



Quantitative trends in annual totals of five common airborne pollen types (*Betula*, *Quercus*, *Poaceae*, *Urtica*, and *Artemisia*), at five pollen-monitoring stations in western Europe

F.Th.M. Spieksma^{1,*}, J.M. Corden², M. Detandt³, W.M. Millington², H. Nikkels¹, N. Nolard³, C.H.H. Schoenmakers⁴, R. Wachter⁵, L.A. de Weger¹, R. Willems⁴ & J. Emberlin⁶

¹Department of Pulmonology, Leiden University Medical Centre, P.O. Box 9600, NL-2300 RC, Leiden, The Netherlands; ²Midlands Asthma and Allergy Research Association, Derby, UK; ³Scientific Institute of Public Health-Louis Pasteur, Mycology Section, Brussels, Belgium; ⁴Algemeen Klinisch Laboratorium, Unit Chemie, Elkerliek ziekenhuis, Helmond, The Netherlands; ⁵Stiftung Deutscher Polleninformationsdienst, Meßstelle Delmenhorst, c/o Zur Löhnhorst 11, D-27777, Gandekersee, Germany; ⁶National Pollen Research Unit, University College, Worcester WR2 6AJ, UK

(*author for correspondence: Laan van Alkemade 1, NL-2341 LJ Oegstgeest, The Netherlands; Phone: +31 71 5153889; Fax: +31 71 5190057; E-mail: spieksma.ftm@wxs.nl)

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Abstract

The existence of long-term (20–33 years) trends in the annual totals of daily airborne pollen concentrations of five common and/or allergenic wind pollinating taxa was evaluated at five pollen-monitoring stations in western Europe: Delmenhorst (D), Helmond (NL), Brussels (B), Leiden (NL), and Derby (UK). At all stations, identical or comparable volumetric traps were used to sample pollen from the air. For grass pollen no increasing or decreasing trends were found at any station. Trends for birch pollen and oak pollen are increasing, but not significant at the stations with the higher annual totals (Delmenhorst and Helmond), probably due to strong year-to-year fluctuations. At all five stations significant increasing trends for stinging nettle pollen were observed. Trends for mugwort pollen are significant at all stations, but in different directions. Longer periods of observations are needed to arrive to more definitive conclusions about trends in airborne pollen concentrations.

1. Introduction

The study of fluctuations and trends in quantities of pollen in the atmosphere is of importance in various respects. One of the phenomena that might be reflected in the annual totals of daily airborne pollen concentrations is evidence of global change in the climate (Frei 1998; Menzel 2000), the hypothesis being that higher yearly average temperatures will lead to more pollen of some taxa in the atmosphere. Another aspect of interest in quantitative studies of atmospheric pollen is the possible relationship with the observed increase in the prevalence of pollen allergy in the human popula-

tion in many parts of the world (D'Amato et al. 1998; ISAAC 1998; Crane et al. 2002).

Reliable assessment of fluctuations and trends in airborne pollen can only be made by using long-term observations, preferably at several locations (Emberlin et al. 1999, 2000). In this study the annual totals of five common and/or allergenic pollen types (*Betula*, *Quercus*, *Poaceae*, *Urtica*, and *Artemisia*) at five pollen-monitoring stations in western Europe are presented. The stations are at Delmenhorst in Germany, at Helmond and Leiden in The Netherlands, at Brussels in Belgium, and at Derby in the United Kingdom. The periods of observation are between 20 years (Delmen-

horst) and 33 years (Leiden), all with 2001 as the last year.

2. Material and methods

2.1. Selection of the pollen types

The choice of the pollen types for this study was based on two criteria. First, the pollen type to be selected must be present in the air in relatively high concentrations every year at all stations. And second, they must include the most important allergenic pollen types, causing allergic sensitisation and pollinosis symptoms in the human population in the region. The number of pollen types was restricted to five, and the pollen types that met one or both of these criteria were *Betula* (birch), *Quercus* (oak), Poaceae (= Gramineae) (grasses), *Urtica* (stinging nettle), and *Artemisia* (mugwort).

2.2. Selection of the monitoring stations

In an earlier large multi-centre study of European pollen calendars more than 20 so-called “natural” pollen regions were distinguished, based on the synchronisation of the flowering periods of the grasses at adjacent stations (Spieksma 1991). One of these regions was designated as “western Europe”, and includes (parts of) Germany, The Netherlands, Belgium, and the United Kingdom. Five pollen-monitoring stations with long-term observation periods covering at least 20 years were selected for this study: Delmenhorst (near Hamburg) in Germany, Helmond and Leiden in The Netherlands, Brussels in Belgium, and Derby in the United Kingdom.

2.3. Sampling and measuring of atmospheric pollen

At all five stations identical pollen traps were operated: the Hirst-type continuous volumetric pollen sampler, mostly the 7-day recording version made by Burkard Manufacturing Co. Average daily pollen concentrations were assessed by scanning an area of the microscope slide, and referring the count of that area to 1 m³ of sampled air averaged over 24 hours. Detailed descriptions of the trap and the methods for preparation and scanning of the microscope slides can be found in Leuschner (1974) and in K  pyl   and Penttinen (1981).

2.4. Details of the monitoring stations

2.4.1. Delmenhorst

Data were collected from 1982 to 1991, and from 1993 to 2001, thus covering a period of 20 years, with only one year (1992) missing. The location of the pollen trap is at a height of 18 m, on the rooftop of a school building in the centre of the city, and did not change. Dominant vegetation in the direct environment of the trap consists of alder and poplar trees. Further away around the school, at 50 to 100 m distance, there are some oak trees and birches, a few plane trees, and lime trees in gardens, along streets, and in a park. To assess the daily airborne pollen concentration three longitudinal bands on the slide were scanned.

2.4.2. Helmond

The uninterrupted period of observations started in 1975, producing 27 years of data until 2001. The pollen trap was placed on the roof of one of the lower buildings of the “Elkerliek” hospital about 20 m above street level. Parks and private gardens are in the direct environment of the hospital, with birches as street trees, and a patch of wood with oak trees is at about 500 m distance. Three longitudinal bands on the microscope slide are scanned covering an area directly corresponding to 1 m³ of air.

2.4.3. Brussels

The series of measurements is from 1974 to 2001, covering an uninterrupted period of 28 years. In 1982 the trap was moved from the 26 m high building of the ULB Medical Faculty in the city centre to the 16 m high rooftop of the “Louis Pasteur” Scientific Institute of Public Health in the South of the city, where it is closer to a large forested region with oak and beech as dominant trees (Detandt and Nolard 2000). No overlapping parallel observations had been carried out; nevertheless, it was decided to include the first eight years of the series (1974–1981) in the presentation of the results, because there is no clearly visible abrupt deflection in the course of the data before and after the year 1981. Moreover, a separate statistical analysis of the data from the year 1982 did not show an essential difference with that over the entire period. Two longitudinal bands on the microscope slide were scanned.

2.4.4. Leiden

Observations started as early as 1969, thus covering a period of 33 years until 2001. From 1969 to 1978

the daily-operated Casella type of trap had been used, and in 1978 the weekly operated Burkard type of trap was installed, which was moved from the 20 m high building of the ENT clinic to the 25 m high rooftop of the West wing of the newly built LUMC hospital in 1985. Three, respectively two overlapping years of parallel observations were used to make correcting adjustments for the changes of type of trap and location (Spieksma and Nikkels 1998). Most of the environment around the trap is occupied by the Leiden central railway station, and by parking lots and streets, with some private gardens and some parks at a distance of 500 m or more to the West, where *Alnus* and *Populus* are the dominant trees. The scanning of three longitudinal bands on the microscope slide corresponds to a number of pollen grains per m³ of air.

2.4.5. Derby

Grass-pollen counts started in 1968, and the other pollen types were monitored from 1970. The trap is placed at a height of 10 m above street level on the roof of a building of the Derby University at the Mickleover site, a suburb approximately 4 km Southwest of the city centre. Up to 1990 a “Morrow Brown” version of the Hirst type trap (Morrow Brown and Jackson 1978) was used, which was sited in the centre of the city until 1989, also at a height of 10 m above street level. In 1991 a Burkard trap replaced the “Morrow Brown” version trap. Statistical analysis of the data set showed that the results could be treated as one population (Corden and Millington 1999). Mounting and staining techniques are according to Morrow Brown and Jackson (1978). Average daily airborne pollen concentrations were assessed as numbers per m³, and were calculated by counting three bands along the length of the slide, and applying the appropriate factor. After the standardization of all UK pollen monitoring stations, from 1990 the daily pollen concentrations were calculated by counting 12 transverse bands on the microscope slide (B.A.F. 1995).

2.5. Assessment of annual means and trends

The annual totals of the daily concentrations of airborne pollen are often highly skewed; so logarithmic means were calculated, to reduce the disproportionate influence of a few extremely low or high annual totals.

The correlation coefficient was calculated, and subsequently the statistical significance of the correlation between the annual pollen totals and the year

number was determined. The trend (%) was assessed by dividing the regression by the log. mean of the annual totals.

3. Results

Graphical presentations of the annual totals of the daily airborne pollen concentrations at the five monitoring stations, for the five selected pollen types *Betula*, *Quercus*, *Poaceae*, *Urtica*, and *Artemisia*, are given as histograms in Figures 1 to 5.

The numerical results of the sums of the annual totals, together with the logarithmic yearly means, the coefficients of the correlation (*r*) between annual total and year number, the levels of statistical significance (*p*) of this correlation, and the quantitative trends (%) are summarized in Tables 1 to 5.

In the histograms of Figures 1 to 5 the year-to-year trends are shown as regression lines of the correlations only, if the level of statistical significance has a *p*-value of 0.05 or lower.

3.1. Betula

The annual totals of the daily concentrations of airborne birch pollen, as shown in Table 1 and Figure 1, are higher at Delmenhorst and Helmond than at Brussels, Leiden and Derby. This difference is due to the fact that in the direct environments of the pollen traps at Delmenhorst and Helmond there are many more birch trees than at the other three stations.

Increasing trends in the annual totals are observed at all five stations. At Delmenhorst, with the highest annual totals (log. mean 5,765) there is a rather high positive trend with an increase of +6.70% per year, but due to very strong fluctuations in the annual totals, particularly in the period 1993–2001, the correlation between the annual totals and the year numbers is statistically not significant.

In contrast with this, Derby, with the lowest annual totals of airborne birch pollen (log. mean 1,010), has a statistically significant regression line for that correlation, also with the highest increasing trend of +8.54% per year. Also the correlation coefficient for the regression line of the increasing trend at Leiden (+4.14%) is statistically significant.

At Delmenhorst a more or less consistent alternating pattern in the year-to-year fluctuation in the annual totals, particularly in the period 1995–2001, is clearly visible in Figure 1. At Helmond and Leiden this pattern is less prominent.

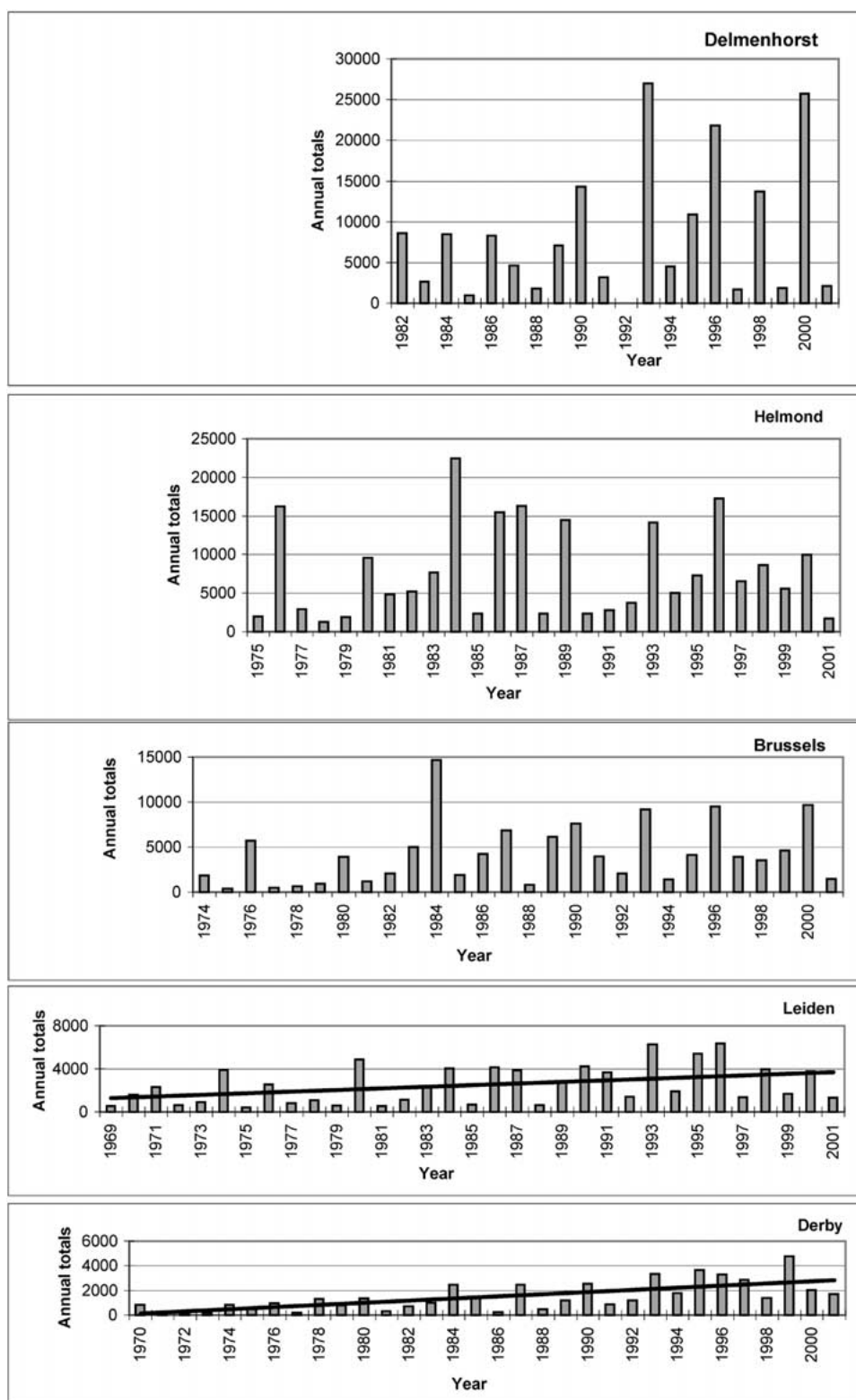


Figure 1. Annual totals of daily airborne concentrations of *Betula* pollen, at five pollen-monitoring stations in western Europe. Regression lines present statistically significant trends.

Table 1. Summary of numerical results of annual totals of *Betula* pollen at five pollen-monitoring stations in western Europe

	Delmenhorst	Helmond	Brussels	Leiden	Derby
Number of years	19	27	28	33	32
Sum of annual totals	169,357	210,044	117,996	81,689	47,021
Logarithmic mean	5,765	5,665	2,878	1,841	1,010
Correlation coefficient (r)	+0.29	+0.06	+0.31	+0.41	+0.69
Level of significance (p)	n.s.	n.s.	n.s.	< 0.05	< 0.005
Trend (%)	+6.70	+0.81	+4.54	+4.14	+8.54

3.2. Quercus

Just as for birch pollen, the annual totals of the daily airborne oak pollen concentrations (Table 2 and Figure 2) are higher at Delmenhorst and Helmond than at Brussels, Leiden, and Derby, again due to the presence of more oak trees in the environment of the first two mentioned stations.

Moderate to high increasing trends in the annual airborne pollen totals, ranging from +3.46% per year at Helmond to +8.65% at Derby, are seen at all five stations. Only for the three highest trends at Brussels, Leiden, and Derby is the correlation coefficient of the regression lines statistically significant. From Figure 2 it seems that the year-to-year increasing trends at all five stations have become more prominent since the year 1992.

A more or less distinct biennial or triennial alternating pattern in the annual totals of airborne oak pollen is observed at four of the five stations, Derby being the exception.

3.3. Poaceae

Airborne pollen concentrations of the grasses are high at all five stations (Table 3 and Figure 3), and there is not much difference between them. The yearly log. means of the annual totals of the daily concentrations range from 3,160 at Brussels to 5,488 at Leiden.

At all five stations, the year-to-year trends in the quantities of airborne grass pollen are very weak, and they are in different directions ranging between -0.88% at Brussels and +0.47% at Delmenhorst. The coefficients of the correlation between the annual totals and the year numbers are statistically not significant.

Year-to-year fluctuations in the annual totals of the daily airborne grass pollen concentrations are not very great, and do not show any consistent pattern over the

years, although long-term fluctuations are observed, particularly at Derby.

3.4. Urtica

Airborne pollen of stinging nettle in North-western Europe is known to be very abundant, as is confirmed by the results of this study (Table 4 and Figure 4). The highest annual totals of the daily concentrations are observed at Leiden (log. mean 6,785), the lowest at Derby (log. mean 4,237).

Trends of year-to-year increasing annual totals of airborne stinging nettle pollen are found at all five stations, with statistical significances of the regression lines representing the correlation coefficients.

Although the year-to-year fluctuations in the annual totals of stinging nettle pollen do not show any particular pattern, it noteworthy to see in Figure 4 that at four of the five stations (Derby being the exception) the year 1997 has the highest annual total in the period of observation.

3.5. Artemisia

Concentrations of airborne mugwort pollen never reach high values, the log. mean values of the annual totals of the daily concentrations ranging from 121 at Derby to 315 at Delmenhorst.

At all five stations a statistically significant regression line for a trend is found. However, at three stations (Delmenhorst, Helmond, and Leiden) the trend is increasing, and at the other two stations (Brussels and Derby) the trend is downward.

The year-to-year fluctuations in the annual totals are not strong, neither do they show any pattern. At Delmenhorst there is a period with relatively high airborne mugwort pollen concentrations between 1993 and 1997, and at Leiden there are two such periods from 1989 and 1992, and from 1995 and 1998.

Table 2. Summary of numerical results of annual totals of *Quercus* pollen at five pollen-monitoring stations in western Europe

	Delmenhorst	Helmond	Brussels	Leiden	Derby
Number of years	19	26	28	33	32
Sum of annual totals	51,775	97,488	38,204	47,245	26,634
Logarithmic mean	2,295	3,114	1,016	1,022	510
Correlation coefficient (r)	+0.42	+0.38	+0.45	+0.61	+0.54
Level of significance (p)	n.s.	n.s.	< 0.05	< 0.005	< 0.005
Trend (%)	+5.07	+3.46	+6.08	+8.05	+8.65

Table 3. Summary of numerical results of annual totals of *Poaceae* pollen at five pollen-monitoring stations in western Europe

	Delmenhorst	Helmond	Brussels	Leiden	Derby
Number of years	20	27	28	33	34
Sum of annual totals	100,471	137,365	92,133	185,732	198,989
Logarithmic mean	4,755	4,925	3,160	5,488	5,260
Correlation coefficient (r)	+0.08	-0.15	-0.22	+0.14	-0.12
Level of significance (p)	n.s.	n.s.	n.s.	n.s.	n.s.
Trend (%)	+0.47	-0.51	-0.88	+0.34	-0.37

Table 4. Summary of numerical results of annual totals of *Urtica* pollen at five pollen-monitoring stations in western Europe

	Delmenhorst	Helmond	Brussels	Leiden	Derby
Number of years	20	27	28	33	32
Sum of annual totals	106,855	200,006	174,845	245,695	142,139
Logarithmic mean	4,966	6,722	5,837	6,785	4,237
Correlation coefficient (r)	+0.58	+0.66	+0.59	+0.69	+0.38
Level of significance (p)	< 0.05	< 0.005	< 0.005	< 0.005	< 0.05
Trend (%)	+3.95	+4.08	+2.57	+3.53	+1.30

Table 5. Summary of numerical results of annual totals of *Artemisia* pollen at five pollen-monitoring stations in western Europe

	Delmenhorst	Helmond	Brussels	Leiden	Derby
Number of years	20	27	28	33	32
Sum of annual totals	7,184	5,496	5,718	12,840	4,523
Logarithmic mean	315	180	175	317	121
Correlation coefficient (r)	+0.56	+0.67	-0.54	+0.61	-0.62
Level of significance (p)	< 0.05	< 0.005	< 0.005	< 0.005	< 0.005
Trend (%)	+5.70	+4.53	-2.53	+5.47	-4.14

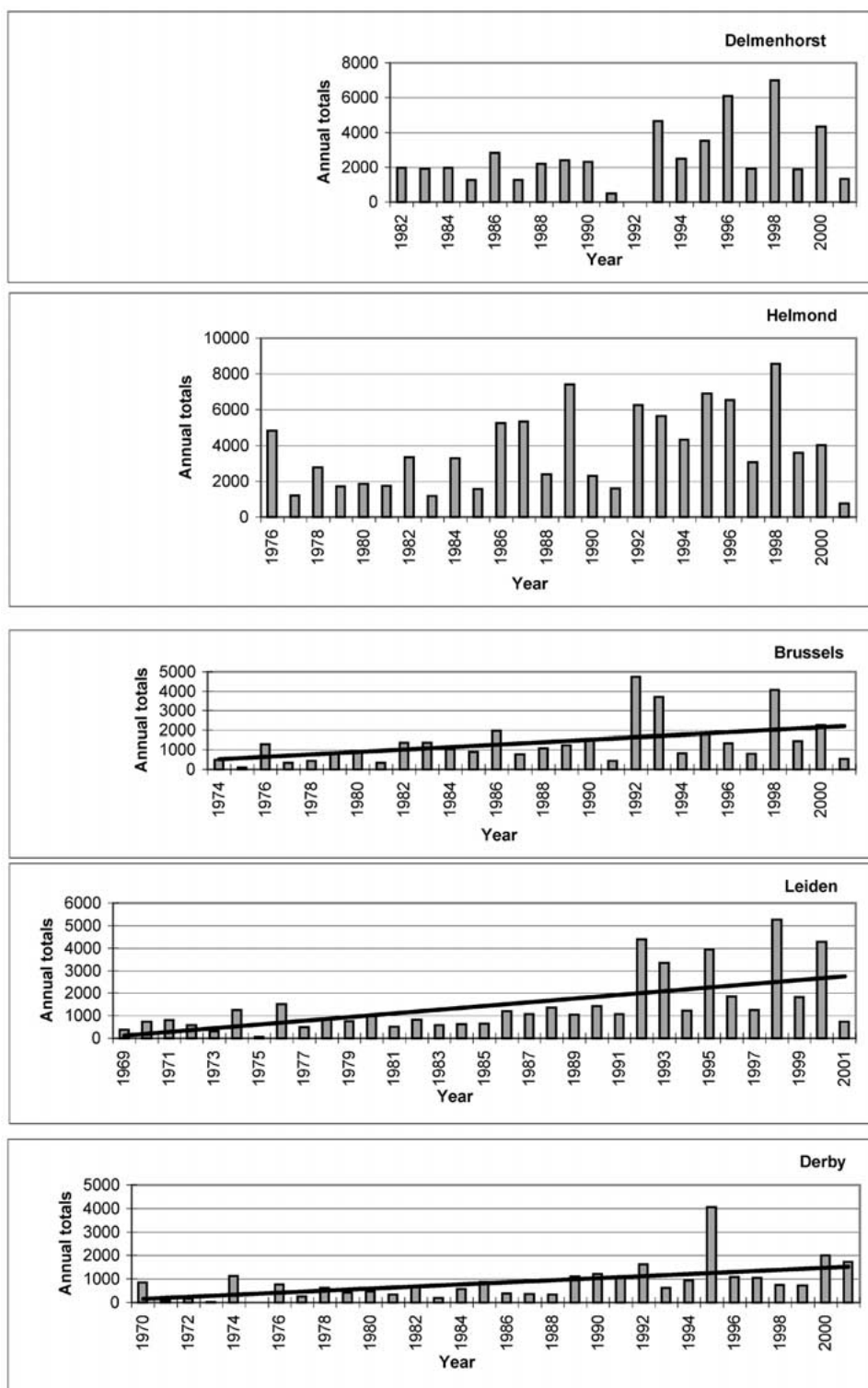


Figure 2. Annual totals of daily airborne concentrations of *Quercus* pollen, at five pollen-monitoring stations in western Europe. Regression lines present statistically significant trends.

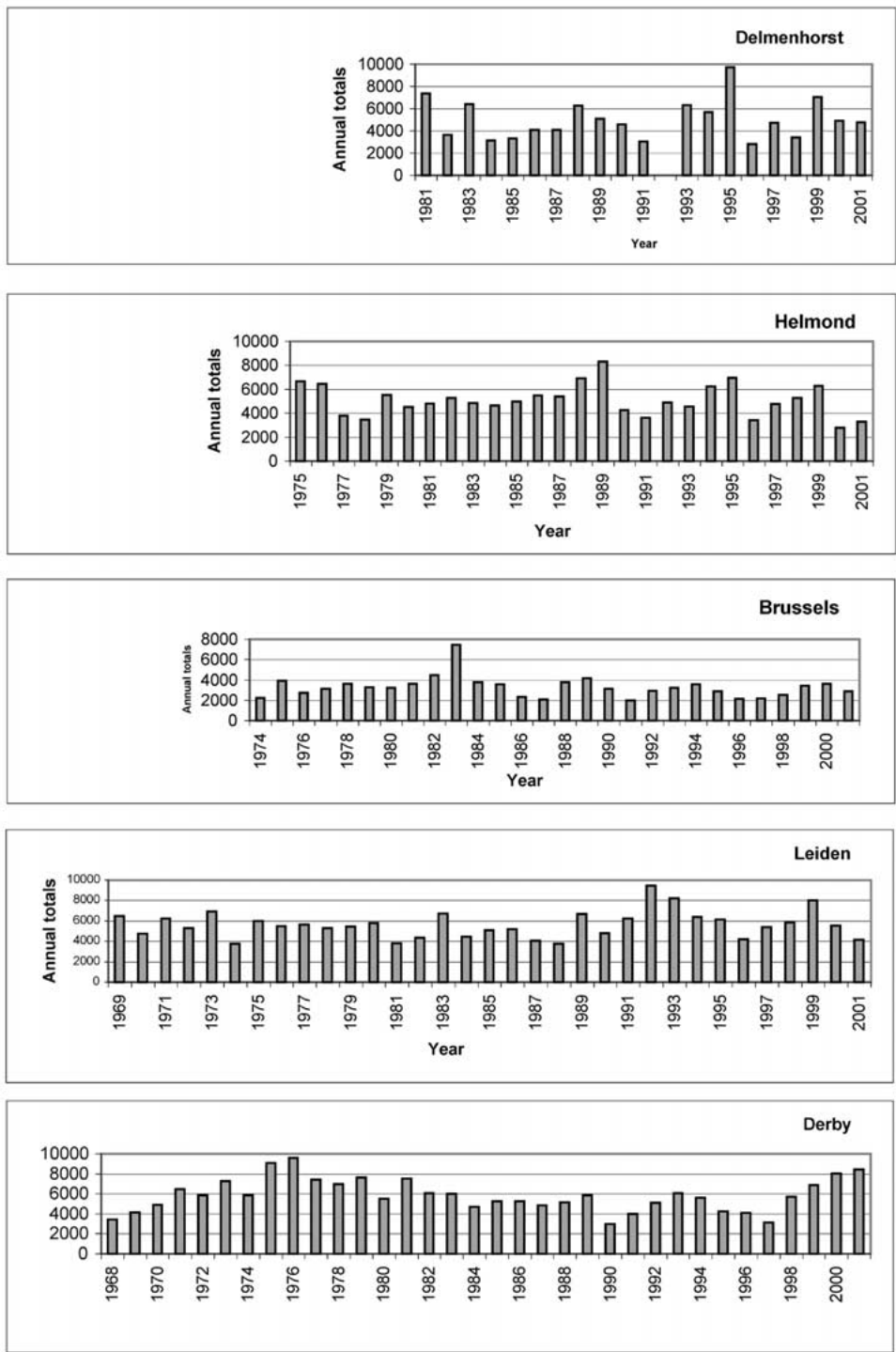


Figure 3. Annual totals of daily airborne concentrations of *Poaceae* pollen, at five pollen-monitoring stations in western Europe.

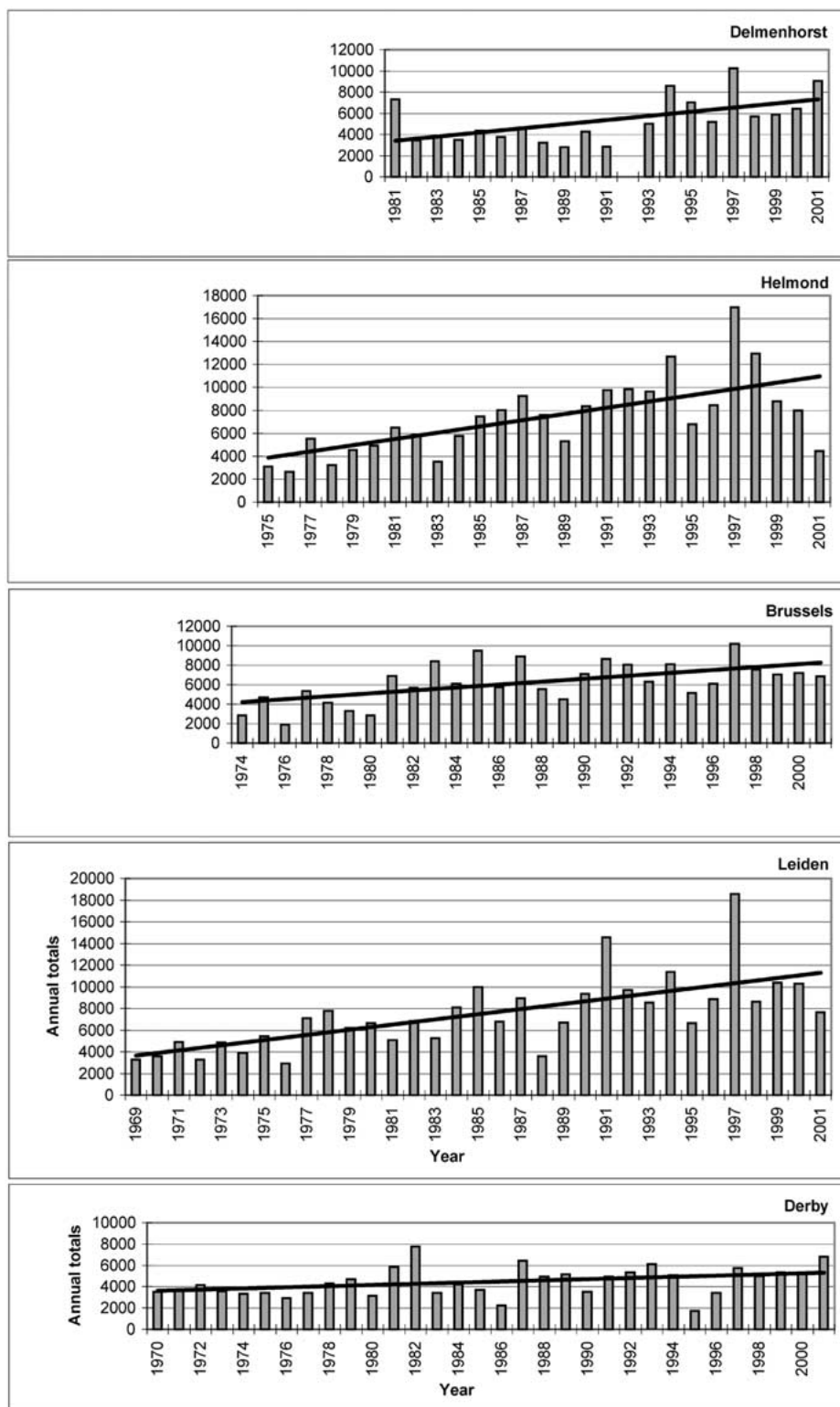


Figure 4. Annual totals of daily airborne concentrations of *Urtica* pollen, at five pollen-monitoring stations in western Europe. Regression lines present statistically significant trends.

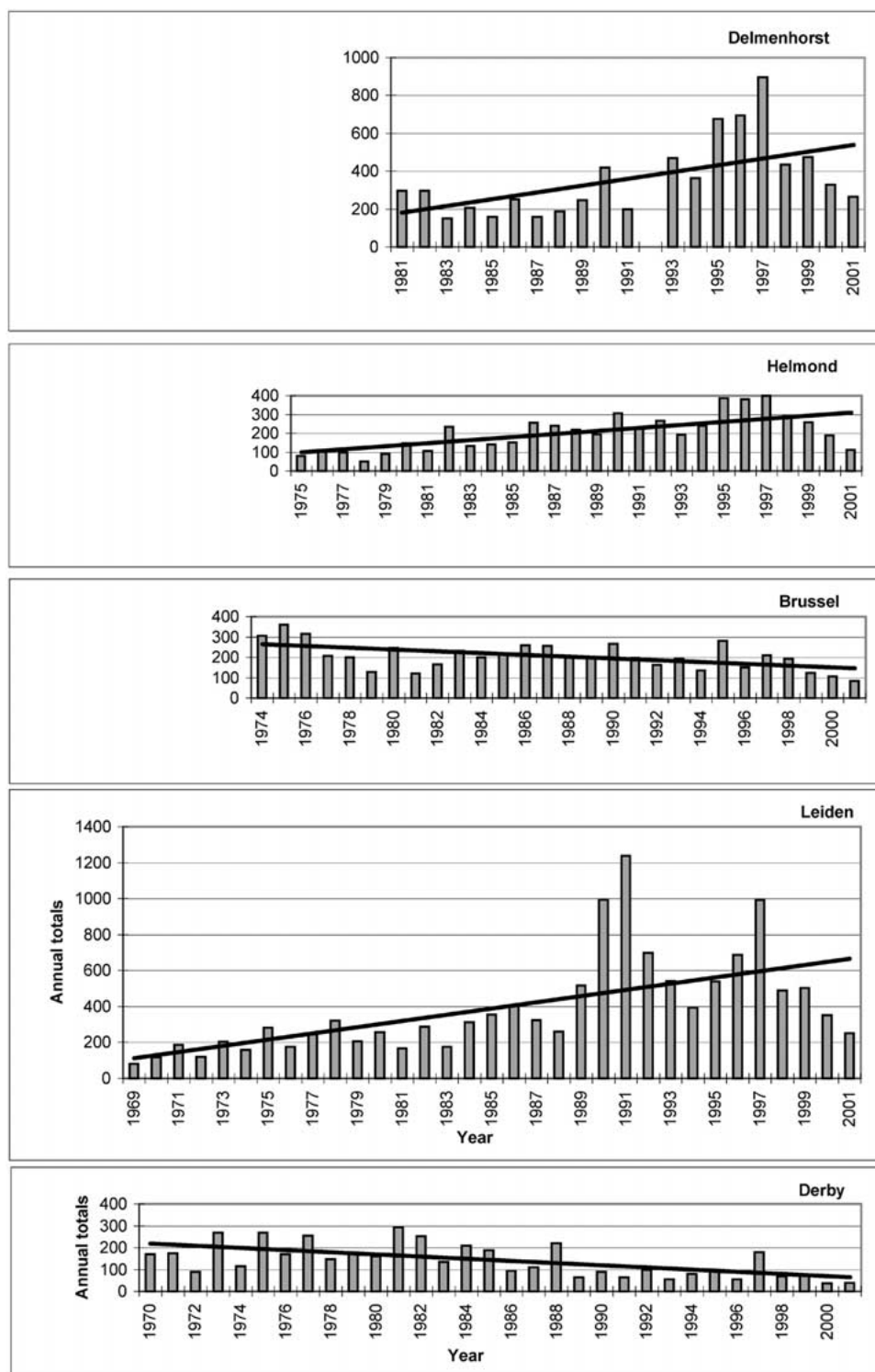


Figure 5. Annual totals of daily airborne concentrations of *Artemisia* pollen, at five pollen-monitoring stations in western Europe. Regression lines present statistically significant trends.

4. Discussion

4.1. *Betula*

The increasing trends in the annual totals of the daily airborne birch pollen concentrations are different at the five stations, showing a statistically significant regression at Leiden and Derby. Increasing trends, sometimes with statistically significant regression lines, have been found in earlier studies for the stations at Basel, Leiden, London, Leicester, Edinburgh, Turku, Copenhagen, and Viborg (Jäger et al. 1991, 1996; Emberlin et al. 1993; Spieksma et al. 1995; Corden et al. 2000; Rasmussen 2002), whereas the results of trends at Brussels and Vienna were not in agreement with each other (Jäger et al. 1991, 1996; Detandt and Nolard 2000). At Helmond no trend was found over a period of 25 years (Willems et al. 2000). In this study it appears that the stations with the smallest annual totals (Leiden and Derby) are showing trend lines that are statistically significant, contrary to the results at the other three stations.

On the other hand, at the stations where the annual totals are high (Delmenhorst and Helmond), due to the nearby presence of birch trees, there are strong, sometimes alternating year-to-year fluctuations. This tendency of the annual totals of airborne birch pollen to show a biennial alternating pattern has also been reported before by several authors (Atkinson and Larson 1990; Jäger et al. 1991; Spieksma et al. 1995; Corden et al. 2000, 2002; Latalowa et al. 2002; Rasmussen 2002). It has been suggested that this alternating pattern is (partly) caused by the supply of assimilates depending on the year-to-year leaf areas on the trees (Dahl and Strandhede 1996). A year with a relatively rich foliage and consequently few catkins may lead to many inflorescences in the next year with fewer leaves. Synchronism could be induced by external, mainly weather conditions, such as sunshine. Other authors have suggested that high pollen production in one year will lead to high fruit production, which will cost much energy inhibiting the development of flowers, and thereby pollen, in the next year (Hicks et al. 1994).

Detandt and Nolard (2000) report a tendency of a three-year cycle in the pattern of the annual totals of airborne birch pollen.

These sometimes-prominent alternating patterns are obscuring the consistency of the increasing trend, and are rendering the correlation coefficient of the regression line insignificant. This would lead to the

suggestion that future studies on year-to-year trends in annual totals of airborne birch pollen should be done with data from stations where there are no birch trees close to the trap, thus giving data representing a larger scale phenomenon, rather than the effect of more local, small scale behaviour of individual or a few birch trees.

One of the causes of an increasing trend in airborne birch pollen concentrations could be the phenomenon that the birch-pollen season is showing a trend towards an earlier starting date, which is a bit greater than the acceleration of the date of the end of the season (Emberlin et al. 1997; Frei 1998), making the birch-pollen season last a bit longer.

Whether the increasing trends in the airborne presence of birch pollen are leading to a higher prevalence of allergic sensitisation in the human population or not should be a matter of future aerobiological and allergological research, as this requires longer-term observations.

4.2. *Quercus*

The increasing trends in the annual totals of airborne oak pollen do not differ very much between the five stations. Just as for birch pollen, the three stations with the smallest oak-pollen quantities (Brussels, Leiden, and Derby) show statistically significant regression lines for the increasing trends, whereas at the stations with high concentrations of airborne oak pollen (Delmenhorst and Helmond) the upward trends have no statistically significant correlation between the annual totals and the year number. The tentative explanation for this finding is basically the same as for the situation with *Betula*, that high annual totals, caused by the nearby presence of the trees are coupled with strong year-to-year fluctuations, reducing the statistical significance of the position of the regression line of the correlation between individual annual totals and year numbers.

An increasing trend has been reported earlier for Brussels (Jäger et al. 1991) and for Derby (Corden and Millington 1999), while no trends were found at Vienna and Leiden (Jäger et al. 1991). More recently Detandt and Nolard (2000) did not find a trend in the annual totals of airborne oak pollen.

As in the case of birch pollen, also the annual totals of airborne oak pollen show a tendency to a biennial alternating patterns at most of the stations, particularly after the year 1993. This tendency has been repor-

ted before in other studies as well (Jäger et al. 1991; Corden and Millington 1999).

The existence of long-term trends and patterns in the annual totals of daily airborne oak-pollen concentrations, and their possible causes, should be studied further. As in the case of birch pollen, this should be done preferably with data from stations without nearby oak trees.

4.3. Poaceae

Quantitative differences in annual totals of airborne grass-pollen concentrations between the five monitoring stations are relatively small. These annual totals show an undulating overall course without any significant trend or consistent pattern. These findings are in agreement with most of the results of other studies (Corden and Millington 1991; Jäger et al. 1991; Spieksma and Nikkels 1998; Emberlin et al. 1999; Detandt and Nolard 2000; Willems et al. 2000), although decreasing trends are found for Leiden by Jäger et al. (1991), and for London and Derby by Emberlin et al. (1993, 1999).

One of the causes of this phenomenon could be the fact that grass pollen, which can be identified only at family level, is originating from many species of wild grasses, with different, overlapping flowering times, over a period of several months. Possible fluctuations and/or trends in the annual totals of airborne grass pollen from individual species would thus be obscured and would not be detectable in the analysis (Spieksma and Nikkels 1998).

Nonetheless, in the discussion about possible causes of the growing prevalence of hay fever and/or grass-pollen allergy, it is of interest to note that changes in the annual totals of daily airborne grass-pollen concentrations as such seem not to be the responsible factor (Emberlin 1994).

4.4. Urtica

A moderately increasing trend in the annual totals of daily concentrations of stinging-nettle pollen, with a correlation coefficient for the regression line being statistically significant, is found at all five monitoring stations. Earlier observations are in agreement with this finding (Jäger et al. 1991; Willems et al. 2000), whereas in an earlier study at Derby (Corden and Millington 1991) no trend was found.

It is known that nettle is often growing abundantly on soils with high nitrogen content. So the cause of the increase of airborne nettle pollen might

be sought in the accumulation in the soil of nitrogen containing substances ("nitrification") as a result of environmental pollution originating from various human activities such as growing traffic intensity and agricultural enterprises.

Allergy to pollen of stinging nettle is diagnosed only very infrequently, so a relationship with growing prevalence with pollinosis will be difficult to show.

4.5. Artemisia

The annual totals of daily airborne mugwort-pollen concentrations are generally small, and the differences might be due not only to the local presence of mugwort plants, but also be related with the height above street level of the location of the pollen trap (Spieksma et al. 2000).

Although the observed trends have statistical regression lines at all five stations, the directions of the trends are not the same. In two earlier studies performed at Brussels (Detandt and Nolard 2000) and at Helmond (Willems et al. 2000) no trends in the annual totals were found.

Mugwort grows typically as temporary pioneer plants on disturbed soils, particularly in places where building activities and other soil-disturbing events on neglected sites offer favourable conditions for pioneer plants. This feature might explain the temporarily high annual totals of airborne mugwort pollen at Leiden in the period 1989 to 1999, when in the direct environment of the pollen trap construction works were carried out for the building of the new hospital, the railway station, and other facilities.

Although *Artemisia* pollen is considered to be allergenic, the prevalence of allergic sensitisation to it is rather low. It causes symptoms of pollinosis only under conditions of high local exposure to mugwort pollen (Spieksma and von Wahl 1991), and a specific growth of the prevalence of allergy has not been reported.

5. Conclusions

Annual totals of daily airborne grass (Poaceae) pollen concentrations are not very different between the urban environments in western Europe. They do not show great year-to-year fluctuations, but overall undulating courses, without any consistent increasing or decreasing trend.

Pollen of stinging nettle (*Urtica*) is one of the most abundant airborne pollen types in northwest-

ern Europe, and still is significantly increasing over the period of observation of 20–33 years, at all five monitoring stations.

The observed significant trends in the relatively small quantities of airborne mugwort (*Artemisia*) pollen, increasing at three stations and decreasing at two stations, are probably the result of the transitory growth of mugwort plants on disturbed soils.

In northwestern Europe, annual totals of daily airborne concentrations of birch (*Betula*) pollen and of oak (*Quercus*) pollen have increasing trends that are significant only at the stations with the lower pollen amounts. Strong year-to-year fluctuations at sites with high annual totals may prevent the attainment of statistical significance of the increasing trends. Biennial or triennial year-to-year fluctuations in the annual totals are observed for birch (*Betula*) and for oak (*Quercus*) airborne pollen quantities.

Particularly for pollen types with great year-to-year fluctuations, like in arboreal taxa such as birch and oak, longer periods of observations are needed to be able to draw more definitive conclusions about quantitative trends in airborne pollen concentrations.

References

- Atkinson H. and Larson K.A.: 1990, A 10-year record of the arboreal airborne pollen in Stockholm, Sweden. *Grana* **29**, 229–237.
- British Aerobiology Federation (B.A.F.): 1995, *A Guide to Trapping and Counting*.
- Brown H. Morrow and Jackson F.A.: 1978, Aerobiological studies based in Derby. I. A simplified automatic volumetric spore trap. *Clin. Exp. Allergy* **8**, 589–597.
- Corden J.M. and Millington W.M.: 1991, A study of Gramineae and Urticaceae pollen in the Derby area. *Aerobiologia* **7**, 100–106.
- Corden J.M. and Millington M.: 1999, A study of *Quercus* pollen in the Derby area, UK. *Aerobiologia* **15**, 29–37.
- Corden J., Millington W., Bailey J., Brookes M., Caulton E., Emberlin J., Mullins J., Simpson C. and Wood A.: 2000, UK regional variations in *Betula* pollen (1993–1997). *Aerobiologia* **16**, 227–232.
- Corden J.M., Stach A. and Millington W.M.: 2002, A comparison of *Betula* pollen seasons at two European sites; Derby, United Kingdom and Poznan, Poland (1995–1999). *Aerobiologia* **18**, 45–53.
- Crane J., Wickens K., Beasley R. and Fitzharris P.: 2002, Asthma and allergy: a worldwide problem of meanings and management? *Allergy* **57**, 663–672.
- Dahl A. and Strandhede S.-O.: 1996, Predicting the intensity of the birch pollen season. *Aerobiologia* **12**, 97–106.
- D'Amato G., Spieksma F.Th.M., Liccardi G., Jäger S., Russo M., Kontou-Fili K., Nikkels H., Wüthrich B. and Bonini S.: 1998, Pollen-related allergy in Europe. *Allergy* **53**, 567–578.
- Detandt M. and Nolard N.: 2000, The fluctuations of the allergenic pollen content of the air in Brussels. *Aerobiologia* **16**, 55–61.
- Emberlin J.: 1994, The effects of patterns in climate and pollen abundance on allergy. *Allergy* **49**, 15–20.
- Emberlin J., Jäger S., Dominguez-Vilches E., Galan Soldevilla C., Hodal L., Mandrioli P., Rantio-Lehtimäki A., Savage M., Spieksma F.Th.M. and Bartlett C.: 2000, 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. *Aerobiologia* **16**, 373–379.
- Emberlin J., Jones S., Bailey J., Caulton E., Corden J., Dubbels S., Evans J., McDonagh N., Millington W., Mullins J., Russel R. and Spencer T.: 1994, Variation in the start of the grass pollen season at selected sites in the United Kingdom, 1987–1992. *Grana* **33**, 94–99.
- Emberlin J., Mullins J., Corden J., Brooke M., Savage M. and Jones S.: 1997, The trend to earlier Birch pollen seasons in the UK: a biotic response to changes in weather conditions? *Grana* **36**, 29–33.
- Emberlin J., Mullins J., Corden J., Jones S., Millington W., Brooke M. and Savage M.: 1999, Regional variations in grass pollen seasons in the UK, long-term trends and forecast models. *Clin. Exp. Allergy* **29**, 347–356.
- Emberlin J., Savage M. and Jones S.: 1993, Annual variations in grass pollen seasons in London 1961–1990: trends and forecast models. *Clin. Exp. Allergy* **23**, 911–918.
- Emberlin J., Savage M. and Woodman R.: 1993, Annual variations in the concentrations of *Betula* pollen in the London area, 1961–1990. *Grana* **32**, 359–363.
- Frei Th.: 1998, The effect of climate change in Switzerland 1969–1996 on airborne pollen quantities from hazel, birch and grass. *Grana* **37**, 172–179.
- Hicks S., Helander M. and Heino S.: 1994, Birch pollen production, transport and deposition for the period 1984–1993 at Kevo, northernmost Finland. *Aerobiologia* **10**, 183–191.
- International Study of Asthma and Allergies in Childhood (ISAAC): 1998, Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema. *Lancet* **351**, 1225–1232.
- Jäger S., Nilsson S., Berggren B., Pessi A.-M., Helander M. and Ramfjord H.: 1996, Trends of some airborne tree pollen in the Nordic countries and Austria, 1980–1993. *Grana* **35**, 171–178.
- Jäger S., Spieksma F.Th.M. and Nolard N.: 1991, Fluctuations and trends in airborne concentrations of some abundant pollen types, monitored at Vienna, Leiden, and Brussels. *Grana* **30**, 309–312.
- Käpylä M. and Penttinen A.: 1981, An evaluation of the microscopical counting methods of the tape in Hirst-Burkard pollen and spore trap. *Grana* **20**, 131–141.
- Latalowa M., Mietus M. and Uruska A.: 2002, Seasonal variations in the atmospheric *Betula* pollen count in Gdansk (southern Baltic coast) in relation to meteorological parameters. *Aerobiologia* **18**, 33–43.
- Leuschner R.M.: 1974, Luftpollenbestimmung in Basel während der Jahre 1969 und 1970. *Verh. Naturforsch. Ges. Basel* **84**, 521–626.
- Menzel A.: 2000, Trends in phenological phases in Europe between 1951 and 1996. *Int. J. Biometeorol.* **44**, 76–81.
- Rasmussen A.: 2002, The effects of climate change on the birch pollen season in Denmark. *Aerobiologia* **18**, 253–265.
- Spieksma F.Th.M.: 1991, Regional European pollen calendars. In: G. D'Amato, F.Th.M. Spieksma and S. Bonini (eds), *Allergenic Pollen and Pollinosis in Europe*. Blackwell: Oxford, pp. 49–65.
- Spieksma F.Th.M., Emberlin J.C., Hjelmroos M., Jäger S. and Leuschner R.M.: 1995, Atmospheric birch (*Betula*) pollen in Europe: trends and fluctuations in annual quantities and the starting dates of the season. *Grana* **34**, 51–57.

- Spieksma F.Th.M. and Nikkels A.H.: 1998, Airborne grass pollen in Leiden, The Netherlands: annual variations and trends in quantities and season starts over 26 years. *Aerobiologia* **14**, 347–358.
- Spieksma F.Th.M., van Noort P. and Nikkels H.: 2000, Influence of nearby stands of *Artemisia* on street-level versus roof-top-level ratio's of airborne pollen quantities. *Aerobiologia* **16**, 21–24.
- Spieksma F.Th.M. and von Wahl P.-G.: 1991, Allergenic significance of *Artemisia* (mugwort) pollen. In: G. D'Amato, F.Th.M. Spieksma and S. Bonini (eds), *Allergenic Pollen and Pollinosis in Europe*. Blackwell: Oxford, pp. 121–124.
- Willems A.J.W.P., Trepels J.J., van Duijnhoven J.L.P. and Schoenmakers C.H.H.: 2000, Correlation of 25 years of pollen-counts (1975–1999) from *Betula*, *Poaceae*, *Urtica* and *Artemisia* with the local meteorological parameters temperature and rain. Second European Symposium on Aerobiology, Vienna, Austria, abstr. P206, pp. 70–71.