

The results of 2-year pollen monitoring of an urban network in Perugia, Central Italy

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Abstract

Continuous pollen monitoring of an urban network consisting of three stations has been undertaken for a period of 2 years in Perugia, central Italy. The aim has been to establish whether the Perugia pollen trap, active since 1983, is still representative of the area following recent urbanisation. Quantitative differences were found between the stations, reflecting different vegetational areas, but only slight differences were detected in relation to the timing of the principal period of pollination. Therefore, although individual pollen traps are necessary to characterize fully the different areas, one trap is sufficient to determine the key allergenic thresholds in the studied area. Copyright © 1996 Elsevier Science Ireland Ltd.

Keywords: Aerobiology; Pollen monitoring; Network

1. Introduction

A pollen monitoring network has been operating in Italy since the early 1980s, and Perugia is one of the centres which has been involved in the project since its inception (Mandrioli, 1992). The aim of this current study is to verify if a single pollen trap is still representative of the various situations in the study area, which is fairly large and orographically diverse and has experienced extension of the built-up area. Our hypothesis is that the newly densely populated urbanised areas, located several kilometres distant from the pollen trap, might not be represented.

We therefore established a small local pollen monitoring network consisting of three stations which we have operated continuously for 2 years. The period under investigation (April 1988 to March 1990) was used not only for a study of the quantitative and qualitative aspects of pollination in Perugia, but also for a related epidemiological investigation in two successive pollination seasons (Romano et al., 1992).

2. Materials and methods

The aerobiological investigation was carried out using identical methodology and employing three Lanzoni VPPS 2000 type volumetric pollen traps (Hirst, 1952). The monitoring method, identification of the pollen grains, and the calculation of the relative concentrations have already been described elsewhere (Frenguelli et al., 1981; Fornaciari et al., 1990; Romano et al., 1991).

The three pollen traps were located in the Perugia area in different districts with high population density, and positioned at three different altitudes (Fig. 1). The sites are representative of three different situations as far as vegetation, urbanization, and buildings are concerned.

The first trap, named Perugia 1, was located on the Perugia hill facing south to the Tiber plain in the southern part of the historical centre of the city, at 20 m above ground level and 445 m above sea level. The dominant winds come from the north east in autumn and winter, and from the south west in spring and summer. The immediate area is mainly characterized by historical buildings surrounded by Etruscan and medieval walls, but also has many tree-lined avenues, gardens and green areas, especially in the valley which stretches down towards the plain.

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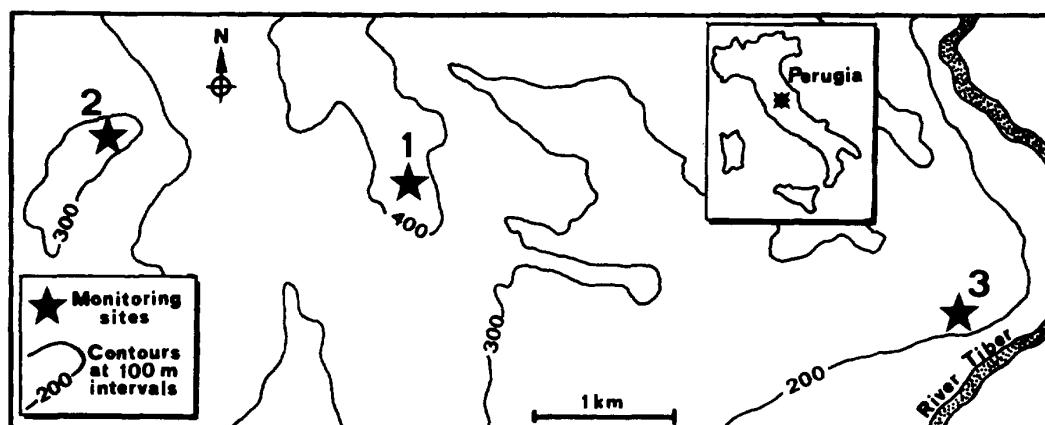


Fig. 1. Location of the three monitoring stations' positions.

The second trap (Perugia 2) was located on a small hill on the western side of the city at 10 m above ground level and 300 m above sea level. The surrounding area is densely populated, was built-up 15 years ago, and is rich in ornamental flora. The prevailing winds come from the north-west through the deep, wooded valley of the Genna stream.

The third pollen trap (Perugia 3) was located at 30 m above ground level and 200 m above sea level on the eastern side of the city, which is on the right bank of the Tiber river. The area has become recently built-up and is densely populated. The prevailing winds come from the south across the river plain which stretches southwards. The surrounding area is cultivated with little arboreal vegetation.

The meteorological data were supplied by the Institute of Ecology of the Faculty of Agricultural Science.

3. Results

The climatic trends described in Fig. 2a–c correspond to the 10-year period (1981–1990), the first year of the current investigation and the second year of investigation, respectively. Differences can be noted in respect of rainfall between the first and second year, especially in the summer period.

The total pollen grains/m³ in the 2 studied years are reported in Table 1. In general, values for the second year are considerably lower than the first. Within the first year, the quantity of total pollen monitored by Perugia 1 and Perugia 2 was similar, while the value for Perugia 3 was much lower. In the second year, the total quantity of pollen grains was

different between the three stations, with the highest value in Perugia 2 and the lowest in Perugia 3.

The percentage of pollen grains of different families monitored by the three stations is given in Tables 2 and 3. The differences between the values of the three stations during the 2 years can be explained by the different environmental situations around the monitoring stations as well as the different climatic trends during the investigative period.

The monthly trends were also compared relatively to the main *taxa* which were present in the urban aerospora.

3.1. *Cupressaceae/Taxaceae*

From a chronological point of view, the monthly atmospheric concentration of this pollen showed a similar trend in the three different stations, although the quantity was different; notably, much lower in Perugia 3 (Fig. 3). In all the stations, the pollen grains were present in the atmosphere primarily during the winter-spring period. The highest concentrations were recorded in March 1989 and February 1990. Overall, the 1990 pollination season began a month earlier than in the previous season.

3.2. *Corylaceae*

In all three monitoring stations, a similar trend of monthly concentrations was observed, with high values in the first 2 months (April and May 1988) and low values in the following 2 years (1989 and 1990) (Fig. 3). The uniform distribution of the sources, which are present in the surrounding woods of the city, is clearly reflected in the aerosporological data.

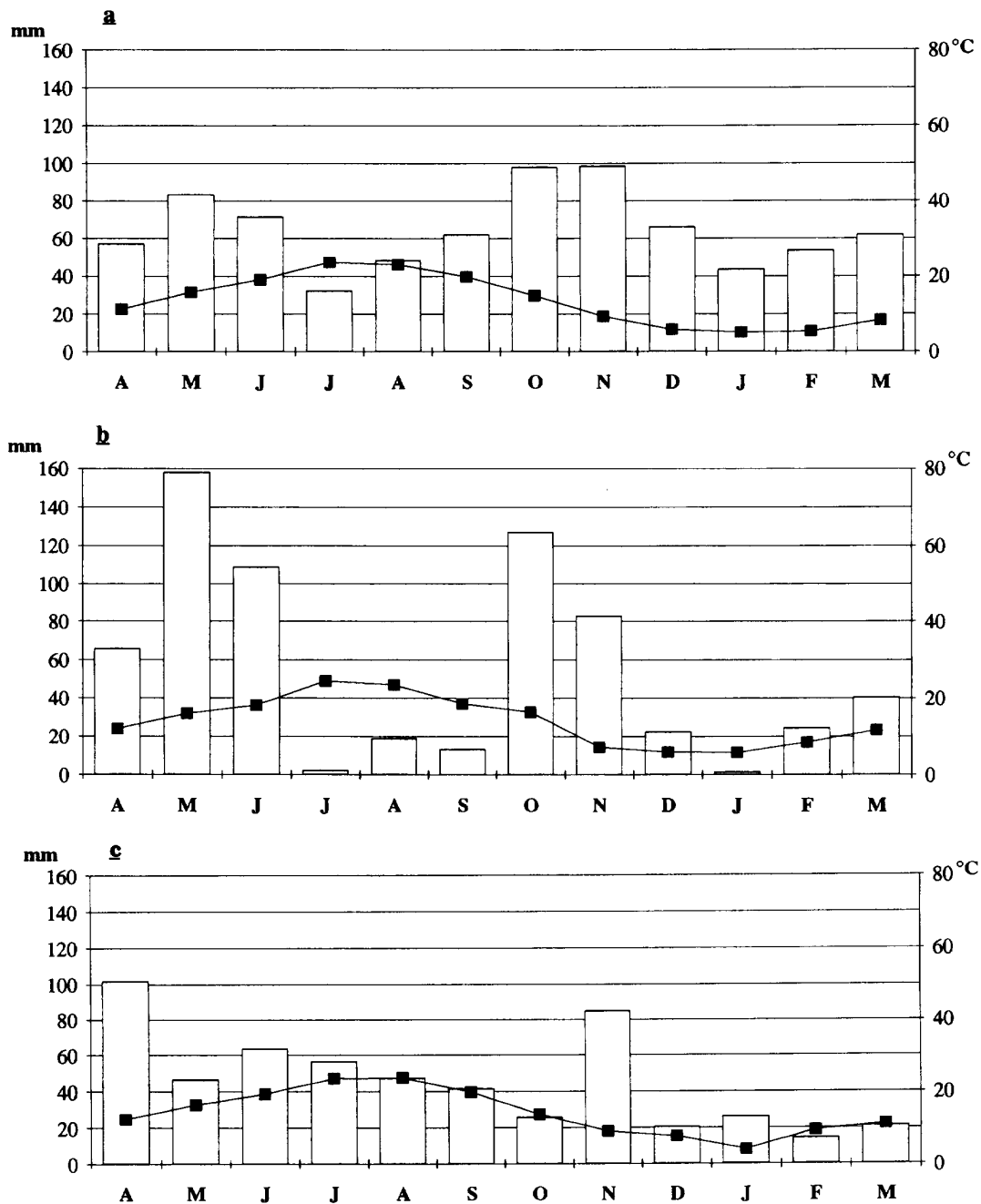


Fig. 2. Climatic trend in Perugia. (a) Climatic diagram of Perugia area (mean on 10 years). □ Total rainfall-Daily mean temperature. (b) Climatic diagram of Perugia area during the first period of study. □ Total rainfall-Daily mean temperature. (c) Climatic diagram of Perugia area during the second period of study. □ Total rainfall-Daily mean temperature.

3.3. Salicaceae — *Populus* spp.

The 1989 and 1990 pollination periods both took place in February and March (Fig. 3). Like the other arboreal taxa, flowering occurred later in 1989 than in 1990. Therefore, during the first year, the pollen con-

tent in the atmosphere was abundant only in March, while in February of the second year a high presence of pollen was recorded. The Perugia 3 station recorded a low concentration of pollen grains, notwithstanding the high presence of poplars near the pollen trap, in particular on the banks of the Tiber river.

3.4. Salicaceae — *Salix* spp.

Similar to poplar, willow is present along the banks of the Tiber river, near Perugia 3. In this case, however, unlike poplar, the high level of captured pollen appears to reflect the abundance and the proximity of the source. In fact, in Perugia 3, during March–April 1989 and March 1990, high levels of pollen concentration were recorded (Fig. 4). The different behaviour of these two genera is likely to be linked with the different method of pollination. Poplar has an anemophilous pollination mechanism and pollen grains can potentially travel farther than those of willow, which is an ambophilous *taxon* whose pollen grains sometimes remain clumped together by an adhesive substance and therefore fall close to the source.

3.5. Pinaceae

The pollen of this family is represented by *Pinus* spp. from March to July. During the 24 months of the investigation, two flowering seasons of *Pinus* and the start of the third, in March 1990, were recorded. In this last instance, the quantity in Perugia 2 was extremely

large (Fig. 4), which prompted a careful study of the recorded trend.

3.6. *Quercus* spp.

In all the monitoring stations, pollen grains were recorded from March to July. The highest concentra-

Table 2
Arboreal and shrub pollen types percentage monitored in the atmosphere of Perugia area and mean percentage in the three different stations

	Perugia 1	Perugia 2	Perugia 3
Fagaceae	18.79	10.00	19.15
<i>Castanea sativa</i> Miller			
<i>Fagus sylvatica</i> L.			
<i>Quercus</i> spp.			
Cupressaceae/Taxaceae	42.49	57.54	31.95
Oleaceae	6.78	4.65	6.54
<i>Fraxinus excelsior</i> L.			
<i>Fraxinus ornus</i> L.			
<i>Ligustrum</i> spp.			
<i>Olea europaea</i> L.			
Pinaceae	2.48	3.35	3.25
<i>Cedrus</i> spp.			
<i>Picea excelsa</i> spp. (Lam.)			
Link			
<i>Pinus</i> spp.			
Corylaceae	5.06	4.24	8.25
<i>Carpinus betulus</i> L.			
<i>Corylus avellana</i> L.			
<i>Ostrya carpinifolia</i> Scop.			
Salicaceae	0.80	0.78	1.67
<i>Populus</i> spp.			
<i>Salix</i> spp.			
Moraceae	0.29	0.04	0.11
<i>Brussonetia papyrifera</i> (L.)			
Vent.			
<i>Maclura pomifera</i> (Rafin.)			
Schneider			
<i>Morus</i> spp.			
Ericaceae	0.24	0.15	0.30
<i>Arbutus unedo</i> L.			
<i>Erica arborea</i> L.			
Betulaceae	0.59	0.55	0.91
<i>Alnus</i> spp.			
<i>Betula</i> spp.			
Caprifoliaceae	0.06	0.04	0.04
<i>Sambucus nigra</i> L.			
<i>Viburnum tinus</i> L.			
Platanaceae	0.32	0.48	0.52
<i>Platanus hybrida</i> Brot.			
Ulmaceae	0.21	0.18	0.23
<i>Celtis australis</i> L.			
<i>Ulmus</i> spp.			
Anacardiaceae	0.04	0.03	0.05
<i>Pistacia</i> spp.			
Araliaceae	0.02	0.01	0.03
<i>Hedera helix</i> L.			
Juglandaceae	0.06	0.03	0.07
<i>Juglans regia</i> L.			
Myrtaceae	0.02	0.02	0.02

Table 1
Total monthly pollen grains recorded in Perugia area in the three different sites of monitoring during the studied period

	Perugia 1	Perugia 2	Perugia 3
April 1988	5837	5465	4964
May	15 222	10 425	11 959
June	11 083	9093	5241
July	3743	4077	3024
August	727	956	766
September	524	372	436
October	207	479	170
November	91	56	39
December	131	95	69
January 1989	4635	2938	293
February	5462	11 676	3855
March	24 014	27 897	9475
Total 12 months	71 676	73 529	40 291
April	5761	7871	5333
May	7434	5219	4163
June	5189	3783	3021
July	2173	2299	1767
August	2567	2060	1755
September	1096	972	708
October	324	539	215
November	139	196	91
December	1660	4951	290
January 1990	2256	6404	718
February	5506	16 022	4549
March	3599	6161	3625
Total 12 months	37 705	56 477	26 235
Total 24 months	109 381	130 006	66 526

Table 2 (continued)

	Perugia 1	Perugia 2	Perugia 3
Rosaceae	0.02	0.00	0.00
<i>Prunus</i> spp.			
<i>Eriobotrya japonica</i> (Thunb.)			
Lindley			
Leguminosae	0.03	0.06	0.09
<i>Acacia</i> spp.			
<i>Amorpha fruticosa</i> L.			
<i>Spartium junceum</i> L.			
Tiliaceae	0.02	0.00	0.00
<i>Tilia</i> spp.			
Palmae	0.04	0.04	0.00
	78.36%	82.19%	73.18%

tions of *Quercus* spp. pollen in the 2 years of the study were recorded in May in Perugia 1. A floristic investigation, carried out in the surrounding area, showed a high number of plants of *Quercus ilex* L., confirming its aerosporological dominance (Fig. 4).

3.7. Urticaceae

In both studied periods, the pollen of this family was most abundant in Perugia 1. This was not unexpected because *Parietaria* spp. is particularly widespread around that station, on the ancient walls of the historical centre (Fig. 5).

3.8. Gramineae

The chronological trend of the pollen of this family in the three stations was identical. In Perugia 2, the highest concentrations were recorded during May and June 1988 (Fig. 5), particularly in the first period of the study. This is because this station is not surrounded by cultivated areas.

3.9. Oleaceae

Some differences were found between the pollen concentration in the three stations; the lowest values were recorded in Perugia 3, especially in June, which is the flowering period of this *taxon*, because of the lower diffusion of *Olea europaea* L. in the area near the station (Fig. 5). This plant prefers hilly zones and does not survive the damp and severe winters of the plain. The difference in the pollen concentration between the two periods of study is due to the alternating pollination trend typical of this species.

Table 3

Herbaceous pollen types percentage monitored in the atmosphere of Perugia area and mean percentage in the three different stations

	Perugia 1	Perugia 2	Perugia 3
Urticaceae	10.30	5.55	6.81
Gramineae	8.28	9.33	14.24
Euphorbiaceae	0.92	0.69	1.27
<i>Mercurialis annua</i> L.			
Compositae tubuliflorae	0.39	0.37	0.97
<i>Ambrosia</i> spp.			
<i>Artemisia</i> spp.			
<i>Xanthium italicum</i> Moretti			
Plantaginaceae	0.37	0.63	6.85
<i>Plantago lanceolata</i> L.			
<i>Plantago major</i> L.			
<i>Plantago minor</i> L.			
Cheno-Amaranthaceae	0.59	0.45	1.00
Papaveraceae	0.06	0.06	0.12
<i>Papaver rhoeas</i> L.			
Polygonaceae	0.11	0.12	0.17
<i>Rumex</i> spp.			
Rubiaceae	0.04	0.07	0.06
<i>Galium</i> spp.			
Umbelliferae	0.18	0.21	0.32
Cruciferae			
Compositae liguliflorae	0.21	0.14	0.25
Cyperaceae	0.04	0.02	0.07
<i>Carex</i> spp.			
Ranunculaceae	0.08	0.01	0.43
<i>Clematis vitalba</i> L.			
<i>Ranunculus</i> spp.			
Cannabaceae	0.07	0.09	0.22
<i>Humulus lupulus</i> L.			
Boraginaceae	0.00	0.02	0.01
<i>Borago officinalis</i> L.			
<i>Echium vulgare</i> L.			
<i>Symphytum</i> spp.			
Typhaceae	0.00	0.01	0.00
<i>Typha latifolia</i> L.			
Rosaceae	0.00	0.02	0.02
<i>Sanguisorba minor</i> Scop.			
Capparidaceae	0.00	0.02	0.01
	21.64%	17.81%	26.82%

4. Discussion

The recorded differences in the total quantity of pollen grains monitored during the two periods of study can be explained to a very large extent by the massive quantity of Cupressaceae/*Taxaceae* pollen in 1988–1989, which was decidedly higher than in 1989–1990 (from 140% to 280% higher, depending on the station). It needs to be recognised that this family represents about half of all monitored pollen grains (Table 2) in Perugia 1 and 2, and about one-third in Perugia 3. Therefore, the variations of Cupressaceae/*Taxaceae* pollen grains have a great influence on the

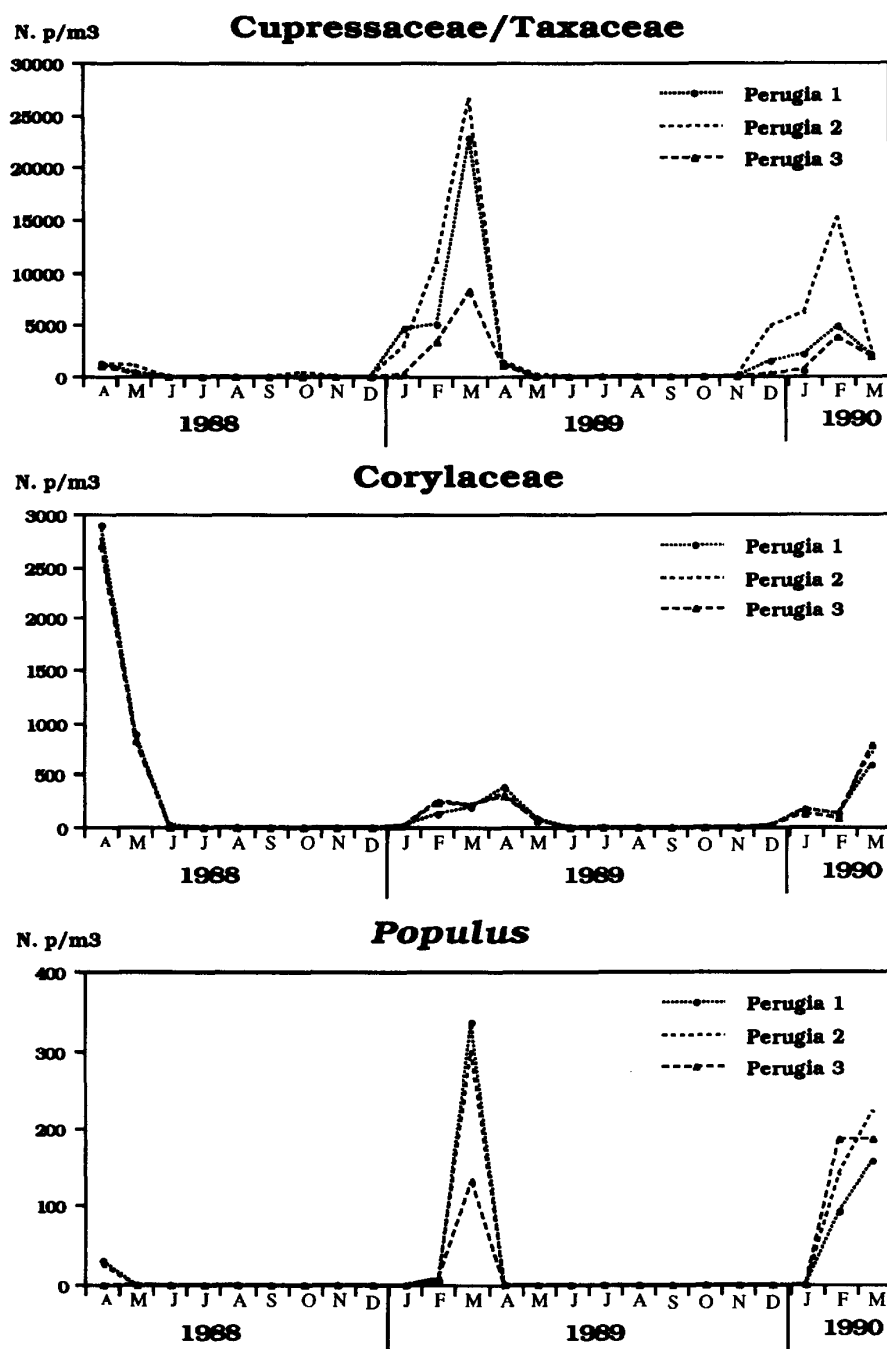


Fig. 3. Monthly concentration of pollen grains in the three stations.

total quantity of emitted pollen. Other differences concern the quantities of Oleaceae, Corylaceae and Gramineae, which were all higher during the spring/summer of 1988 than in the same period of 1989.

These data can be explained by the different climatic characteristics recorded in the two examined periods. The 1988–1989 winter was colder than both the

polyannual mean and also the 1989–1990 winter, but it was followed by above average temperatures at the end of February and during all of March, i.e. 11.7°C compared with a mean of 7.5°C. This period was without rain in the second and third 10 days of March, with only a low quantity in the first 10 days of the month.

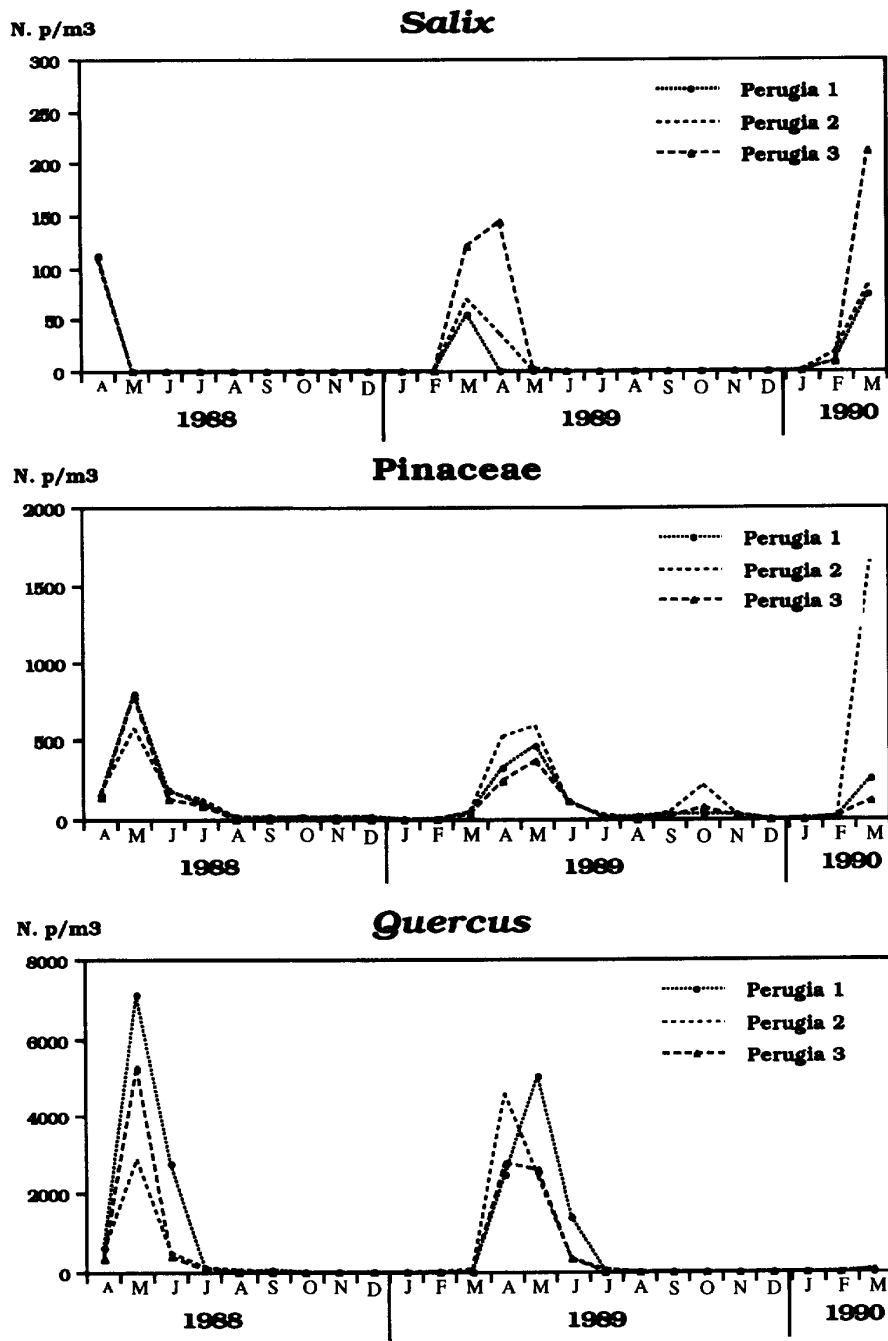


Fig. 4. Monthly concentration of pollen grains in the three stations.

This climatic pattern might explain the 'explosion' of arboreal flowering and in particular that of Cupressaceae/Taxaceae during that period. However, such a precocious season was arrested or slowed down in the following month of April and at the start of May. These months were characterised by a slightly lower

mean temperature compared to the 10-year mean (-0.5°C), by heavy winds, by considerable rainfall (102 mm as compared to 53 mm in the 10-year mean), and by frequent fogs along the valleys. There was a slowing down of the normal seasonal trend with lower quantities of pollen grains than in the preceding period.

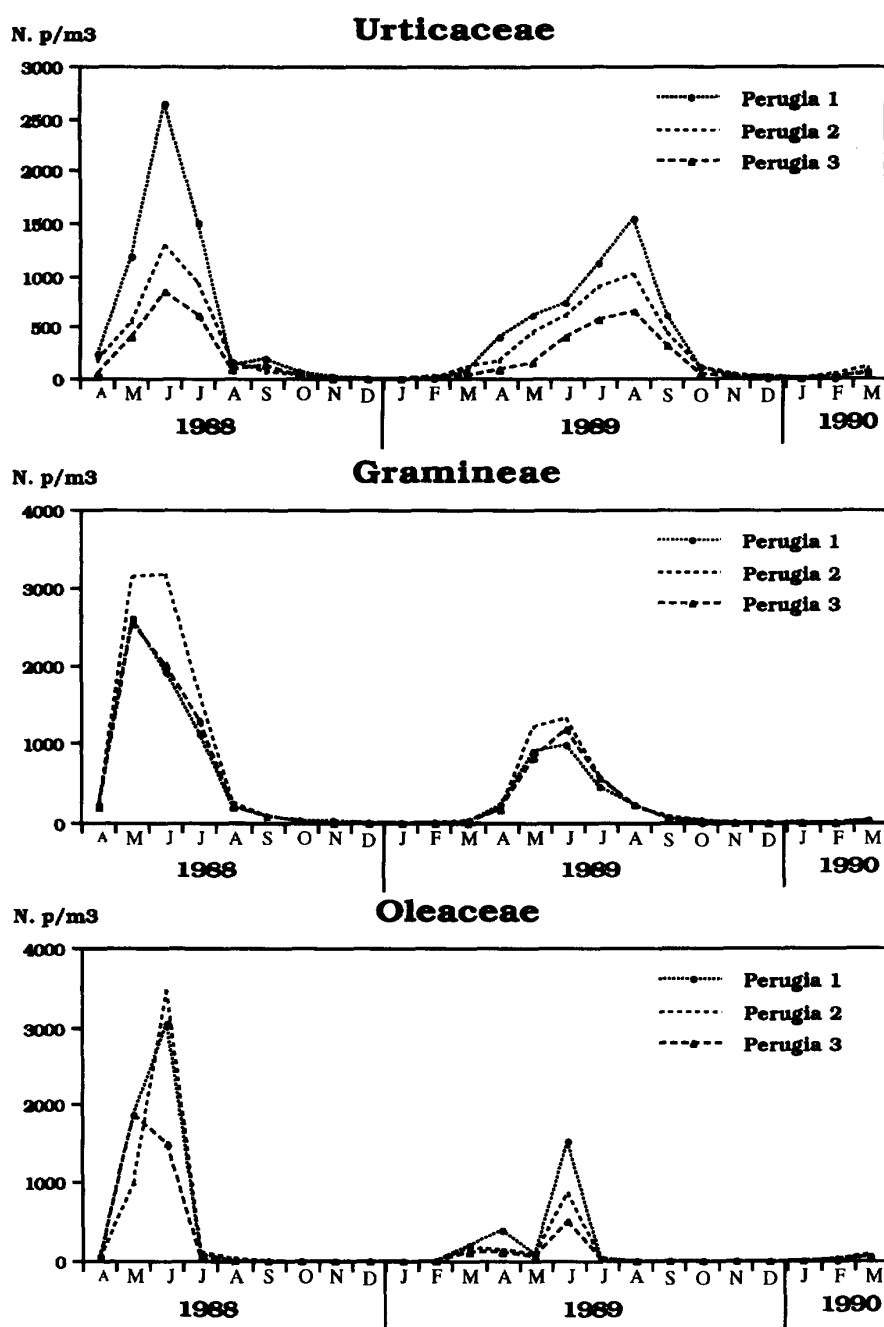


Fig. 5. Monthly concentration of pollen grains in the three stations.

The 1988 spring was characterized by temperatures near or slightly higher than the 10-year mean. During May 1988, in spite of high rainfall which occurred during the second 10 days of the month, the temperature trend was 0.5°C higher. The highest quantities of pollen were, therefore, recorded in the first and third 10 days of May and in the first part of June.

As far as timing of pollination is concerned, no great variations were recorded between the stations. The principal periods of pollination of the families examined showed only slight differences. In the case of *Quercus* (Fig. 4), for example, during 1988–1989 the main period of pollination was April 26th–27th in all of the stations; while during 1989–1990, it was April

10th–11th, with a delay of only a day between the stations. For Gramineae (Fig. 5), the principal period of pollination started on May 11th–14th in 1988–1989 with a delay of 3 days between the stations, and on the same day, April 25th, in 1989–1990, an advance of about 18 days on the previous period.

There were no qualitative differences for those species which are prevalently or completely anemophilous. However, over 90% of the monitored pollen grains belong to only seven families (Perugia 3: 90%; Perugia 2: 94%; Perugia 1: 99%). These families are: Cupressaceae/Taxaceae, Fagaceae, Oleaceae, Corylaceae and Pinaceae in the arboreal group, and Gramineae and Urticaceae in the herbaceous group (Tables 2 and 3).

There were some differences between the abundance of pollen grains in the stations as a result of differences in the vegetational sources around the pollen traps. For species with mixed pollination (anemophilous and entomophilous) and those which are fully entomophilous or auto-pollinating, their pollen grains are present in low quantities in the atmosphere because the flowering mechanism of these species is not adequate to liberate large quantities of pollen. The pollen grains of some families are therefore not recorded by volumetric traps, or are recorded in only limited quantities provided the source is relatively near the pollen trap. In our network, Perugia 1 recorded traces of arboreal Rosaceae, Lauraceae, and Cruciferae, perhaps as a consequence of the nearness of the Botanical Garden where these plants are present in abundance. Another example is Palmae pollen, recorded in both Perugia 1 as a result of the presence of the Botanical Garden, but also in Perugia 2 as a consequence of ornamental plants in local private gardens.

5. Conclusions

These latter examples tend to underline the efficiency of the monitoring system because it demonstrates the capture of limited traces of grains in the atmosphere, thus confirming the validity of volumetric monitoring. The pollen grains of these *taxa* do not, however, have to be considered in environmental monitoring because they do not clearly express the actual distribution of the species and they cannot be used to clearly identify the different phases of flowering. Hence, qualitative and quantitative differences cannot be ascribed to the pollen traps as they represent different vegetational situations around the stations. In an extremely heterogeneous territory such as the Perugia region, with a succession of plains and hills with altitudes varying between 180 m and 600 m above sea-level, rich in woods, cultivated and uncultivated zones, as well as densely populated areas, monitoring with three traps was, however, both

sufficient and useful to characterize the differential presence of pollen grains in the atmosphere. The following key conclusions can also be drawn:

- there were no significant differences in the traps in the main period of pollination, because the area does not have strong climatic differences;
- some differences were recorded in the relative abundance of families, which demonstrates that if they can be transported over long distances, there is a pollen concentration gradient around the emission source even in relatively nearby zones, as in the present study;
- while qualitatively and chronologically one trap can be sufficient to establish a census of species and to determine a pollen calendar for allergenic reasons, in a heterogeneous area such as the one examined in this paper, three traps are necessary to quantitatively characterized different vegetational situations.

For that reason, one pollen trap is enough to act as the network 'alarm' because the country is climatically homogeneous and the influence of meteorological parameters is similar. Three pollen traps enable a recording of the different levels of concentration of pollen particles in areas not far from each other. This revealed an interesting allergenic result such as, for example, the differential presence of *Parietaria* spp. in Perugia 1, and Gramineae in Perugia 3 in relation to other allergenic species.

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