

Pollen Seasons: Forecasts of the Most Important Allergenic Plants in Finland

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Occurrence of airborne pollen in Finland has been studied for 10 years in Turku (southern Finland), 8 years in Oulu, 4 years in Kuopio (central Finland) and 7 years at Kevo (northern Lapland). Observations on the pollen seasons of alder, birch, grasses and mugwort are presented. All these pollens occur in south and mid-Finland in quantities capable of causing allergy symptoms. Except for birch pollen, allergenic pollens occur in far lower concentrations than in central Europe. In northern Lapland only birch and pine pollen concentrations are high. Pollens may occur without signs of local flowering when there are southerly winds. This finding suggests that long-distance transport is an essential contributing factor to the occurrence of pollens. There are wide year-to-year variations in the start of pollen seasons and the quantities of pollens. The variations in the start of birch and grass pollen seasons could very much depend on the mean temperature in April. However, a forecasting model based on this and other spring-time temperature parameters often fails to give sufficiently accurate forecasts.

Key words: allergy; pollen; pollen seasons.

Accepted for publication 25 November 1985

CLINICAL ASPECTS

Except for birch pollen concentrations, pollen counts in Finland are much lower than those in central Europe. In clinical practice this means less symptoms for grass pollen-sensitive subjects. According to grass pollen data, which have been continuously recorded for many years, an essentially similar situation exists in all Nordic countries. This fact could more often be taken into consideration as an alternative way of treatment. For instance, an allergic patient could simply select a place for his summer vacation according to data about pollen concentrations. The details of local pollen forecasts are sufficiently accurate to allow a patient to prepare himself by taking preventive medications.

Precise knowledge of the occurrence of pollens in the atmosphere is an important tool in the diagnosis and treatment of hay fever. Continuous survey and reporting of pollen occurrence is a long tradition in many countries, and on the basis of this work (1, 2) pollen calendars have been constructed throughout Europe. Pollen forecasts can be made with some accuracy, e.g. in the case of grass (5) and birch pollens (16).

Based on 10 years' observations, the aim of this paper is to present the variations in timing and magnitude of pollen seasons in four locations from south to north Finland. The wide variability in pollen occurrence is compared with meteorological factors.

MATERIAL AND METHODS

The sampler used was a Hirst-Burkard trap (Burkard Manufacturing Co., Rickmansworth, Herts., England) (13). A Melinex transparent plastic tape was made adhesive with toluol solu-

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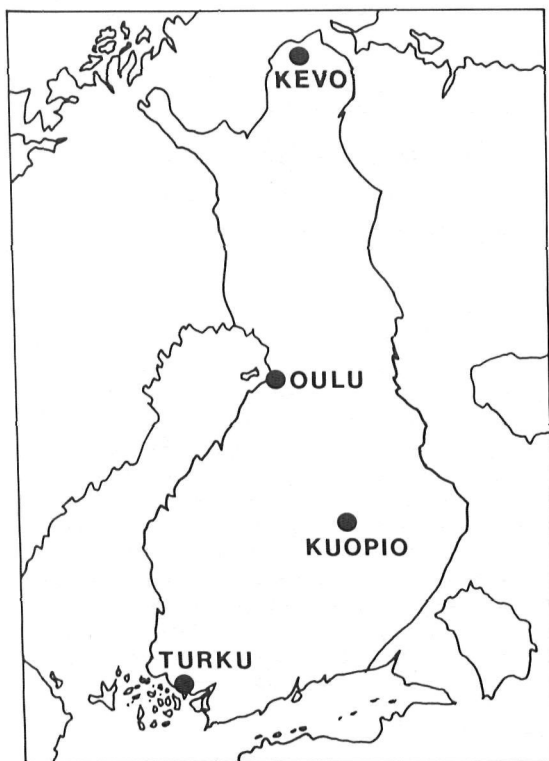


Fig. 1. Map of the sampling sites in Finland. Turku is located in the hemiboreal zone, Kuopio and Oulu in the northern boreal zone and Kevo in the subarctic zone.

tion of vaseline and paraffin. The tape was fixed around a drum, which was rotated by a 7-day clockwork at a speed of 2 mm/h. A built-in vacuum pump continuously sucks air through a slit against the adhesive tape, on which the airborne particles were attached. Daily sections of the tape (48 mm each) were mounted in Gelvatol (polyvinyl alcohol) under a cover glass. Pollen samples thus obtained were not stained nor fixed. They remained in native state and were easy to analyse. The results are given as pollen grains per cubic meter air (p.g. per m³) (13).

The sampling locations were the universities of Turku (40 m above sea level), Kuopio (100 m) and Oulu (25 m) and the Subarctic Research Station of Kevo (107 m) (Fig. 1). The samplers were situated at approx. 15 m above ground level except the Kevo sampler, which was placed at 5 m. The sampling period was all

the year round in Turku, from April to November in Kuopio and Oulu, and from May to October at Kevo.

Start of pollination was checked by visual observation.

RESULTS AND COMMENTS

Observations about pollen occurrence are shown in Figs. 2–5 as maxima, averages, and minima ever observed for a given calendar day. Also presented is the number of years pollen has occurred in the air. These are presented as the means of 3 consecutive days, starting from the onset of pollen occurrence. The ranges of the beginning and end dates of seasons and the maximum pollen concentrations in different parts of Finland vary considerably in different years (Table 1).

The earliest observations and the appearances of large amounts of pollen in the atmospheric air are given in Table 2. The correlations of mean spring-time temperatures with start of pollen seasons are given in Table 3. It is shown that there is a significant negative correlation between the mean temperature of April and the start of the birch and grass pollen seasons. The mean temperature of May has clearly less importance on pollination. The mean spring-time temperatures do not offer a reliable basis for forecasting the start of the pollen season. There are deviations of more than a week in the forecasts based on these parameters.

Alder (Fig. 2)

Alnus incana (grey alder) occurs in the whole of Finland and *A. glutinosa* (alder) as far as southern Lapland. *A. incana* generally starts flowering 1 week earlier than *A. glutinosa* (6). The two species probably share common major allergens (10).

The beginning of alder flowering varies within limits of 1 month. The variation in pollen amounts is large, because the weather is unstable in April. For example, in Turku the maxi-

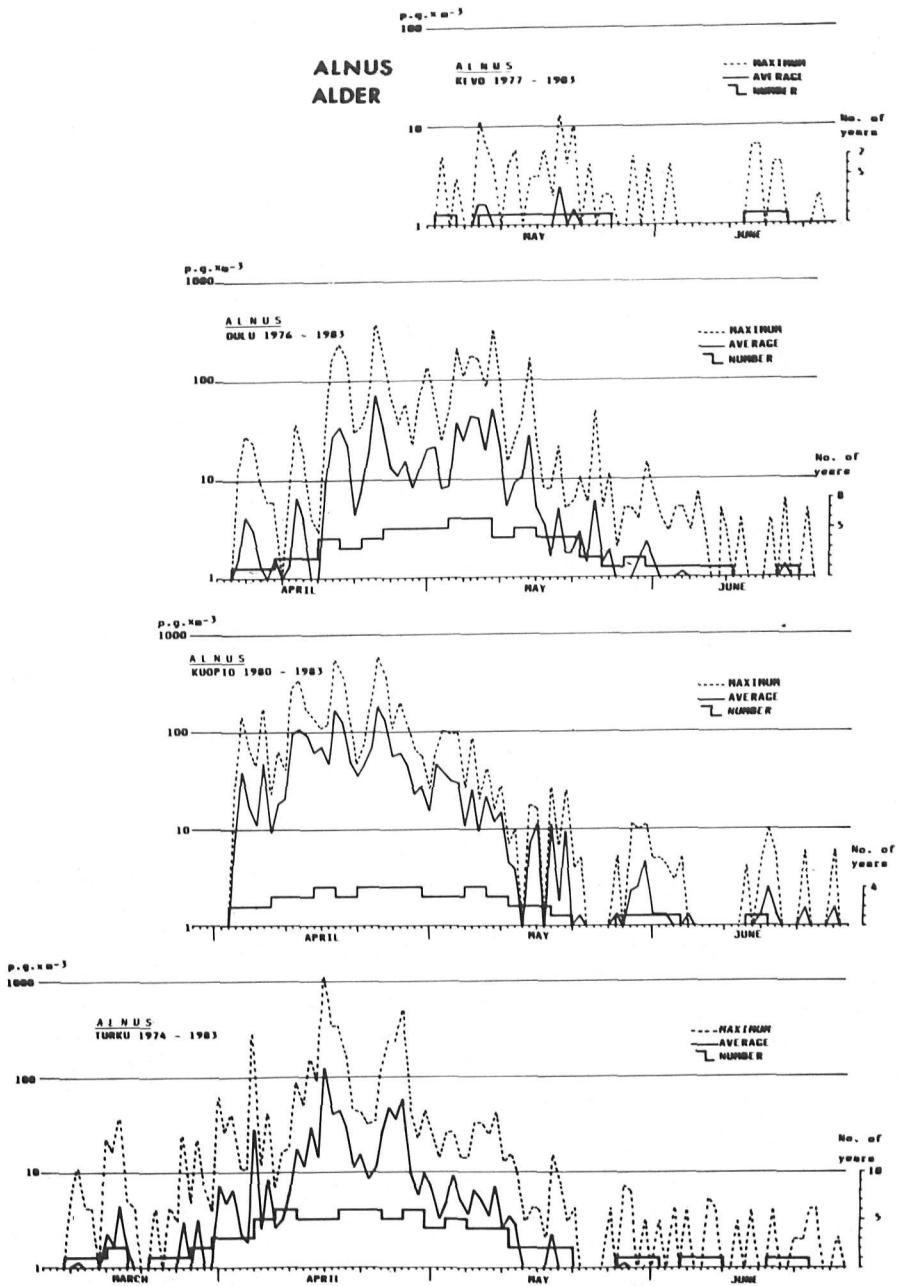


Fig. 2. Occurrence of *Alnus* (alder) in Turku, Kuopio, Oulu and Kevo. Maxima, averages and minima in a given day are presented. Note the logarithmic presentation. Number of years show in how many years airborne pollen has occurred out of observed years. This is calculated as the means of 3 consecutive days starting from the onset of flowering.

mum probability of alder pollen occurrence during season on a given day is only 60 % (Fig. 2). In central Finland (Kuopio and Oulu) there is a more regular alder pollen season with less

days without airborne pollen than in south-western Finland. Most of the alder pollen may be shed into the air within a few days. This happens when the pollen season has a sudden

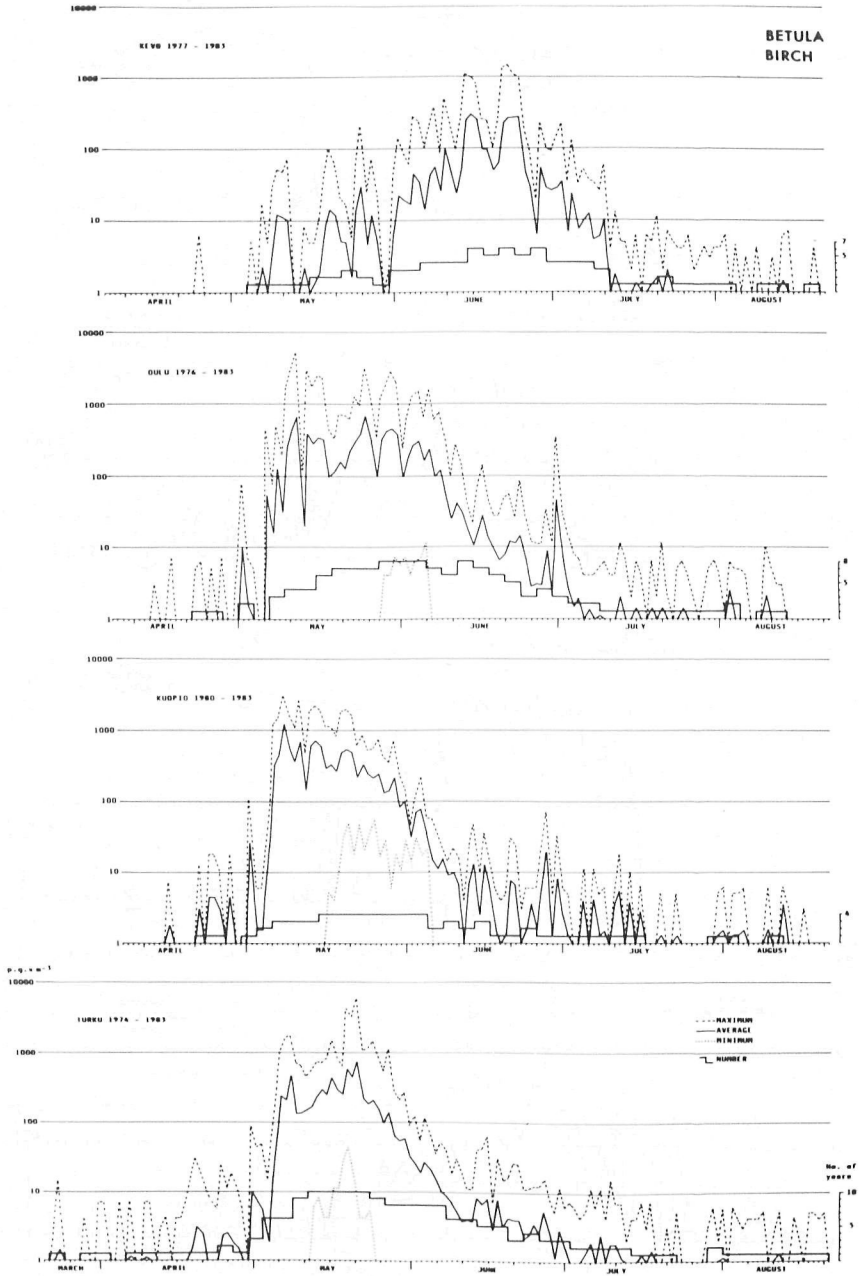


Fig. 3. *Betula* (birch) pollen. For explanation, see Fig. 2 legend.

late start with very warm weather. The forecasting of alder pollen is therefore unpredictable and subject to large errors. In south and central Finland airborne alder pollen grains may occur until the end of June.

Grey alder is the only alder species in the extreme north, and rare. This explains the short season and low maximum frequencies. There is a low occurrence of airborne alder pollen from May to mid-June.

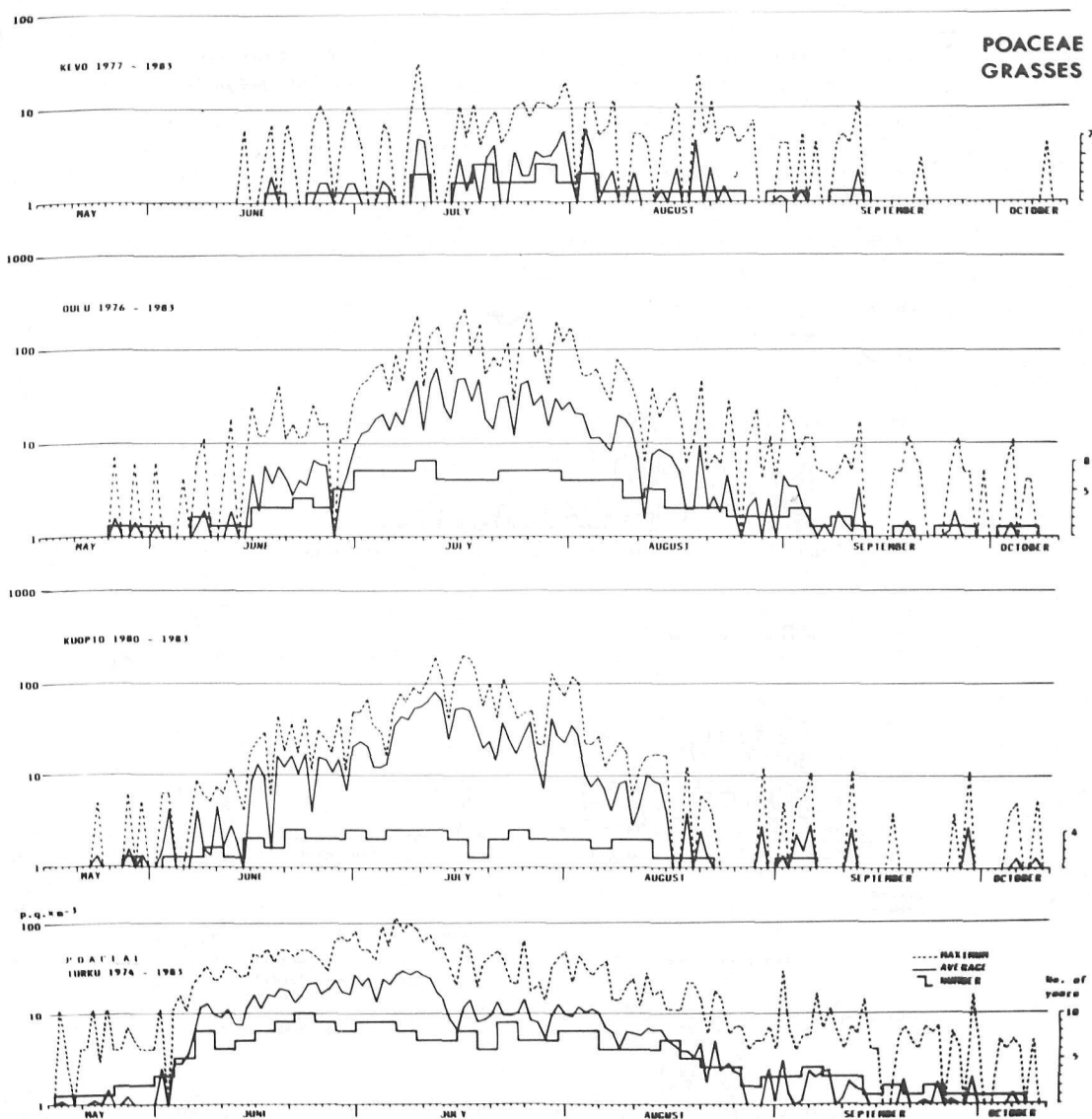


Fig. 4. Poaceae (grasses) pollen. For explanation, see Fig. 2 legend.

Birch (Fig. 3)

The three birch species in Finland: *Betula pendula* (silver birch), *B. pubescens* (birch) and *B. nana* (dwarf birch) grow throughout the country. All these species probably have highly cross-reacting allergens (10). *B. pendula* starts flowering 1-2 weeks earlier than *B. pubescens*. The beginning of flowering shows large variation. The mean temperature in April, which varies

between 1.4 and 5.3°C influences the beginning of birch pollination (Table 2).

Most of the birch pollen observed in April in southwestern Finland and in May in the north, occurs with south or southwesterly winds, indicating long-distance transport. At the same time there are no visible signs of local flowering. Another explanation is that strong winds are capable of shaking pollen grains out of local trees before the actual flowering. Birch flower-

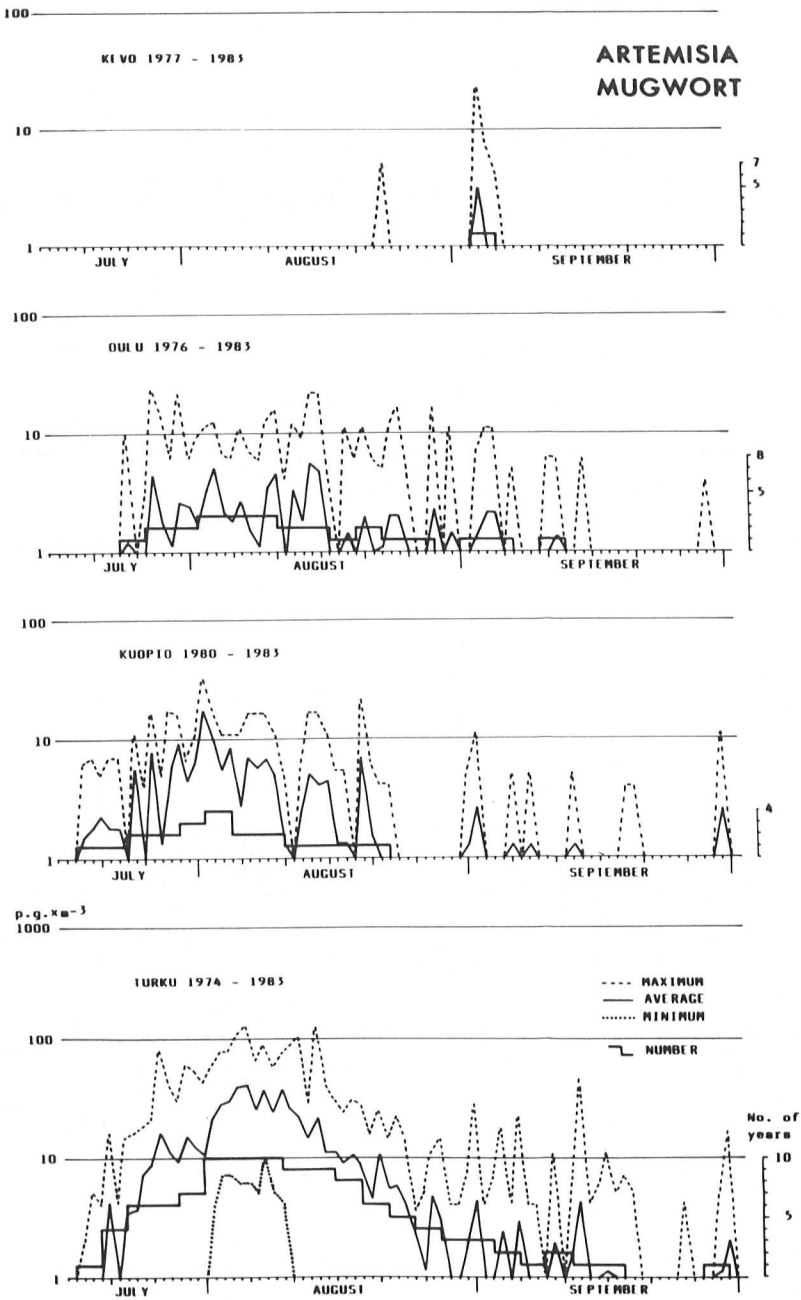


Fig. 5. *Artemisia* (mugwort) pollen. For explanation, see Fig. 2 legend.

ing generally starts approximately 1 month later in the north than in the south.

A few pollen grains are known to occur in the air all the year round. These findings are probably due to secondary emissions, and their clinical

significance is not clear. The pollen may have a partial lack of protein material. Birch-sensitive patients have been observed to start having symptoms when birch pollen reaches a concentration of 200 p.g. per m³ (17). This

concentration is exceeded in all parts of Finland over a season of 1–4 weeks. Allergic patients from European countries where birch does not grow may be allergic to birch owing to partial immunological identity between birch pollen allergens and those of several fruits and vegetables (7).

Grasses (Fig. 4)

Approximately 40 genera of grasses are represented in Finland. Various species have different flowering times. Some of these species have much the same allergens, while in others they differ (10). *Anthoxanthum odoratum* (sweet ver-

Table 1

Date range of pollen seasons and maximum daily concentrations observed in 1974 to 1983

	Start of pollen occurrence		Range of yearly maximum values per m ³	End of pollen occurrence	
	Earliest	Latest		Earliest	Latest
<i>Alder</i>					
Turku	March 11	April 7	25-1134	May 9	Sept. 25
Kuopio	April 13	April 14	142-580	May 18	June 17
Oulu	April 4	April 17	26-305	May 21	June 18
Kevo	May 2	May 14	4-12	May 8	June 17
<i>Birch</i>					
Turku	April 16	May 8	124-5859	June 15	July 15
Kuopio	April 21	May 16	696-2997	June 15	July 20
Oulu	April 22	May 17	288-5039	June 19	July 28
Kevo	May 6	May 22	207-1407	June 29	July 31
<i>Grasses</i>					
Turku	May 14	June 6	46-112	Sept. 11	Oct. 19
Kuopio	May 23	June 6	50-187	Sept. 9	Oct. 19
Oulu	May 26	June 11	40-263	Sept. 9	Nov. 2
Kevo	June 14	July 19	8-29	Aug. 19	Sept. 10
<i>Mugwort</i>					
Turku	July 17	July 29	22-126	Sept. 9	Oct. 19
Kuopio	July 11	July 26	11-32	Aug. 20	Sept. 29
Oulu	July 24	Aug. 11	11-23	Aug. 12	Oct. 9
Kevo	Aug. 23	Sept. 3	5-22	Aug. 24	Sept. 5

Table 2

Start of birch and grass pollen seasons and mean temperature in April and May in 1974 to 1983

	Mean temperature		Birch pollen		Grass pollen	
	April	May	1st obs.	> 100/m ³	1st. obs.	> 30/m ³
1974	3.2	8.0	May 4	May 17	May 20	June 19
1975	3.7	11.5	Apr. 16	May 6	May 14	June 8
1976	2.0	10.9	May 4	May 11	June 4	June 25
1977	1.4	9.1	May 4	May 5	June 6	June 15
1978	1.5	10.3	May 5	May 16	May 31	June 15
1979	2.1	10.1	May 2	May 21	May 23	June 17
1980	5.3	8.1	Apr. 30	May 5	May 18	June 11
1981	2.0	11.7	May 8	May 12	May 24	June 23
1982	2.6	8.7	May 1	May 6	May 27	June 27
1983	5.2	11.2	Apr. 20	May 5	May 17	June 15

nal-grass) and *Hierochloe* (holy-grass) species are the first to flower in the spring. Their pollen amounts are generally low, as they seldom grow in such large quantities as *Alopecurus* (fox-tail) and *Phleum pratense* (timothy). The start of flowering may have 1 month's variation, and between south and north there may be a difference of 2 months. Some species have a second flowering period in the autumn. If the autumn is warm a few pollen grains can occur in south and central Finland until the end of October. This can sometimes be associated with symptoms in hay fever patients. The mean temperature in April (1.4 to 5.3°C) has a significant negative correlation with the first occurrence of grass pollen. The mean temperature in May and the beginning of June roughly determines the date when grass pollen concentration exceeds 30 p.g. per m³ (Table 3).

In general, the amount of grass pollen is far lower than that reported for central Europe and Great Britain (1). In fact, the limit of 50 p.g. per m³, at which all grass pollen-sensitive subjects have symptoms (Davies, R. R. & Frankland, A. W.: oral communication), is only irregularly exceeded in Finland. A hay fever patient may experience that a therapy which is adequate in Finland will not prevent symptoms when travelling in Central European countries. And, vice versa, a hay fever patient from central Europe may experience far less symptoms in Finland than at home. A similar situation regarding grass pollen concentrations occurs in all Nordic countries north of Denmark (3, 8, 11, 12, 15).

Table 3

Correlations of the dates of first observation and > 100 pollen grains per m³ of birch pollen, and the dates of first observation and < 30 pollen grains per m³ of grass pollen to the mean temperature in April and May

Mean temperature	Birch pollen		Grass pollen	
	1st obs.	> 100/m ³	1st obs.	> 30/m ³
April	-0.62	-0.59	-0.83	-0.60
May	-0.27	-0.27	-0.30	-0.37
April + May	-0.56	-0.57	-0.67	-0.61

> 0.497 90 % of significance
 > 0.576 95 %
 > 0.708 99 %
 > 0.823 99.9 %

Mugwort (Fig. 5)

Seven *Artemisia* (wormwood) species occur in Finland. *A. vulgaris* (mugwort) is the commonest and occurs as far up as 67°N. It is rarely met in northernmost Finland. The start of flowering has 1–2 weeks' variation; the difference between Oulu and Turku is 1 week. The mugwort pollen season in south Finland lasts from about July 20 to September 15, and only in south Finland is there a regular peak season. In Kuopio the pollen season generally starts 1 day later than in the south, but the season is shorter. Also mugwort may have a second flowering period, and a few pollen grains occur in the south even during October, and in central Finland during September.

Others

Pinus sylvestris (pine) and *Picea abies* (spruce) pollens occur at the beginning of June. Pine pollen concentrations are generally high, (up to 2000 p.g. per m³ in the whole country. Spruce does not flower every year. The flowering cycle evidently lasts 4 years. The highest pollen concentrations in south Finland have been 180 p.g. per m³. Less than 1 % of the patients undergoing routine skin prick tests in our hospital show positive reactions to pine and spruce pollen extracts. Some of them have symptoms which may be due to these pollens.

Corylus avellana (hazel) occurs in low quantities in southwestern Finland, where it plays an allergenic role in limited geographical areas.

Approximately 30 *Salix* (willow) species and their hybrids occur in Finland. They are entomophilous (insect pollinated) plants, but airborne pollen also occurs in amounts causing allergic symptoms in south Finland from the end of April to June. In northern Finland pollen amounts are lower.

Airborne pollen of *Urtica dioica* (nettle) occurs in south Finland from June to August with daily concentrations which sometimes exceed 100 p.g. per m³. This may not be enough to cause symptoms in significant numbers of patients, because these pollens are small, 10–15 µm. Birch pollen grains are substantially larger

(25 μm), and 200 per m^3 are needed before causing symptoms in sensitive subjects (17). Grass pollen grains measure about 30 μm in diameter, and are estimated to cause symptoms in sensitive subjects when the pollen count exceeds 50 per m^3 (Davies, R. R. & Frankland, A. W.: oral communication). Only a few per cent of the subjects routinely tested in skin prick tests in our hospital show positive reactions to nettle. They do not generally show symptoms which could be associated with nettle pollen.

Taraxacum officinale (dandelion) and *Leucanthemum vulgare* (oxeye daisy) pollen occur extremely rarely in traps located at roof level. On the other hand, their pollen occur in relatively high concentrations at ground level, especially if the vegetation is agitated (9). Both these pollens partially share common allergens with mugwort (10).

DISCUSSION

According to our experience, pollen concentrations can be reliably predicted when the season has started, provided the general weather forecasting holds true. A real breakthrough, from the point of view of allergic patients, would be several weeks' forecast. The use of mean temperatures, rather than mean long-term pollen data makes it possible to obtain closer estimates of first pollen occurrence and first high concentrations. This will not succeed as well as grass pollen forecasting in England and central Europe (4, 5). Probably more sophisticated models will be necessary. Such a model has been suggested by Törnevik for birch pollen in Sweden (16).

There are many factors in Finland compared with central Europe which may make forecasting complicated. The winter may be cold and the deeply frozen soil will be late in thawing. Thus, in spite of a normal mean spring temperature, pollination will be delayed.

An exceptionally warm period in spring and summer is possible if the east-European "continental" air mass stays over Finland. If such a situation occurs, there will be a sudden increase in pollen amounts very early in the spring. This may be further amplified by an adaptive mech-

anism in northern plants. Birches in Lapland have the potential to start pollination after a shorter warm period than birches in southern Finland (14). This may hold true for other plants as well. It is also possible that instead of warm periods, there may be chilly periods. This means that even in south Finland snow-fall and daily mean temperatures below 0°C are possible at the beginning of June. It is not known whether these periods affect the viability of pollen-producing mechanisms.

In both southern and northern Finland there is a period before the "real" birch pollen season, during which a long-distance transport of pollen seems to be the only explanation for pollen occurrence. If this is true, local temperature factors alone will not be able to explain the early birch pollen occurrence, but also the wind parameter should be taken into consideration.

The presented material shows that the pollen occurrence in Finland as well as in other Nordic countries (3, 8, 11, 12, 15) differs very much from that of central Europe (2). This difference mostly favors allergic patients except those sensitive to birch pollen. The nordic climate and the acclimatized vegetation appear to be factors which make it difficult to forecast pollen occurrence.

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