

Temporal and geographical variations in grass pollen seasons in areas of western Europe: an analysis of season dates at sites of the European pollen information system

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Abstract

Geographical and temporal variations in the start dates of grass pollen seasons are described for selected sites of the European Pollen Information Service. Daily average grass pollen counts are derived from Network sites in Finland, the Netherlands, Denmark, United Kingdom, Austria, Italy and Spain, giving a broad longitudinal transect over Western Europe. The study is part of a larger project that also examines annual and regional variations in the severity, timing of the peak and duration of the grass pollen seasons. For several sites, data are available for over twenty years enabling long term trends to be discerned. The analyses show notable contrasts in the progression of the seasons annually with differing lag times occurring between southern and northern sites in various years depending on the weather conditions. The patterns identified provide some insight into geographical differences and temporal trends in the incidence of pollinosis. The paper discusses the main difficulties involved in this type of analysis and notes possibilities for using data from the European Pollen Information service to construct pan European predictive models for pollen seasons.

Introduction

The development of the European Pollen Information service during the last decade has linked National Pollen Networks throughout Europe (Jaeger, 1998). This has facilitated the analysis of geographical and temporal patterns in pollen seasons on a much broader scale than has been possible before the formation of the integrated network. This paper presents some preliminary aspects of a comparative study of grass

pollen seasons over areas of Western Europe from 1976 to 1997. The specific aims of the study are first: to determine whether there are any temporal and spatial patterns in the start dates, duration and occurrence of peak days in the records for grass pollen at the sites. Secondly the research aims to examine the main patterns identified in the features of the grass pollen seasons in relation to environmental and geographical factors particularly land use changes and climatic factors. This paper concentrates on a descrip-

tive account of the start dates of the grass pollen season over the study area. Other aspects of the work will be published in subsequent papers.

Previously, research has been conducted on the features of the grass pollen seasons within some countries in Europe (Emberlin et al., 1994; Emberlin et al., 1998) and a few studies have compared selected different locations (e.g. Galan et al., 1995). However little comparative analysis has been done over large sections of the European Network encompassing major differences in climate and biogeography. The results of the current study will be useful in palynological investigations, especially as an aid to determining the biotic responses of grass flowering to climatic trends. The analyses will also be relevant in assessments of the aerobiological implications of landuse changes. Information on the geographical contrasts in grass pollen seasons will provide environmental background data for use in the interpretation of spatial patterns that have been observed in the prevalence of seasonal allergic rhinitis and respiratory allergies (Strachan et al., 1997; ISAAC, 1998).

Materials and methods

Records of daily average grass pollen concentrations have been analysed for selected sites in Finland, the Netherlands, Denmark, United Kingdom, Austria, Italy and Spain, giving a broad longitudinal transect over western Europe. The data are derived from 12 pollen monitoring sites (Figure 1). These were selected to represent the main biogeographical regions of the transect that spans approximately 32 degrees of both longitude and latitude. Climatically the conditions at the sites range from Continental sub- Arctic in northern Finland to cold continental in southern Finland, through cool maritime in Denmark and the western temperate maritime zone in the Netherlands and United Kingdom to moderate continental in Austria, and Mediterranean in Italy and Spain (Pearce and Smith, 1994). The climatic zonation is reflected in the vegetation and land use but grasses form a notable component of the local flora throughout the transect. The daily records of airborne pollen concentrations monitored at the sites are all taken by standard volumetric spore traps of the Hirst design situated on exposed roof tops. Details of the data available for the sites are given together with descriptive statistics for start dates on Table 1. Comparative results for certain time spans are presented in the results section. For

example, nine of the sites have records since the mid 1970s giving over twenty years of data and eleven sites have continuous data from 1985.

At each site the daily average pollen counts have been analysed to identify the main parameters of the season. The start of the grass pollen season has been defined as the first day with a daily count higher than 1% of the annual total, presupposing that no more than six subsequent days followed with a zero count.

Geographical and annual patterns in the start dates have been examined for all of the sites in the study for the period 1991–1997. In addition, results have been investigated for five sites with data from 1985. These have been selected to represent the main climatic zonation over the transect. In the cases of sites with twenty year data sets, longer term trends have been investigated by the calculation of five year running means in order to smooth annual variations. The patterns evident are being investigated in relation to changes in land use and climatic factors. For example data on land use, including pasture, forestry and arable land has been obtained from EC Agricultural Statistics Year books (1975–1998) and meteorological data for key long term sites has been obtained. The relevant analyses will be presented in subsequent papers.

Results

Patterns considering all 12 sites from 1991 to 1997

Considering the starts of the grass pollen season in recent years, the average difference between the most southerly site (Cordoba in Spain) and the most northerly site (Kevo in Finland) is 73 days, giving a mean rate for the northerly progress of the start of the season of 2.3 days per degree of latitude. Over the seven year period the minimum lag time over the whole transect was 60 days. This featured in 1991 and also in 1993, both cool wet summers in many regions giving a late start to the grass pollen season over much of western Europe. In contrast the maximum lag time was 92 days, occurring in 1992 when the early summer was generally warm and dry.

The start dates follow the same general latitudinal pattern over the transect annually (Figure 2) with some notable differences occurring in exceptional years. For instance in the cool wet conditions of 1991 the season started at the Netherlands and Austrian sites uncharacteristically later than at Copenhagen.

The timing of the onset of the season at any latitude would be modified by local factors such as altitude and



Figure 1. The Locations of the European Pollen Information sites used in the study.

continentality. This can be illustrated by the three most southerly sites. Bologna and Cordoba are separated by only $6^{\circ}75'$ of latitude but by $15^{\circ}63'$ of longitude. Both sites are situated on inland plains (altitudes of traps are 45m and 120m a.s.l. respectively). The start dates for the grass pollen season are very similar being only three days different on average with a maximum difference of 9 days (1993) and in two years start dates at the two sites are the same. In contrast Perugia which is within 1° longitude of Bologna has later start dates (average start of season occurs 27 days after Bologna). It is likely that this difference is related to the higher altitude of the trap at Perugia (445m a.s.l.).

Considerable contrasts exist in the ranges of start dates both at individual sites and between climatic regions. For the two northern Finnish sites, the average maximum differences in start dates is 30 days (calculated as the mean of the difference between the earliest and latest start dates at each site). At Turku (southern Finland) it is 50 days. At Copenhagen the difference in start dates over the period 1991–1997 has been only 16 days but was 30 days if the period from 1977 is considered. In the case of the three sites in the north western maritime area (Netherlands and UK) the mean difference in start dates 1991–1997 is 27 days. This contrasts with 19 days for the two sites

in continental Europe (Austria). The three sites in the Mediterranean climatic zone have a mean annual maximum difference of 24 days.

Patterns over the transect from 1985 to 1997

Data are available for the period 1985 to 1997 for eleven sites over the transect. The start dates for the grass pollen season at five of these are discussed here as representative of the main climatic zones in the central part of the transect (Table 2 and Figure 3). The average difference in start dates from Bologna (Italy) to Turku (Finland) is 47 days but this varied from as little as 24 days in 1993, to 69 days in 1994. The grass pollen season starts notably earlier at Bologna in all years than at the other four sites where the start dates are more clustered. At each site the start dates differ considerably annually but there is a general pattern of increasing variation in start dates from the south of the transect (Bologna with a maximum difference of 11 days) to the North (Turku with 50 days difference).

Table 1. Statistical Data for Start Day of the Grass Pollen Season (Sampled from 1974).

Site	Latitude	Years sampled	Average	St. Dev	Min	Max
Kevo	69.45N, 27.01E	1976–1996	188.15	11.34	163	209
Oulo	64.58N, 25.43E	1976–1997	172.64	8.66	152	197
Turku	60.28N, 22.12E	1974–1997	160.63	9.11	131	181
Copenhagen	55.43N, 12.27E	1977–1997	143.24	7.67	128	158
London	51.30N, 0.10W	1974–1997	157.08	6.94	141	181
Leiden	52.09N, 4.29E	1977–1997	148.55	6.5	129	163
Helmond	51.28N, 5.40E	1975–1997	151.13	4.74	138	163
Vienna	48.11N, 16.22E	1976–1997	143.52	5.74	132	160
Klagenfurt	46.38N, 14.19E	1979–1997	139.74	5.93	130	155
Bologna	44.30N, 11.18E	1985–1996	116.42	5.32	108	129
Perugia	43.08N, 12.24E	1985–1996	131.42	5.85	115	146
Cordoba	37.55N, 4.45W	1991–1997	120	7.71	109	136

N.B. Start day = The number of days after January 1st.

Table 2. Descriptive Statistics for start dates of the grass pollen season at five sites 1985–1997.

	Bologna	Vienna	Helmond	London	Turku
Mean	116	143	148	155	163
Std Dev	6.7	7.2	6.7	9.7	13.9
Max	129	158	163	181	181
Min.	108	133	138	141	131

N.B. Days as from January 1st.

Trends in start of season dates at four sites 1977–1997

Five year running means for start of season dates have been calculated for four of the sites with long term data sets as examples of the biogeographical regions where data are available (Figure 4). These means are discussed in the next section.

Discussion and Conclusions

At all of the sites many species of grass contribute to the grass pollen catch but the spectrum differs regionally. In the vegetation regions at all four of the sites for which running means of start dates have been calculated, the majority of grass species are those that require the longer days of late spring and early summer to initiate flowering. To some extent this limits the biotic response to climatic shifts but the timing of flowering at any one latitude can differ by several weeks. This is mainly in relation to cumulated temper-

atures from the start of the growing season. Start dates in southern Finland have become slightly later; those in London are becoming slightly earlier, whereas those in the Helmond and Vienna have become notably earlier. In these three cases the earlier starts are probably due to warmer weather in the spring and early summer. Many areas of temperate western Europe have experienced above average temperatures during these months in recent years (Deutscher Wetterdienst, 1996; Emberlin et al., 1997; Mayes, 1998). Start dates in these areas are likely to continue to be frequently earlier than the long term averages as the trend towards warming is predicted to be sustained (Lockwood, 1998). The start dates of the grass pollen season which have been identified are an approximation based on a statistical approach. The figures can be taken as representative of the site environs for each area. It is very difficult to achieve a satisfactory definition of the start of season based on threshold levels required for allergic reactions as these not only differ between people but also for individuals through time depending on factors such as stress. In addition the data are daily averages which can mask short term peaks. Typically small amounts of grass pollen are present in the air at the start and end of the seasons. The application of the 1% method eliminates these tails and provides a mechanism for comparing seasons across broad geographic regions for several purposes. It is not intended to be an exact measure as any definition of a start date for a pollen season will be subjective. Slightly different results may have been obtained by using an alternative definition of the start of season. However the general geographical patterns would be the same.

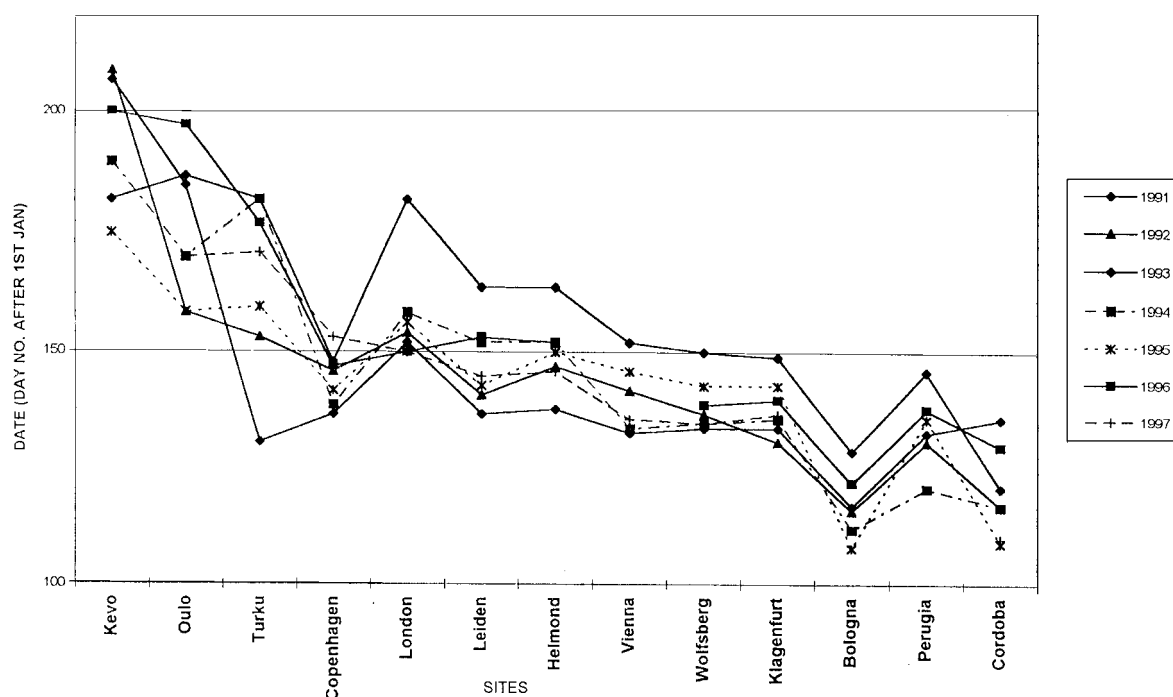


Figure 2. Start dates in the grass pollen season over western Europe 1991–1997.

The analyses have shown that notable variations occur in start dates both at individual sites and in the timing of the lags between sites over the transect annually. The course of the start of the grass pollen season northward through western Europe features in the same main pattern annually with few exceptions but the speed of its progress differs from year to year depending on weather conditions. The descriptive analysis provided so far has illustrated the extent of the variation in different regions and has demonstrated that variability in start dates tends to increase with latitude. Countries in northern Europe have been found to have generally higher prevalence rates of seasonal allergic rhinitis than those in the south. For example in an international study of hay fever among children ages 13–14 years the average percentage prevalence in Finland was 27.53, in the United Kingdom it was 35.08 and in Austria it was 17.05. In comparison the figures for Italy and Spain were 16.23 and 9.33 respectively (ISAAC, 1998). It is important that adequate warning of the onset of the grass pollen season is given, especially in those areas where the season may be severe and the start date highly variable. Environmental modelling is difficult in data sets with high variability as case repetition is rare. This problem is compounded by the fact that

the start of the seasons have become earlier in many areas in recent years, possibly as a response to warmer weather. These recent shifts need to be accommodated in forecasting.

These aspects present a clear need for the development of accurate prediction models at the European scale in order to improve forecasting the onset of the season regionally. Similarly, the results of the long term trends emphasise the need for continued monitoring over a wide network of sites. The starts of the grass pollen season in the various locations are likely to continue to change in response to climate. This may be progressive or transitory but in either case it is important to have accurate comparable data for environmental modelling.

The main geographical and temporal patterns in start dates described in this paper are being analysed in relation to weather patterns and aspects of land use. The results of this work will be published in subsequent papers together with analysis of the dates of peak counts and durations of the seasons. The results will provide insight to the changing aeroallergen load across Europe and will help in the formation of more accurate prediction models to forecast the start dates and features of grass pollen seasons.



Figure 3. The course of start dates at five sites 1985 to 1997.

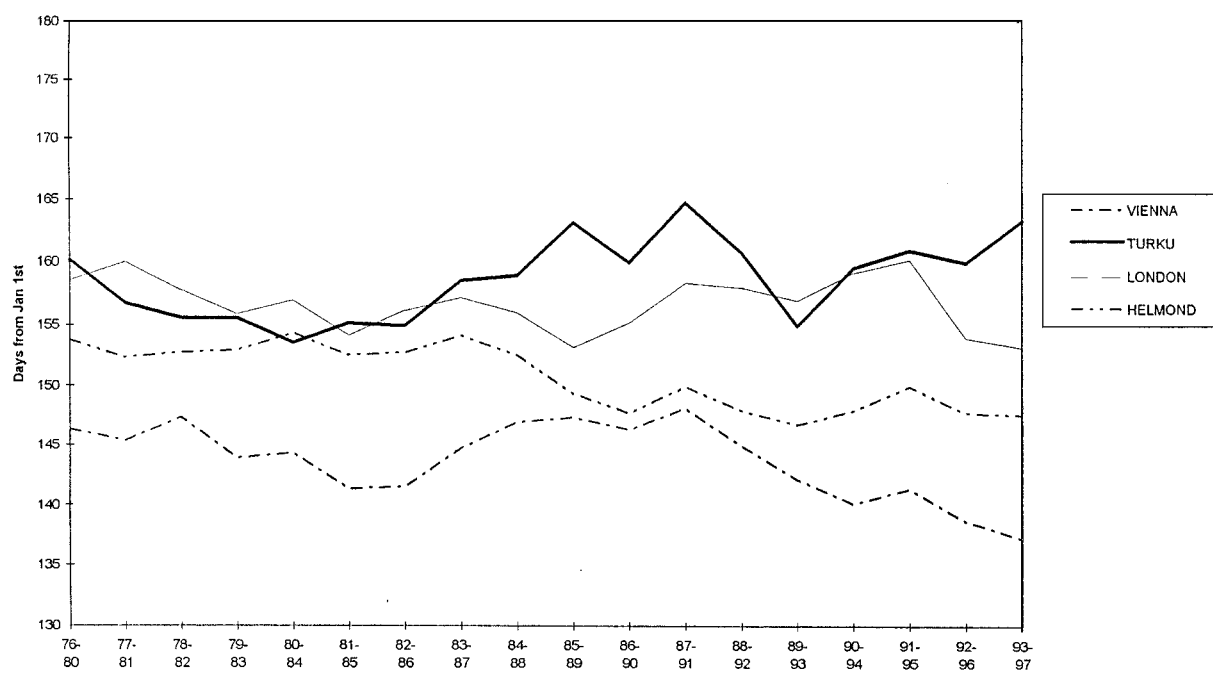


Figure 4. Five year running means for start days at four long term sites 1976–1997.

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