

Atmospheric pollen dynamics in Münster, north-western Germany: a three-year study (2004–2006)

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Received: 7 March 2011 / Accepted: 11 January 2012
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Abstract An aeropalynological study was carried out in the atmosphere of Münster, the largest city in the region of North Rhine-Westphalia (north-western Germany), based on the data obtained during a 3 year of air-monitoring study (2004–2006) using a Hirst-type volumetric pollen trap. During the studied period, a total of 34 pollen types were identified in the atmosphere of the city, 20 corresponding to woody taxa and 14 to herbaceous taxa. The mean annual pollen index was 34,737, although there were important fluctuations from year to year. March to August was the period when more than 95% of the annual total was collected. The 10 most abundant pollen types detected were *Betula*, Urticaceae, *Taxus/Cupressaceae*, *Quercus*, *Alnus*, Poaceae, *Pinus*, *Fraxinus*, *Platanus* and *Fagus*, in order of abundance, which, together, accounted for 89.15% of the total pollen. To better observe the overall dynamics of the different pollen types in the atmosphere of Münster, a pollen calendar was drawn up. This showed typical features of North European pollen calendars: a winter period with very little pollen, short intense seasonal periods, and a high representation of pollen types from species characteristic of mixed Mid-European and riverside forests, such

as *Alnus*, *Betula*, *Corylus*, *Fagus*, *Picea*, *Pinus*, *Populus*, *Salix*, *Fraxinus* and *Carpinus*.

Keywords Aerobiology · Pollen · Munster · North-west Germany

1 Introduction

As is well known, knowledge of the pollen content of the atmosphere is considered a very useful tool in the treatment and diagnosis of hay fever, an allergic disease that has strongly increased throughout Europe in the recent decades (Marshall 2004). In Germany, many aerobiological studies have been carried out by the German Pollen Information Service (PID, Stiftung Deutscher Polleninformationsdienst, www.pollenstiftung.de) and by the Weather German Service (DWD, Deutscher Wetterdienst), thanks to the project OMNIBUSS (Online-Monitoring Natürlicher Inhalativ-allergener Bioaerosole und Sonstiger Staubkomponenten), in which other institutions are also participating. However, and paradoxically, in the scientific literature, it is difficult to find papers related with aerobiological studies conducted in Germany. The few papers that we did find are related to partial studies or form part of other more ample works (Kersten et al. 1991; Spiekma et al. 2003; Estrella et al. 2007).

As members of the Spanish Aerobiology Network, we had already carried out many studies of the atmosphere of

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several localities in southern Spain, but in 2003, we were requested, by the a.e.r.o.medi Company (Aerobiology and Environment Research and Observation, The Netherlands), to initiate a study of the atmosphere of the German city of Münster, testing at the same time the usefulness and effectiveness of a new staining solution for mounting aerobiological samplers, based on Pyrogallol red (Csiba and Szecsenyi-Nagy 1989; Shojaee et al. 1996). The study began in February 2004.

The city of Münster, with almost 300,000 inhabitants approximately, is the largest city in the German state of North Rhine-Westphalia. It is located in north-western Germany ($51^{\circ}57'47''\text{N}$, $7^{\circ}37'43''\text{W}$) and presents a mean elevation of 60 m above sea level (Fig. 1). Geologically, the region is characterized by clay and sandy soils of sedimentary origin, crossed by many rivers and streams. The natural vegetation around the city is composed of beeches, alders, birches, ash trees, oaks and hornbeams that can appear either as isolated trees or in more or less dense forests. There are also important areas of grassland and crops that are mainly dedicated to the cultivation of rye, wheat, corn and hops, among other plants. The ornamental plants present in the urban vegetation are mainly native trees of the region. Climatologically, Münster has a temperate subhumid continental climate, with a mean annual temperature of 9.4°C . The annual rainfall is 714 mm, with the peculiarity that it is quite persistent throughout the year.

The aim of this work is to present a study of the atmospheric pollen content of Münster and show the seasonal behaviour presented by the different pollen types, as well as total pollen, along the years studied. This information will be useful to keep the population informed in general about pollen phenology and the levels reached in the atmosphere of this city, which might contribute to preventing allergenic diseases. With the data obtained, a pollen calendar was drawn up for the locality.

2 Materials and methods

The study is based on the atmospheric pollen records obtained from 12 February 2004 to 31 December 2006, using a Hirst volumetric pollen trap (Hirst 1952), a Burkard seven-day recorder, situated on the flat roof of the University Clinic Hospital of Münster, 15 m above ground level. The Clinic Hospital is located about 3 km east of the city centre, in an open area without nearby buildings that could obstruct the free circulation of air. The sampler operated uninterruptedly, aspirating a constant flow of 10 l/m^3 of air. In this sort of sampler, the atmospheric particles impact on a Melinex[®] tape impregnated with silicone fluid which, after exposure, is cut into 24-h fragments (48 mm) and mounted on slides using glycerine jelly stained with Pyrogallol red as mounting substance.

Fig. 1 Location of the aerobiological sampling site



Counts of the different pollen types were made with the aid of a light microscope, four longitudinal sweeps per slide being made at a magnification of 400X, according to the methodology proposed by the Spanish Aerobiology Network, the REA (Galán et al. 2007). Pollen concentrations are expressed as the number of pollen grains/m³ of air. The annual pollen index is defined as the annual sum of the mean daily concentrations.

The main pollen season (MPS) for the most abundant pollen types was calculated as described by Andersen (1991). This corresponded to 95% of the annual total, beginning the first day on which the cumulative daily count reached 2.5% of the annual pollen index and finishing the day on which 97.5% of the annual pollen index had been registered.

The pollen calendar was constructed following Spieksma's model (Spieksma 1991), which transforms 10-day mean pollen concentrations into a series of classes according to Stix and Ferretti (1974) and represents them in pictogram form by columns of increasing height. In the pollen calendar, the different taxa follow the order in which the maximum peaks appear, and only those taxa that showed a minimum 10-day mean value equal or greater than 1 pollen grain/m³ of air are included.

The meteorological data here included were provided by the German Weather Service and correspond to the Münster-Osnabrück station, 3 km away from the sampling site.

3 Results and discussion

3.1 Meteorological data

During the study period (2004–2006), the mean temperature in Münster was higher than average, ranging from 10.1°C in 2004 to 10.9°C in 2006. This increase was also noted in the case of minimum and maximum temperatures, which suggests that this locality is experiencing the general increase in temperatures that the entire European continent has been suffering during recent years as a consequence of global warming (Table 1). During the same period, the wettest year was 2004 (824.5 mm) and the driest 2006 (592.2 mm).

The lowest temperatures were registered in January–February, gradually rising to reach their

maximum values in July–August before falling again until the end of the year. On the other hand, rainfall was distributed throughout the year, with 154–164 rainy days from January to December, which means that relative humidity is always high, over 75% as average (Table 1). These parameters are typical for a mild-continental climate and determine the surrounding vegetation which, in turn, will be reflected in the pollen spectrum of the atmosphere of the locality.

The predominant winds in Münster during the period of study were those blowing from the 3rd quadrant, especially westerly and south-westerly (Fig. 2), with few calm periods (0.47%). This behaviour was similar for the 3 years studied, and these winds are probably responsible for a great part of the pollen grains recorded in the aerobiological station, arriving from the mixed forest located west and south-west of the city.

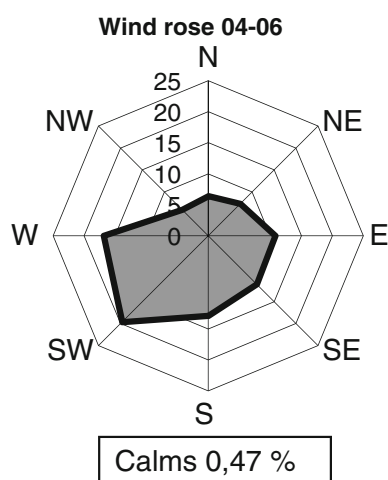
3.2 Aerobiological data

In the atmosphere of Münster, a total of 34 pollen types were identified during the period 2004–2006. Although varying widely from year to year, the mean annual pollen index obtained was 34,737, the lowest value being registered in 2005 (25,078) and the highest in 2004 (42,769). The locality showed a very pronounced seasonality since March–June was the period with the most intense incidence of atmospheric pollen, with 83.3% of the annual total counts on average, April (38%), May (19.9%), March (14.9%) and June (10.5%) being the months in which the concentrations were highest. On the contrary, December (0.02%), November (0.1%), January (0.2%) and October (0.3%) were the months in which the lowest pollen concentrations were registered (Figs. 3 and 4).

As the year progressed, several pollen peaks were detected due to the successive flowering of the different taxa. The first peak was normally detected in late February or early March, due to the pollination of species such as *Alnus glutinosa*, *Taxus/Cupressaceae*, *Corylus*, *Populus* and *Salix*. In April and May, the pollen from taxa such as *Fraxinus*, *Betula*, *Platanus*, *Fagus*, *Quercus*, *Picea* and *Pinus* reach their highest concentrations, while Poaceae and Urticaceae pollinate during the summer season mainly. In late May, concentrations drop dramatically, remaining relatively low until October, when the levels become practically zero.

Table 1 Monthly and annual values of the main meteorological parameters recorded by the Münster–Osnabrück station during the sampling years

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual total
<i>2004</i>													
T. max (°C)	4.7	6.9	9.7	15.5	16.9	20.8	21.9	24.6	20.0	15.1	8.3	5.1	14.1
T min (°C)	0.3	1.2	0.9	5.2	6.8	10.2	12.5	14.9	10.3	7.5	1.9	0.0	6.0
T mean (°C)	2.5	4.1	5.3	10.4	11.9	15.5	17.2	19.8	15.2	11.3	5.1	2.6	10.1
Thermal range (°C)	4.3	5.7	8.8	10.3	10.1	10.6	9.4	9.7	9.7	7.6	6.4	5.1	8.1
Rainfall (mm)	111.9	53.4	30.3	54.9	76.8	41.7	113.6	105.2	66.7	32.7	82.5	54.8	824.5
RH (%)	85.6	82.5	75.7	69.7	73.7	74.2	77.6	72.8	76.2	81.4	91.3	90.9	79.3
No of days with rainfall	18	16	10	12	9	11	18	17	14	9	12	10	156
<i>2005</i>													
T. max (°C)	6.7	3.9	10.3	15.8	17.7	22.1	23.3	21.2	21.0	17.8	8.1	5.0	14.4
T min (°C)	1.5	-1.5	2.5	5.6	7.5	11.2	13.4	11.7	10.4	8.4	2.6	1.0	6.2
T mean (°C)	4.1	1.2	6.4	10.7	12.6	16.6	18.3	16.4	15.7	13.1	5.3	3.0	10.3
Thermal range (°C)	5.2	5.3	7.8	10.3	10.2	10.9	10.0	9.5	10.6	9.4	5.5	4.0	8.2
Rainfall (mm)	60.6	54.9	70.2	43.7	121.4	48.2	80.7	80.4	92.1	40.9	61.4	40.2	794.7
RH (%)	85.0	83.2	77.5	70.3	71.9	69.4	76.0	79.3	78.7	82.3	90.3	90.2	79.5
No of days with rainfall	17	15	16	11	15	10	17	16	11	9	12	15	164
<i>2006</i>													
T. max (°C)	3.0	3.5	7.1	13.3	19.3	22.8	29.4	21.3	23.7	17.0	11.6	8.0	15.0
T min (°C)	-3.2	-0.8	-0.2	4.2	9.5	11.9	16.2	12.5	12.9	9.8	5.1	4.0	6.8
T mean (°C)	-0.1	1.3	3.5	8.7	14.4	17.3	22.8	16.9	18.3	13.4	8.3	6.0	10.9
Thermal range (°C)	6.1	4.3	7.3	9.1	9.8	11.0	13.2	8.8	10.8	7.3	6.5	4.1	8.2
Rainfall (mm)	20.6	43.6	76.3	50.9	88.8	19.6	39.1	83.3	15.0	52.9	53.6	48.5	592.2
RH (%)	84.8	87.9	79.4	74.0	65.5	66.2	60.8	80.0	73.9	81.3	85.6	85.6	77.1
No of days with rainfall	8	14	14	17	15	6	8	16	2	13	18	12	143

**Fig. 2** Wind direction frequencies (%) registered in Münster during the period 2004–2006 (mean values)

The behaviour of total pollen during the 3 years studied varied from year to year. The most similar were 2004 and 2006, while 2005 presented a different profile, with lower levels and pollen concentrations that were more evenly distributed from March to September (Fig. 4). This different behaviour is also evident if we take into account the percentages of pollen generated by woody and herbaceous plants (Fig. 5). These percentages were similar in 2004 and 2006, with 79.5% of the total pollen produced by woody plants and 20.5% by herbaceous plants in 2004 and 82 and 18%, respectively, in 2006. However, in 2005, the percentages from woody and herbaceous plants were 54 and 46%, respectively. This was mainly due to the annual pollen index of *Betula*, which drastically decreased that year, varying from 16,314 and 14,387 in 2004 and 2006, respectively, to 2,864 in

Fig. 3 Monthly values of total pollen reached in the atmosphere of Münster during the period 2004–2006

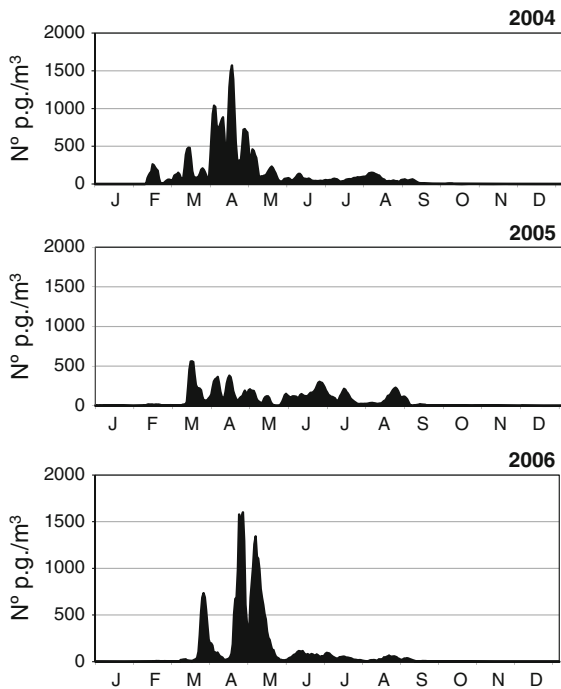
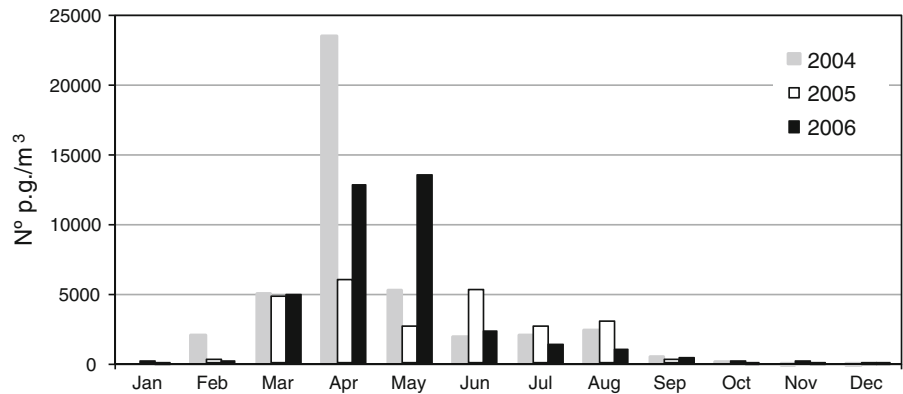


Fig. 4 Daily mean concentrations of total pollen registered in Münster during the years 2004–2006

2005, but also due to the decreases in the pollen levels of many arboreal species such as *Alnus*, *Carpinus*, *Fagus*, *Fraxinus*, *Pinus*, *Platanus* and *Quercus*, all of which showed their lowest annual pollen indices that year. This alternance in the pollen production of tree species is a phenomenon that has been reported by many authors (Andersen 1980; Corden et al. 2000; Latalowa et al. 2002; Scevková et al. 2010). In contrast, the pollen from some herbaceous plants such as Poaceae and Urticaceae registered a strong increase in 2005 (Table 2, Fig. 6). This increase in herbaceous pollen could be due to the mild temperatures registered

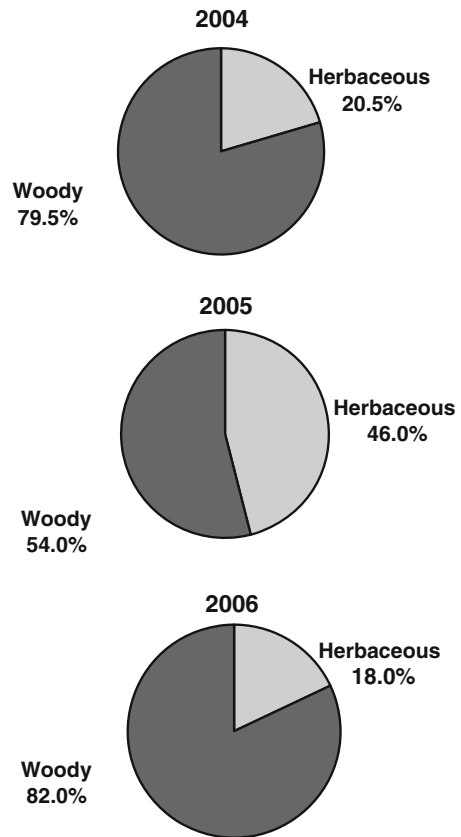


Fig. 5 Annual percentage of pollen from woody and herbaceous plants recorded during the sampling years

in winter 2005 and to the abundant rainfall registered in May, prior to the start of the main pollen season of the above-mentioned pollen types (Table 1).

The ten pollen types with the greatest influence in the atmosphere of Münster during the period studied were in order of abundance: *Betula*, Urticaceae, *Taxus/Cupressaceae*, *Quercus*, *Alnus*, Poaceae, *Pinus*,

Table 2 Annual pollen indices obtained by the different pollen types during the years 2004–2005, including mean of the period and percentage out the total

Taxa	2004	2005	2006	Mean (04–06)	% Annual mean
<i>Aesculus</i>	50	35	48	44	0.13
<i>Alnus</i>	3,130	1,780	2,890	2,600	7.48
<i>Ambrosia</i>	0	4	7	4	0.01
Apiaceae	7	7	9	8	0.02
<i>Artemisia</i>	275	236	61	191	0.55
<i>Betula</i>	16,313	2,863	14,384	11,187	32.20
Brassicaceae	70	111	38	73	0.21
<i>Carpinus</i>	1,746	23	429	733	2.11
<i>Castanea</i>	13	12	17	14	0.04
Che.-Amar.	37	30	42	36	0.10
Compositae ^a	25	27	22	25	0.07
<i>Corylus</i>	383	1,097	600	693	2.00
Cupressaceae	3,461	2,695	2,440	2,865	8.25
Cyperaceae	0	4	4	3	0.01
<i>Fagus</i>	1,478	3	925	802	2.31
<i>Fraxinus</i>	1,265	679	1,530	1,158	3.33
<i>Humulus</i>	91	63	102	85	0.25
<i>Juglans</i>	34	19	75	43	0.12
<i>Larix</i>	32	0	26	19	0.06
<i>Mercurialis</i>	23	13	23	20	0.06
<i>Olea</i>	1	36	4	14	0.04
<i>Pinus</i>	1,910	1,030	1,314	1,418	4.08
<i>Picea</i>	121	39	451	204	0.59
<i>Plantago</i>	73	68	69	70	0.20
<i>Platanus</i>	1,824	99	1,496	1,140	3.28
Poaceae	2,465	3,496	1,678	2,546	7.33
<i>Populus</i>	451	564	346	454	1.31
<i>Quercus</i>	2,774	1,880	3,701	2,785	8.02
<i>Rumex</i>	178	130	142	150	0.43
<i>Salix</i>	413	449	306	389	1.12
<i>Typha</i>	6	5	17	9	0.03
<i>Ulmus</i>	82	96	49	76	0.22
Urticaceae	3,579	7,050	2,761	4,463	12.85
Others pollen types	459	435	359	418	1.20
Total	42,769	25,078	36,365	34,737	100

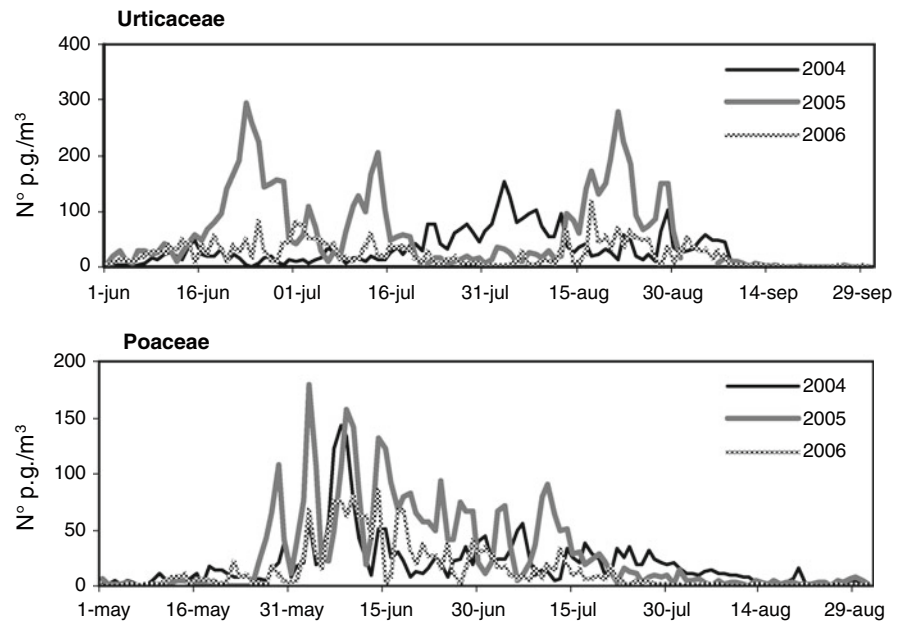
^a Excluding *Ambrosia* and *Artemisia*

Fraxinus, *Platanus* and *Fagus*, which, together, accounted for 89.15% of the annual total pollen, on average (Table 2). Of all the pollen types, *Betula*, with 32.2% of the total pollen recorded during the study period, represented almost a third of the pollen count. An important feature is the high representation of forest species in the atmospheric pollen spectrum

(Fig. 8). These all are species that form part of the Mid-European mixed forest, which are well-represented in the surrounding areas.

The highest daily mean concentrations were registered in April during the years 2004 and 2006, with 2,507 pollen grains/m³ of air recorded on 16 April 2004 and 3,514 pollen grains/m³ of air on 25 April 2006.

Fig. 6 Seasonal behaviour of the main pollen types: herbaceous plants



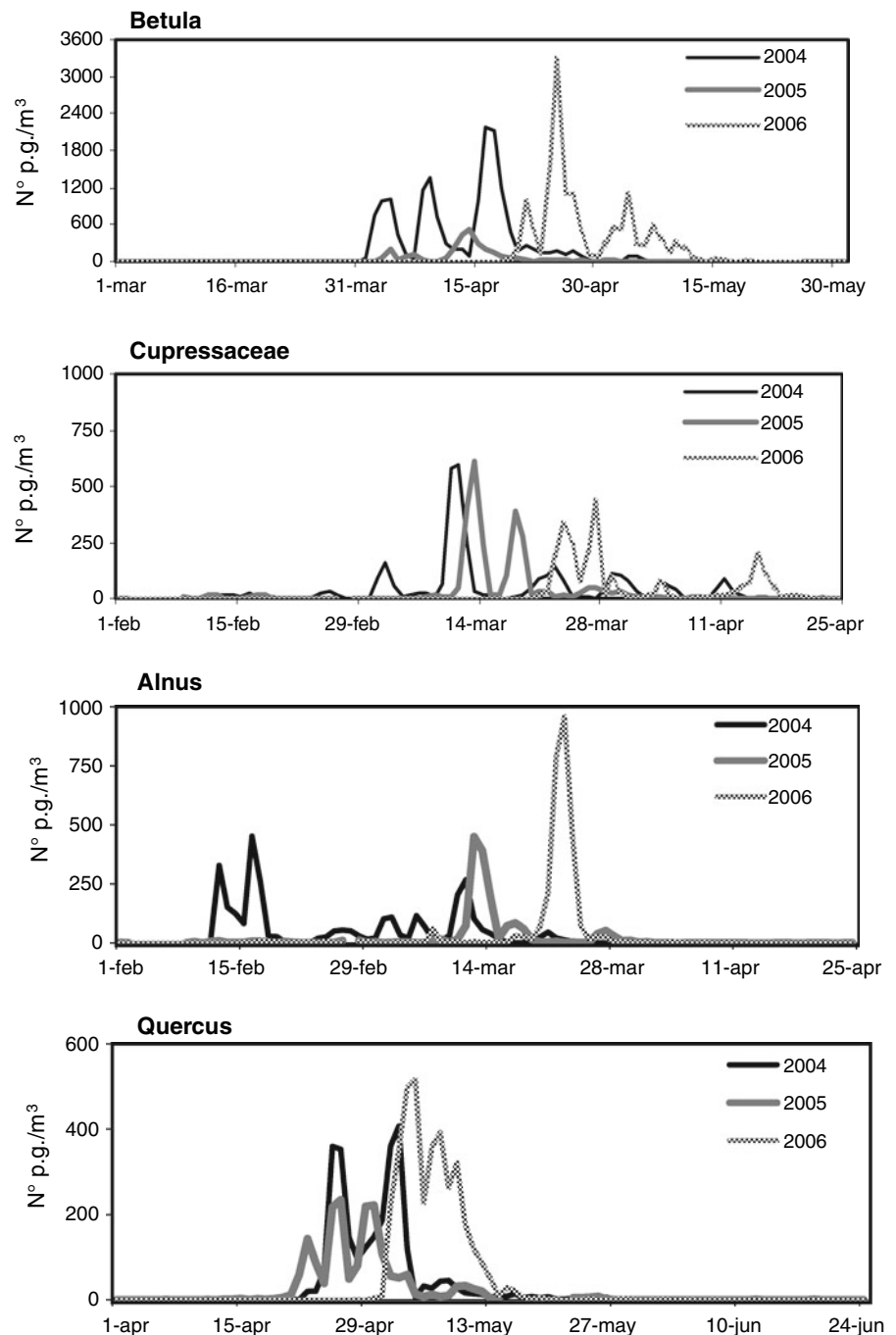
However 2005, once again, differed as the peak day was 16 March, when concentrations were lower than in other years: 1,128 pollen grains/m³ (daily mean). The annual peaks registered coincided with the peak days of *Betula* in 2004 and 2006, with 2,175 and 3,514 pollen grains/m³ of air, respectively, and the peak day of *Taxus/Cupressaceae* pollen in 2005 (612 pollen grains/m³ of air) (Figs. 4 and 7).

Although a 3-year period is too short to produce a pollen calendar, it was decided to construct one as a way of showing, at a glance, the general behaviour followed by all of the studied taxa in the atmosphere of Münster (Fig. 8). The calendar shows how April and May are the months of greatest variability as regards the pollen types recorded (17), followed by March and June (9) and July (8). In general, the pollination periods are short and intense, especially in the case of arboreal species, with main pollen seasons that hardly last 2 months. In contrast, some pollen types such as Poaceae and Urticaceae presented a longer pollen season and were more persistent in the atmosphere of the city. The pollen calendar obtained for Münster and the behaviour followed by the atmospheric pollen present many similarities with those previously provided by Spieksma (1991) for Western Europe and Central Germany and by Johnsen et al. (1991) for Danish localities such as Copenhagen and Odense. It

was also similar to the behaviour described by Winkler et al. (2001) for Western Germany.

Betula, the most abundant pollen type, showed great differences in the annual pollen index from year to year (Table 2, Fig. 7). The highest concentrations were detected in April and May, the main pollen season being short but intense. In fact, the duration of the MPS ranged between 20 and 31 days, with concentrations of more than 3,000 pollen grains/m³ registered on peak days. The seasonal behaviour is similar to that described for *Betula* by different authors in north-west and North Europe (Spieksma et al. 2003; Siljamo et al. 2008), and the cyclic rhythms of years with high and low pollen production observed have been also described for this pollen type in different localities by authors such as Andersen (1980), Nilsson and Peerson (1981), Jäger et al. (1991), Emberlin et al. (1993), El-Ghazaly et al. (1993), Spieksma et al. (1995), Latorre (1999) and Peternel et al. (2005). In 2006, the start of the MPS was delayed by 20 days compared with the previous 2 years, probably due to the colder temperatures registered from January to April of that year. A similar delay was also observed in other spring time pollen types such as *Taxus/Cupressaceae*, *Quercus* and *Alnus* (Fig. 7). This influence of temperatures in the start of the pollen season was previously highlighted by Emberlin et al. (2002).

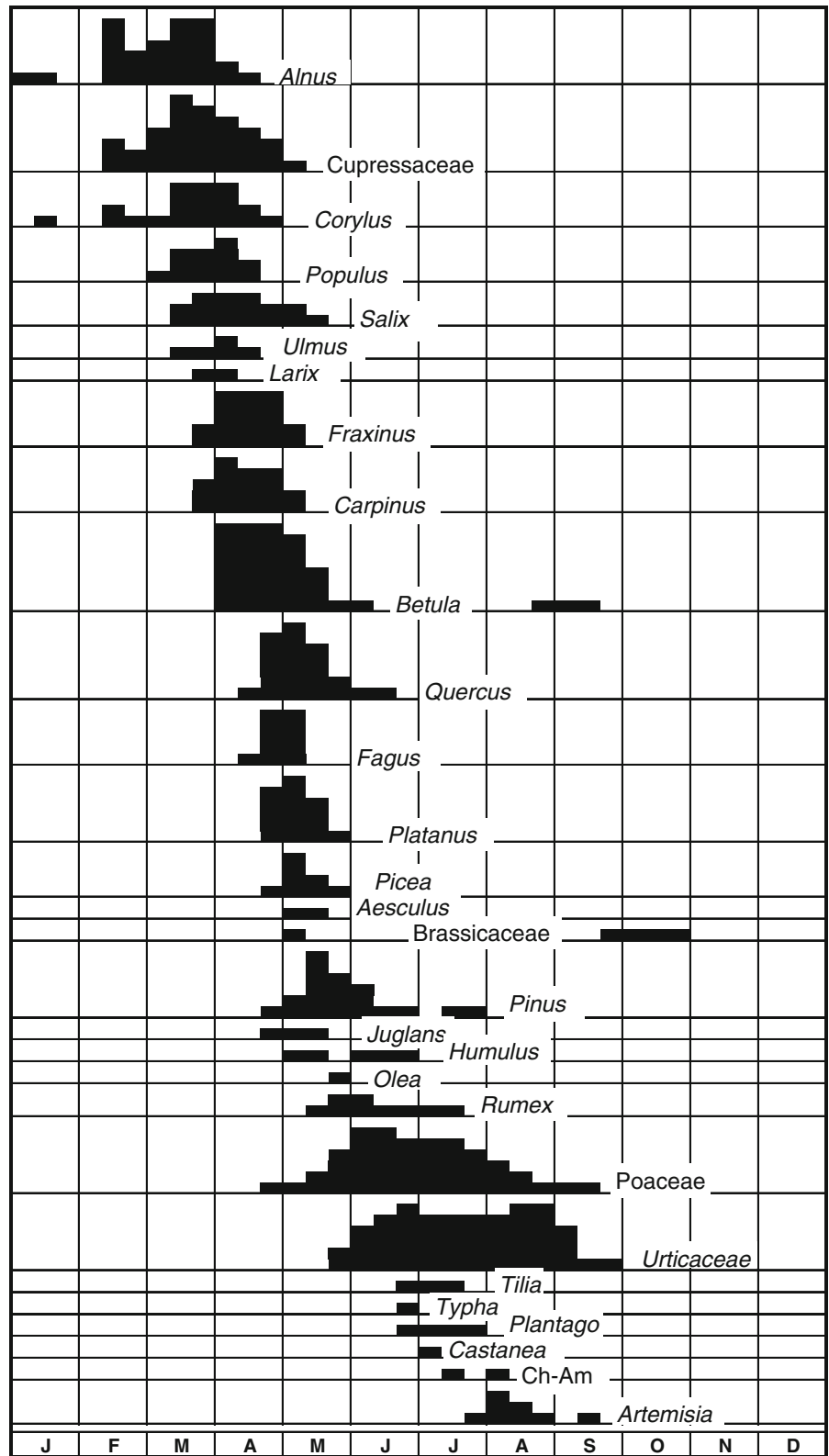
Fig. 7 Seasonal behaviour of the main pollen types: woody plants



The second most abundant pollen type in Münster was *Urticaceae* (12.85%), which also showed great interannual differences not only in the annual pollen index, but also the maximum values reached, which were highest in 2005 (Table 2, Fig. 6). The pollen collected corresponds to trizonoporate grains, which

include different species belonging to the genera *Urtica* and *Parietaria* very frequent in the city. The highest concentrations were detected in June, July and August, several peaks being registered during this main pollen season, which lasted between 84 and 92 days. *Urticaceae*, together with *Poaceae*, showed

Fig. 8 Pollen calendar for Münster (2004–2006).
Ch-Am, Chenopodiaceae-
Amaranthaceae



the longest pollen seasons in the air pollen spectrum of Münster (Fig. 8), probably due to the successive flowering of the different species in the case of Poaceae and a long flowering period in Urticaceae. The seasonal behaviour and the quantities detected during the study are similar to those reported by Spieksma et al. (2003) for the German city of Delmenhorst, located 150 km north-west from Münster and the levels detected are similar to those of other localities of north-western Europe. In Derby, Corden and Millington (1991) detected annual pollen indices of 400–3,200 and Spieksma (1986) obtained mean values of 6,488 for the period 1977–1981 in Leiden.

Taxus/Cupressaceae pollen type is represented by several species of *Juniperus* but also by *Taxus baccata*, belonging to the Taxaceae family, with the same pollen morphology. It represented 8.25% of total airborne pollen during the studied period. There were no great interannual differences regarding the annual pollen index, which ranged from 3,462 in 2004 to 2,439 in 2006 (Table 2). The MPS comprises the month of February, March and April, the highest concentrations always being detected in March with a maximum daily peak of 612 pollen grains/m³, reached on 16 March 2005 (Fig. 7). The MPS of this pollen type lasted from 40 days in 2006 to 63 in 2004, being one of the longest MPS, together with those of Urticaceae and Poaceae.

Quercus is the fourth pollen type in abundance order. During the period studied, the annual pollen index varied from 1,881 in 2005 to 3,702 in 2006 (Table 2), April and May being the months in which the highest concentrations were detected. *Quercus* pollen presented a short and intense pollination period, lasting 20 days on average. Indeed, in 2006, the year with the highest pollen index, the MPS only lasted 13 days. The peak day always occurred in late April or early May. In 2006, the pollen season showed a slight delay, as in the case of the pollen of the other spring time pollen types (Fig. 7). The seasonal behaviour and the annual pollen indices registered were similar to those obtained for other cities of north-western Europe such as Brussels, Leiden and Delmonhorst (Spieksma et al. 2003).

Alnus, represented in the area by *A. glutinosa*, showed an annual pollen index ranging from 1,782 in 2005 to 3,133 in 2004 (Table 2). The MPS comprises the months of February and March, mainly, as observed in other localities of Central Europe

(Kasprzyk et al. 2004) and was characterized by the presence of several successive peaks of different intensities. In 2005 and 2006, the peak day was in March, but in 2004, it occurred 1 month earlier (17 February) probably because the mean temperature registered during this month was higher. In contrast, in 2006, the delay in the peak day mentioned above for other pollen types was also observed in *Alnus* (Fig. 7). In general, in Europe, *Alnus* pollen presents higher concentrations as latitude increases. However, in Münster, although the seasonal behaviour was similar to that of other nearby cities, the annual pollen indices were higher than those reported by authors such as Detandt and Nolard (2000) and Spieksma (1986) for the cities of Brussels and Leiden, respectively, probably due to the quantity of rivers and streams present in the area, since *Alnus* grows along their edges.

The percentage of total pollen represented by Poaceae (7.33%) in the studied period was similar to that of *Alnus*. Poaceae pollen is present in the atmosphere mainly from early May to the end of August (Fig. 6). It is, together with the pollen of Urticaceae and *Taxus/Cupressaceae*, the type with the longest pollen season: 79 days on average. This is due to the successive flowering of a high number of species present in the area, what leads to the occurrence of several peaks during the MPS. The annual pollen index ranged from 1,680 in 2006 to 3,597 in 2005, the year in which Urticaceae also reached its highest values (Table 2). These levels registered are similar to those obtained by Spieksma et al. (2003) for Brussels but lower than those obtained by the same authors for other localities of north-western Europe. The peak day was always detected in the first half of June, the maximum value (180 pollen grains/m³) being registered on 3 June 2005. For the same period (2004–2006), Puc (2011) detected the maximum peaks approximately 15 days later in Szczecin, north-western Poland.

Poaceae is one of the most common aeroallergens present in the atmosphere worldwide. The MPS of this pollen type varies depending on the latitude and height, as described by Emberlin et al. (2000) and Sánchez et al. (2003). So, in Münster, the start of the season and the peak days occur approximately 2 weeks before they do so in other cities situated further north (Yli-Panula 1997).

The rest of the pollen types worthy of mention were in order of abundance: *Pinus*, *Fraxinus*, *Platanus*,

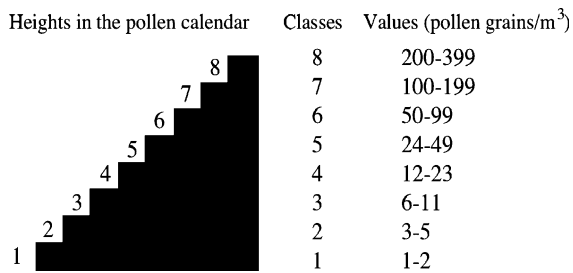


Fig. 9 Classes and pollen concentration values represented in the calendar-graph

Fagus, *Carpinus*, *Corylus*, *Populus* and *Salix*. The annual mean percentage reached by these pollen types ranged from 4.08% of the total in the case of *Pinus* to 1.12% in the case of *Salix*. The seasonal behaviour and the levels reached can be seen in Table 2 and Figs. 8 and 9.

Finally, as regards the dye used, Pyrogallol red, it is a valid alternative to basic fuchshine, traditionally used in Aerobiology. However, its use for pollen counts has no special relevance as the function of the dye, in this case, was only to make easier the detection and count of pollen grains.

4 Conclusions

During the period 2004–2006, a total of 34 pollen types were identified in the atmosphere of Münster, 20 corresponding to woody taxa and 14 to herbaceous taxa.

The mean annual pollen index was 34,737, although with important variations from year to year, March to August, both inclusive, being the period in which more than 95% of the annual total pollen, on average, is collected.

The 10 most abundant pollen types in the atmosphere of Münster were *Betula*, *Urticaceae*, *Taxus*/*Cupressaceae*, *Quercus*, *Alnus*, *Poaceae*, *Pinus*, *Fraxinus*, *Platanus* and *Fagus*, in order of abundance, which, together, accounted for 89.15% of the total pollen recorded. *Betula*, with 32.2%, represented almost a third of the pollen count.

The pollen calendar of Münster presents the typical features of northern Europe pollen calendars, with a winter period with very few pollen, short and intense seasonal periods, and a high representation of pollen types from species characteristic of mixed Mid-

European woodland and riverside forests, such as *Alnus*, *Betula*, *Corylus*, *Fagus*, *Picea*, *Pinus*, *Populus*, *Salix*, *Fraxinus* and *Carpinus*.

Due to the high concentrations reached as well as to their allergenicity, many pollen types should be considered as potential allergens, which may cause allergic disorders into the atopic population living in the city.

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