

Ulmus (Elm). Source: *Ulmus glabra* (native throughout); *U. procera* and other spp. native to parts of southern Britain and also planted often in considerable numbers in towns. Season compact on the whole, though long (the various species not flowering simultaneously). (1 January-) 16 February-26 April (-31 May). A.A.I. suburban Cardiff 4.6 %, central Cardiff 41.9 %; H.A.I. 51.1 %; H.D.I. 114.7 %. Antigenic (Freeman, 1950); Frankland (1956) reported one case of clinical sensitivity; Williams (1956) has observed clinical sensitivity at Cardiff.

9. DISCUSSION

(i) *Application of Thommen's postulates.*

The tree pollen types listed below meet the requirements of Thommen's postulates (Thommen, 1931), i.e. they are antigenic and their pollen is liberated in Great Britain in large quantities over a wide area:—*Alnus*, *Betula*, *Corylus*, *Fagus*, *Fraxinus*, *Quercus* and *Ulmus*. Of these *Corylus* has the lowest percentage figures of incidence, but its ubiquity justifies its inclusion in the list. *Platanus* has extremely high figures of incidence in London only. *Carpinus* and *Castanea* should also be reckoned with in SE England. The pollen of *Tilia*, *Populus* and *Sambucus* though sometimes present in large quantity is probably of local significance only; and the same applies in an even greater degree to the other types listed, with the possible exception of *Ericaceae*, on which our data may not be typical.

It is noteworthy that in general individual types of tree pollen seldom attain an incidence at all comparable with that of grass pollen: the exceptions being *Quercus*, *Platanus* (in London) and *Ulmus* (in central, not suburban Cardiff).

(ii) *The potential effect of massive and prolonged exposure.*

It seems to be generally accepted that massive, prolonged and repeated exposure to an inhalant allergen is specially conducive to sensitisation. The kinds of pollen which, to judge from their recorded abundance, are most likely to produce this effect in Great Britain are *Quercus* and, in certain areas, *Ulmus* (e.g. central Cardiff) and *Platanus* (London); and in a lesser degree *Betula* and *Fraxinus*: though only the first three named can be compared for abundance with grasses. All of the types mentioned have compact seasons and produce very high concentrations over periods of 7 to 21 days according to type. These periods are, however, short in comparison with the 45-day period of intense exposure to grass pollen which obtains generally in Great Britain (Hyde, 1952); and presumably the allergic potentialities of the pollens concerned are correspondingly lower. Furthermore, high concentrations of a given type of pollen do not recur year after year (as with grass pollen). A bumper year may be followed by one or more in which pollen frequency is insignificant; oak was excessively abundant in 1946 and has not since exceeded 40 per cent of the figure then recorded. It would seem that pollens of such variable annual abundance are less likely to occasion sensitivity than is one of high and relatively uniform abundance like grass pollen.

(iii) *Difficulties of diagnosis.*

It may be postulated that before any patient's illness can be diagnosed as an allergic reaction to a particular kind of inhalant it must be shown that he experienced his symptoms at a time or times when the inhalant concerned was present in large quantities in the air. The application of this postulate to tree pollen allergy is rendered difficult both by the variable phenology of tree pollens and by their highly variable abundance from year to year. It is true that most types of tree pollen exhibit a constant period and that the occurrence of symptoms within this period may give the physician a clue to

aetiology: but so much overlapping takes place that he may still be confronted with several possibilities. He can prove that his patient's symptoms occurred in a given year when significant quantities of a particular type of pollen were in the air only by consulting analyses of concurrent samples taken from the air. Even if he has done so and has also found that his patient is skin-sensitive to the pollen concerned, his calculations may be completely upset by variation in pollen abundance from year to year. If he subjects his patient to a course of hyposensitisation in preparation for the second season, he may find that in that year the amount of pollen present is insignificant: the patient may be free from symptoms, but he might well have been even without treatment.—These difficulties may account to some extent for the small number of proved cases of tree pollen allergy in Great Britain.

10. SUMMARY

1. The distribution of trees and woodland in Great Britain is briefly described from the point of view of allergy and the main results of a 15-year survey of pollen incidence are set out.

2. The incidence of twenty-one kinds of tree pollen is described and it is shown that seven of these are liberated in large quantities over a wide area in Great Britain, viz. *Alnus* (alder), *Betula* (birch), *Corylus* (hazel), *Fagus* (beech), *Fraxinus* (ash), *Quercus* (oak), and *Ulmus* (elm), and three others over important areas in London or SE England, viz. *Carpinus* (hornbeam), *Castanea* (sweet chestnut) and *Platanus* (plane). All the types named (with the possible exception of *Castanea*) are antigenic and therefore potential allergens, though only three, viz. *Platanus*, *Quercus* and *Ulmus* have a recorded pollen incidence comparable with that of grasses in Great Britain.

3. The quantitative incidence of most kinds of tree pollen is very variable from year to year: this probably hinders the development of sensitivity and it certainly complicates diagnosis.

4. Diagnosis is further complicated by variable phenology.
5. Regular pollen trapping and analysis are essential to satisfactory diagnosis and treatment.

It is a pleasure to acknowledge my indebtedness to all those who at various times have assisted by exposing slides to trap pollen from the air and whose names (if not recorded in previous publications) are given either at the foot of Table A or on page 228. During its earlier years the research described received generous aid in the form of a Government Grant voted by the Royal Society of London. I should also like to thank Dr. D. A. Williams for reading this article in draft and also Dr. W. Frain-Bell and Dr. A. W. Frankland for the loan of their respective theses.

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