

Pollen spectrum variations in the atmosphere of Cagliari, Italy

Mauro Ballero* & Andrea Maxia

Department of Botanical Sciences, University of Cagliari, Viale S. Ignazio da Laconi 13, I-09123 Cagliari, Italy
(*author for correspondence, E-mail: ballero@unica.it)

Received 5 April 2001; accepted in final form 22 September 2003

Key words: aerobiology, airborne pollen, atmospheric concentration, bioaerosol, Cagliari, pollen season

Abstract

We report on airborne pollen sampling in the atmosphere of Cagliari (southern Sardinia) in the two-year period 1999–2000, with the aim of supplementing and extending the knowledge of the city air plankton. The total pollen grains was 23,087. They belong systemically to 52 families, including 32 trees and/or shrubs and 20 herbaceous essences. The families with the highest airborne pollen incidence were the *Cupressaceae*, *Pinaceae*, *Urticaceae*, *Anacardiaceae*, *Oleaceae*, and the *Polygonaceae*. Compared to a previous monitoring, more families and fewer airborne pollen grains were observed in this study. In addition, one air pollen component was observed that had never been monitored in previous samplings. On comparing our data with national mean figures, the major anthesis is brought forward by a month as a result of the particular meteorological conditions that characterise the Sardinian climate. The studies carried out disclosed the relationship between air pollen concentration and meteorological factors. We also compiled a pollen calendar showing data on monthly pollen concentrations, from which a great deal of useful and important information has been obtained.

Introduction

In the past few years, air quality analysis in city centres has taken on an important role in the field of environmental research and prevention. The problem of the presence of pollen grains that could cause allergies in immunologically predisposed persons in the city air plankton is very important, especially when tree and/or shrub essences of a proven allergenic role are planted in areas dedicated to public parks and gardens.

Thanks to the continuous evolution of aerobiological studies and the many, ongoing botanical observations, a more extended and specific mass of information has become available to determine biological aerosols both qualitatively and quantitatively.

This work analyses the airborne pollen component in the city of Cagliari (southern Sardinia), supplementing and extending the existing, useful knowledge on the city air plankton produced both by autochthonous (Ballero et al., 1987; Ballero e Ariu, 1997) and non-autochthonous (Ballero et al., 2000) vegetation.

The studies carried out led to a full assessment of the pollen concentrations (number of pollen grains per cubic metre of air) both from the systemic point of view and numerically, and disclosed the relationship between pollen concentrations and climatic data such as temperature, rainfall, wind, and relative air humidity.

Materials and methods

The city of Cagliari is characterised by a semiarid, mesothermal type of climate with hot summers with a large water deficit and mild winters with a small water surplus (Arrigoni, 1968). The wind is the most characterising element as it blows for most of the year from W NW and S SE quadrants at times with great intensity.

The climatic limiting factors therefore selected a type of vegetation that can be included in the climax of undergrowth and littoral thermoxerophilous maquis, whose pollen grains have been identified by

us as belonging to the components of the city air plankton.

The air pollen samplings were carried out with a Burkard type volume sampler equipped with a weekly drum, positioned in the city centre of Cagliari at about 25 metres above the ground and away from pollen sources (Hirst and Hurst, 1967; Michel et al., 1979).

The techniques of aerobiological sampling, pollen grain count, and phenological sampling followed the recommendations of the Italian Aerobiological Association (D'Amato, 1981; Feliziani, 1996; Puppi Branzi, 1996; Mandrioli et al., 1998).

The air pollen component was determined using special guides and taxonomic atlases (Ciampolini e Cresti, 1981; Erdtman, 1952; Feliziani, 1986; Hyde and Adams, 1958) and a pollen reference collection prepared by us.

The aerobiological monitoring was carried out in 1999–2000 during which period the phenological phases were also analysed in detail.

Results and discussion

The total number of sampled pollen grains (Sum of the daily concentration for the two year period) was 23,087, 20,038 of which (i.e. 87% of the total) are due to trees and/or shrubs, while 3,049 (13%) are produced by herbaceous plants. The assessed families were 52, including 32 (62% of the total) trees and/or shrubs and 20 (38%) herbaceous essences (Table 1).

Numerically, the families that were most represented during the monitoring period were the following: the *Cupressaceae*, *Pinaceae*, *Urticaceae*, *Anacardiaceae*, *Oleaceae* and *Polygonaceae*. Slightly lower values were shown by: the *Poaceae*, *Fagaceae*, *Chenopodiaceae*, *Arecaceae*, *Ulmaceae*, *Asteraceae*, *Myrtaceae*, *Casuarinaceae* and *Moraceae*. These are followed by a number of families with much fewer pollen grains which include: the *Betulaceae*, *Euphorbiaceae*, *Corylaceae*, *Salicaceae* and *Plantaginaceae*. Finally there was a large group of taxa with a very small number of monitored grains, such as: the *Rubiaceae*, *Juglandaceae*, *Liliaceae*, *Caryophyllaceae*, *Rosaceae*, *Platanaceae*, *Malvaceae*, *Juncaceae*, *Boraginaceae*, *Brassicaceae* and *Taxodiaceae*.

A closer analysis of Table 1 shows that although the city of Cagliari is surrounded by vast wet and brackish zones, only a small percentage (5% of the total) of the air pollen component is attributable to halopsammophilic essences such as: the *Cyperaceae*

(*Carex* spp., *Cyperus* spp.), *Juncaceae* (*Juncus acutus* L., *Juncus capitatus* Weigel.), *Chenopodiaceae* [*Arthrocnemum fruticosum* (L.) Moq., *Suaeda fruticosa* (L.) Forsskal, *Atriplex halimus* L.], *Polygonaceae* (*Polygonum scoparium* Req. ex Loisel.), *Plantaginaceae* (*Plantago coronopus* L., *Plantago lanceolata* L.) and *Caryophyllaceae* (*Silene* spp.).

This value is not very high considering the large percentage of halopsammophilic essences that are present around the city. The cause of the absence of pollen grains from the city air plankton is the wind, which blows from N NW and S SW directing the bioparticles towards the suburbs of Cagliari. Values higher than ours were found by Ballero et al. (1985) for the city of Oristano (central Sardinia), where the brackish zones are upstream and downstream from the winds that invest the entire city centre sending the pollen grains towards the city.

A small quantity of pollen grains (13% of the total) is attributed to entities considered synanthropic and ruderal, such as: the *Poaceae* [*Cynodon dactylon* (L.) Pers., *Dactylis glomerata* L., *Bromus* spp., *Poa annua* L.], *Urticaceae* (*Urtica* spp., *Parietaria* spp.), *Chenopodiaceae* (*Beta vulgaris* L., *Chenopodium* spp.), *Polygonaceae* [*Emex spinosa* (L.) Campd., *Rumex obtusifolius* L.], *Euphorbiaceae* (*Mercurialis annua* L.), and *Asteraceae* [*Artemisia arborescens* L., *Senecio* spp., *Aster squamatus* (Sprengel) Hieron., *Taraxacum officinale* Weber].

This component can be attributed mostly to the careless management of some of the urban periphery areas, which have been left uncultivated and therefore have become the domain of this ecological category. Our observation could be received favorably by the local authority through vast works of restoration aimed at removing the sources of a large number of allergenic pollens, considering that the percentage of persons suffering from allergies in the city is of about 9–10%.

Among these entities we may also include the *Simaroubaceae* [*Ailanthus altissima* (Miller) Swingle], non-autochthonous plants of China that were introduced into our country for ornamental purposes and have now become fully acclimatised and become spontaneous and infestive.

The pollen load of the *Asteraceae* (202 grains) is made up mainly (71% of the subtotal) of pollen grains of *Artemisia arborescens* L., while the remaining 39% is made up of *Inula viscosa* (L.) Aiton, *Senecio* spp., *Calendula arvensis* L., *Aster squamatus* (Sprengel) Hieron., *Taraxacum officinale* Weber, *Sonchus oleraceus* L. and *Ambrosia* spp. As regards *Ambrosia*

Table 1. Comparison between the mean concentrations found in the 1999–2000 two-year period (1st column) and those found in the 1981–1985 monitoring (2nd column)

Trees and shrubs	1981–1985	1999–2000	Herbs	1981–1985	1999–2000
<i>Aceraceae</i>	1	–	<i>Acanthaceae</i>	1	–
<i>Adhatodaceae</i>	1	–	<i>Apiaceae</i>	22	101
<i>Agavaceae</i>	15	–	<i>Asteraceae</i>	202	657
<i>Anacardiaceae</i>	917	496	<i>Boraginaceae</i>	3	44
<i>Arecaceae</i>	290	–	<i>Brassicaceae</i>	4	191
<i>Betulaceae</i>	89	195	<i>Cannabaceae</i>	1	–
<i>Bignoniaceae</i>	1	–	<i>Caryophyllaceae</i>	3	19
<i>Cactaceae</i>	1	–	<i>Cheno-Amaranthac.</i>	357	818
<i>Caprifoliaceae</i>	11	172	<i>Convolvulaceae</i>	–	4
<i>Casuarinaceae</i>	106	1595	<i>Cyperaceae</i>	8	29
<i>Corylaceae</i>	52	114	<i>Euphorbiaceae</i>	72	779
<i>Cupressaceae</i>	11806	3942	<i>Geraniaceae</i>	4	–
<i>Ericaceae</i>	57	153	<i>Iridaceae</i>	–	6
<i>Fagaceae</i>	484	564	<i>Juncaceae</i>	2	241
<i>Juglandaceae</i>	1	59	<i>Lamiaceae</i>	–	4
<i>Lauraceae</i>	3	–	<i>Liliaceae</i>	3	19
<i>Leguminosae</i>	54	194	<i>Papaveraceae</i>	–	203
<i>Malvaceae</i>	1	–	<i>Plantaginaceae</i>	53	400
<i>Moraceae</i>	104	–	<i>Poaceae</i>	487	1835
<i>Myrtaceae</i>	110	220	<i>Polygonaceae</i>	638	301
<i>Oleaceae</i>	828	1218	<i>Potamogetonaceae</i>	1	–
<i>Phytolaccaceae</i>	4	–	<i>Rubiaceae</i>	1	18
<i>Pinaceae</i>	4708	920	<i>Urticaceae</i>	1186	10416
<i>Platanaceae</i>	1	–	<i>Verbenaceae</i>	1	–
<i>Polygalaceae</i>	1	–			
<i>Rosaceae</i>	6	364			
<i>Salicaceae</i>	52	306			
<i>Simaroubaceae</i>	49	487			
<i>Taxodiaceae</i>	1	–			
<i>Thymelaeaceae</i>	2	–			
<i>Tiliaceae</i>	49	58			
<i>Ulmaceae</i>	233	5			

spp., the plant has not been observed in Sardinia since 1927 (Fiori, 1927). For this reason we presume that the pollen grains could have reached the city bioatmosphere from the south of France or northern Italy (Piedmont, Lombardy and Liguria), transported by the strong mistral wind that invests the island from the north-west for most of the year.

Not all the pollen grains released in the atmosphere are deposited immediately near the source of emission or in a radius of a few tens of metres from it. In fact a small percentage is transported by currents of air over very large distances (Hirst and Hurst, 1967; Michel et al., 1979). A further confirmation

of long distance pollen diffusion is supplied by the studies by Dyakowska (1948), Polunin (1955), and Hafsten (1960), who captured specific pollen grains at hundreds of kilometres from the nearest source of emission.

The air pollen component of the *Oleaceae* (828 grains) is mostly made up of grains of *Olea europaea* L. (64% of the subtotal), while the remaining 36% is made up of *Fraxinus ornus* L., *Ligustrum vulgare* L. and *Phillyrea* spp.

As reported by Ballero et al. (2000), besides the autochthonous component, we also have a large group of plants of exotic origin introduced to deco-

rate the city's ornamental gardens, parks, and avenues, and that affect the composition of the city air plankton quite significantly. We quote the *Casuarinaceae* (*Casuarina stricta* Aiton), *Moraceae* [*Ficus* spp., *Maclura pomifera* (Rafin.) Schneid.], *Malvaceae* (*Lagunaria patersonii* G. Don), *Anacardiaceae* (*Rhus laevigata* L., *Schinus latifolius* Engl., *Schinus dependens* Orteg.), *Arecaceae* [*Brahea armata* S. Wats, *Washingtonia filifera* Q.A. Linden] H.A. Wendl., *Phoenix dactylifera* L., *Phoenix canariensis* Chabaud] and *Ulmaceae* (*Celtis australis* L.).

When such essences are introduced in the city for ornamental reasons one should take into consideration not only the plant's facility of growth and acclimatization, but also the quantity of pollen released in the atmosphere and the possibility that this might trigger allergic reactions in predisposed subjects.

The pollen grains emitted by Mediterranean maquis essences have been monitored with a certain frequency. These essences are: the *Fagaceae* (*Quercus* spp.), *Cupressaceae* (*Juniperus* spp.), *Anacardiaceae* (*Pistacia lentiscus* L.), *Ericaceae* (*Arbutus unedo* L., *Erica* spp.), *Myrtaceae* (*Myrtus communis* L.) and the *Oleaceae* [*Olea europaea* L. var. *sylvestris* (Miller) Brot., *Phyllyrea* spp.].

Besides anemophilous pollen grains, we also monitored the entomophilous grains, which are raised from the ground into the atmosphere under the action of strong air currents. Among these we quote the pollen grains of the *Bignoniaceae* (*Jacaranda mimosifolia* Don), *Lauraceae* (*Laurus nobilis* L.), *Leguminosae* (*Robinia pseudoacacia* L.), *Acanthaceae* (*Acanthus mollis* L.), *Verbenaceae* (*Vitex agnuscastus* L.), *Caprifoliaceae* (*Sambucus* spp., *Viburnum tinus* L.), *Rubiaceae* (*Galium* spp.), *Liliaceae* (*Asphodelus* spp., *Allium* spp., *Asparagus* spp.), *Brassicaceae* (*Eruca sativa* Miller), *Geraniaceae* (*Geranium molle* L.) and the *Apiaceae* (*Daucus carota* L.).

From the values reported in Table 1, we can observe that there is a sharp difference in air pollen concentration between the two types of pollen, i.e. the anemophilous and the entomophilous. Consequently, only the pollens released by anemophilous plants are present in high concentrations, while those released by entomophilous plants are present only in extremely small quantities.

On comparing the data found by us with those previously reported by Ballero et al. (1987), there was a larger number of families and a smaller concentration of airborne pollen grains. As many as 33 families:

the *Myrtaceae*, *Cupressaceae*, *Asteraceae*, *Pinaceae*, *Anacardiaceae*, *Fagaceae*, *Casuarinaceae*, *Oleaceae*, *Polygonaceae*, *Ulmaceae*, *Poaceae*, *Urticaceae*, *Chenopodiaceae*, *Betulaceae*, *Caprifoliaceae*, *Corylaceae*, *Ericaceae*, *Juglandaceae*, *Leguminosae*, *Rosaceae*, *Salicaceae*, *Simaroubaceae*, *Tiliaceae*, *Boraginaceae*, *Caryophyllaceae*, *Brassicaceae*, *Cyperaceae*, *Euphorbiaceae*, *Juncaceae*, *Liliaceae*, *Plantaginaceae*, *Rubiaceae* and the *Apiaceae* are present in both samplings.

In our contribution we observed the presence of 19 new taxa which had not been observed in the previous work by Ballero et al. (1987). They are: the *Moraceae*, *Agavaceae*, *Malvaceae*, *Geraniaceae*, *Phytolaccaceae*, *Arecaceae*, *Cactaceae*, *Potamogetonaceae*, *Verbenaceae*, *Aceraceae*, *Cannabaceae*, *Acanthaceae*, *Thymelaeaceae*, *Adhatodaceae*, *Bignoniaceae*, *Platanaceae*, *Taxodiaceae*, *Polygalaceae* and the *Lauraceae*; while no pollen grains of the *Lamiaceae*, *Convolvulaceae*, *Iridaceae* or the *Papaveraceae* were observed. Only the *Anacardiaceae*, *Cupressaceae*, *Pinaceae*, *Polygonaceae* and the *Ulmaceae* show a remarkable increase in air pollen concentration values, while the other monitored families recorded much lower values than in the past. The different results could be due to the extemporaneous nature of the conditions governing the grain release and transport, as well as new environmental conditions (greater anthropic influence), climatic mutations (high mean seasonal temperatures and prolonged drought), and finally the fact that the sampler was placed in a different position in the city.

The highest air pollen concentrations (mean for the two-year period – Figure 1) were found in the months of February and March with a total 17,091 sampled grains (74% of the total). In February the number of monitored grains was 6,381 (30% of the total), systematically belonging to 29 families, including the *Cupressaceae* with 5782 grains (85% of the subtotal) and the *Pinaceae* with 764 grains (11% of the subtotal) which are the main sources of pollen grain release. While in March the number of monitored grains was 10,260 (44% of the total), systematically belonging to 30 families, including the *Cupressaceae* with 5,231 grains (51% of the subtotal), the *Pinaceae* with 3,603 grains (35%), the *Anacardiaceae* with 457 grains (4%), and the *Polygonaceae* with 308 grains (3%).

Far lower values were recorded in August and December, with a total 230 grains (0.99% of the total). In August the number of sampled grains was 117

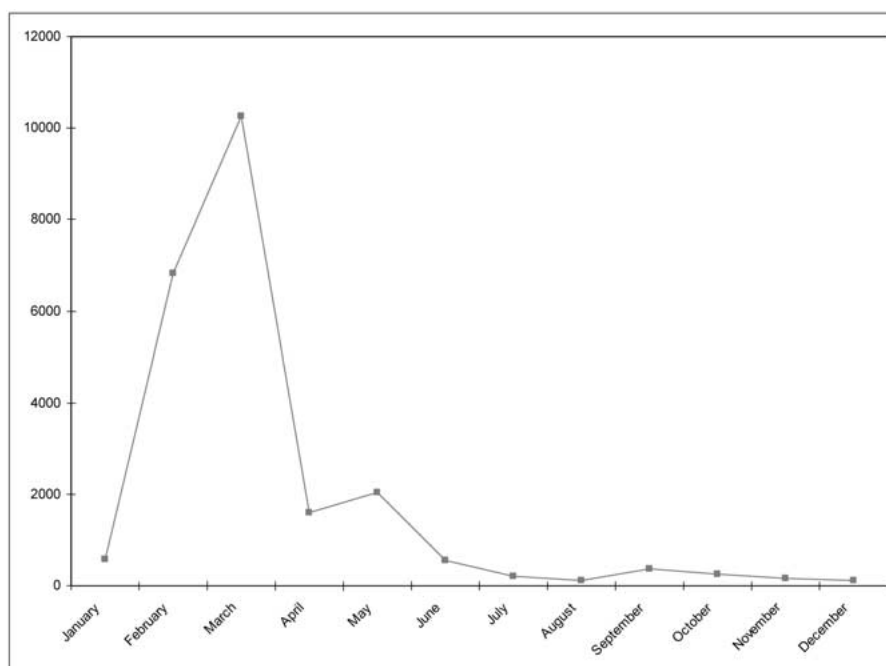


Figure 1. Pollen concentrations found in the atmosphere of Cagliari in the 1999–2000 two-year period. Mean values for the two-year period.

(0.50% of the total), systematically belonging to 17 families, including the *Arecaceae* with 35 grains (30% of the subtotal) and the *Urticaceae* with 26 grains (26%). While in December the number of monitored grains per cubic metre of air was 113 grains (0.48% of the total), systematically belonging to 12 families, including the *Cupressaceae* with 43 grains (38% of the subtotal) and the *Arecaceae* with 27 grains (24%) which present the highest monthly concentrations.

On comparing the above considerations with data referring to national mean values, the major anthesis is put forward by a month as a result of the particular meteorological conditions that characterize the climate in Sardinia.

Thanks to these observations it was possible to assess the interrelations between these concentrations and local meteorological conditions and estimate the action of the individual atmospheric agents on the release and diffusion of pollen grains in the atmosphere.

Precipitation causes the so-called “rain washing” phenomenon, and reduces the air pollen concentration both by passively dragging the bioparticles to the ground and by hydrating them and consequently increasing their weight and depositing them to the ground by gravity. Figure 2 shows that between September and December when precipitation

increases, the number of pollen grains suspended in the atmosphere decreases.

Since temperature acts on the formation of pollen grains and the opening of the anthers, it regulates the presence of the bioparticles suspended in the air both numerically and heterogeneously. It can be seen from Figure 3 that pollen values decrease on increasing the temperature and that in August they reach the minimum concentration of 117 grains per cubic metre of air at the maximum temperature of 26.7 °C.

Since pollen grains are highly hygrophilous cells, they hydrate in the presence of a high percentage of relative humidity in the air, thus gaining weight and falling to the ground by gravity. In this way the amount of pollen in the atmosphere decreases. However, a careful analysis of Figure 4 shows an anomalous behavior of these two parameters, as no clear correspondence is seen between the values of relative humidity in the air and air pollen concentration.

Finally, the wind plays an important role in the dispersion of bioparticles. By blowing at speeds greater than 10 km/h for most of the year, it rapidly removes the pollen grains away from the source of emission and from the different layers of the atmosphere, and lifts non vital pollen grains from the ground, which are recognized because completely dehydrated and partially damaged.

Table 2. Pollen calendar of the monitored families in the atmosphere of Cagliari and related monthly pollen concentrations (mean values for the two-year period)

	J	F	M	A	M	J	J	A	S	O	N	D
<i>Acanthaceae</i>			1									
<i>Aceraceae</i>				1								
<i>Adhatodaceae</i>			1									
<i>Agavaceae</i>				8			1	1	3	2		
<i>Anacardiaceae</i>	3	16	457	410	15	1	8			1		6
<i>Apiaceae</i>		1	2	2	4	5	1	3	2	1	1	
<i>Arecaceae</i>	7	2		12	2	6	18	33	40	69	74	27
<i>Asteraceae</i>	2	2	4	12	125	8	7	5	12	18	7	1
<i>Betulaceae</i>	9	67	11	1	1							
<i>Bignoniaceae</i>										1		
<i>Boraginaceae</i>			1	1	1							
<i>Brassicaceae</i>									3	1		
<i>Cactaceae</i>				1								
<i>Cannabaceae</i>						1						
<i>Caprifoliaceae</i>		2	9									
<i>Caryophyllaceae</i>				3								
<i>Casuarinaceae</i>	15	8							16	37	16	14
<i>Cheno-Amaranthac.</i>	2	1	3	26	97	22	12	12	160	20	1	1
<i>Corylaceae</i>	1	28	8	4	11							
<i>Cupressaceae</i>	465	5782	5231	86	31	10	5	2	97	41	13	43
<i>Cyperaceae</i>		2	1	1	3	1						
<i>Ericaceae</i>		2	32	20	3							
<i>Euphorbiaceae</i>	7	14	15	20	7	3	1	1	1	1	1	1
<i>Fagaceae</i>		1		37	371	48	23	4				
<i>Geraniaceae</i>				1	1	1	1					
<i>Juglandaceae</i>				1								
<i>Juncaceae</i>			1	1								
<i>Lauraceae</i>		1	1	1								
<i>Leguminosae</i>	1	1	2	5	12	20	2	1	2	2	3	1
<i>Liliaceae</i>							1	1	1			
<i>Malvaceae</i>										1		
<i>Moraceae</i>			8	30	59	5	1	1				
<i>Myrtaceae</i>	1	1	1	1	2	23	61	14	2	2	1	1
<i>Oleaceae</i>		6	115	191	421	92	3					
<i>Phytolaccaceae</i>					3	1						
<i>Pinaceae</i>	4	764	3603	208	84	26	9	4	3	1	1	1
<i>Plantaginaceae</i>				26	20	5	1	1				
<i>Platanaceae</i>				1								
<i>Poaceae</i>		1	4	52	299	72	25	7	8	17	2	
<i>Polygalaceae</i>			1									
<i>Polygonaceae</i>	4	16	308	170	105	6	2	1	1	1	19	5
<i>Potamogetonaceae</i>		1										
<i>Rosaceae</i>		1	1	3	1							
<i>Rubiaceae</i>											1	
<i>Salicaceae</i>	1	12	37	1	1							
<i>Simaroubaceae</i>		1		6	10	29	3					
<i>Taxodiaceae</i>	1											
<i>Thymelaeaceae</i>		1	1									
<i>Tiliaceae</i>	2	6	5	27	3	1	1		1	1	2	
<i>Ulmaceae</i>		7	196	30								
<i>Urticaceae</i>	49	84	200	204	348	167	33	26	14	27	22	12
<i>Verbenaceae</i>											1	

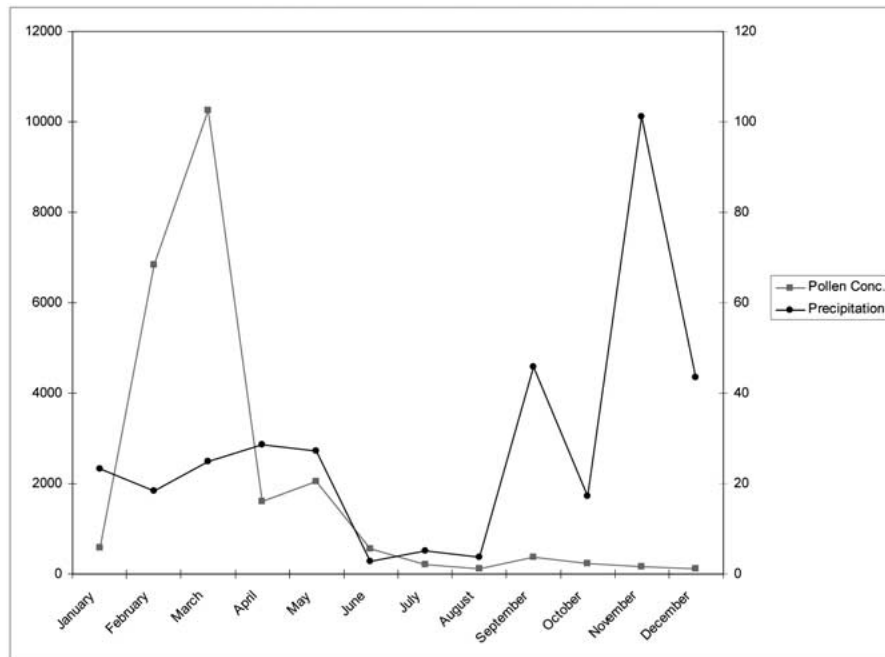


Figure 2. Pollen concentrations and rainfall found in the atmosphere of Cagliari in the 1999–2000 two-year period. Mean values for the two-year period.

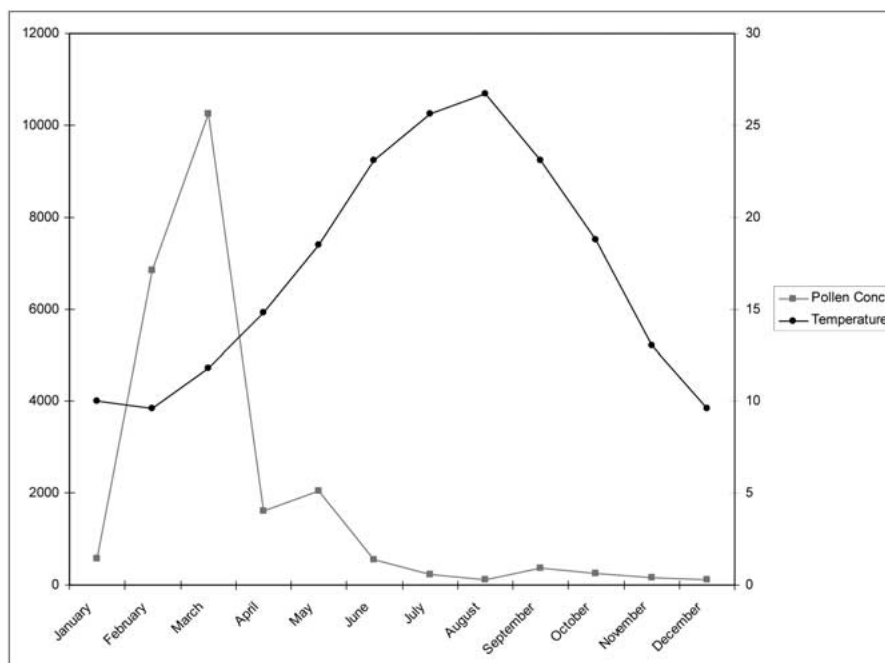


Figure 3. Pollen concentrations and temperatures found in the atmosphere of Cagliari in the 1999–2000 two-year period. Mean values for the two-year period.

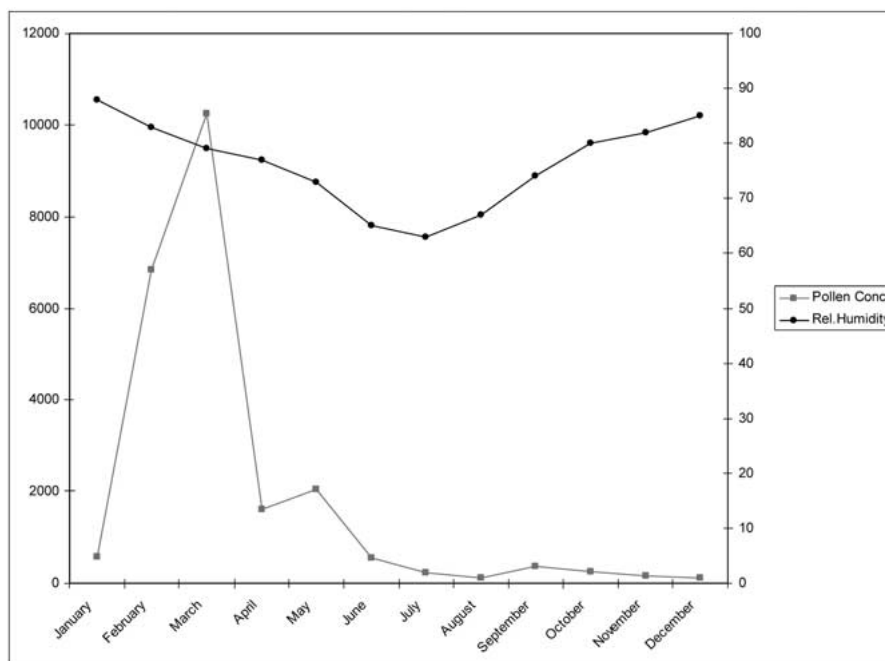


Figure 4. Pollen concentrations and relative humidity found in the atmosphere of Cagliari in the 1999–2000 two-year period. Mean values for the two-year period.

The data reported by us do not agree with those of Singh and Babu (1980), who state that the ideal environmental conditions for pollination are a temperature of 25–30°C, no rainfall, a relative air humidity of 60–90%, a wind velocity of 5–15 km/h, and presence of light and sunshine.

From our samplings, we prepared a pollen calendar (Table 2) showing monthly pollen concentrations (mean values for the two year period).

Among the monitored entities, the *Asteraceae*, *Pinaceae*, *Cupressaceae*, *Urticaceae*, *Polygonaceae*, *Chenopodiaceae*, *Leguminosae*, *Euphorbiaceae* and *Myrtaceae* are present all the year round though in lesser quantities in some months, while the *Arecaceae*, *Apiaceae*, *Tiliaceae*, *Poaceae* and *Anacardiaceae* were monitored for most of the year. Finally, pollen grains of the *Aceraceae*, *Cannabaceae*, *Cactaceae*, *Taxodiaceae*, *Phytolaccaceae*, *Thymelaeaceae*, *Boraginaceae* and *Caprifoliaceae* were sampled in low concentrations for a few months.

On analyzing the air pollen concentration values, most families monitored by us release their pollen grains in the atmosphere between February and May, while the lowest values are found in the summer-autumn. It can be seen therefore that the pollen grains are distributed prevalently in the first part of the year,

that is in a relatively short time span of about 120–150 days.

On examining the air pollen concentrations of the individual families monitored during the entire year, we observe that the *Cupressaceae* present their highest pollen concentration in February with 5,782 grains and a daily mean concentration of 207 grains, and a second highest concentration in March with 5,231 grains and a daily mean concentration of 187 grains. The *Pinaceae*, on the other hand, show their highest concentration in March with 3,603 grains and a daily mean concentration of 116 grains. The *Anacardiaceae* show a far lower maximum concentration in March with 457 grains and a daily mean of 15 grains. Finally, the *Oleaceae* show their highest air pollen concentration in May with 421 grains and a daily mean concentration of 14 pollen grains. All the other studied taxa show daily mean values below 10 grains.

Conclusions

The results obtained with our research are a further positive contribution to our knowledge of the composition of the city pollen aerosol.

This study showed that the highest pollen concentrations are found in February and March. This is the phase in which all the macro- and microclimatic elements not only allow a larger emission of grains but also a better dispersion in the atmosphere. It can be seen from this that pollen allergies in our city present earlier than indicated in the generic "pollen bulletins" published by the national media, which are unreliable and misleading.

Several frequent restoration works in uncultivated and/or rural areas, and the planting of autochthonous and non-autochthonous trees and/or shrubs in the city environment have led to a change in the pollen composition of the air plankton. In fact, an important element that must be assessed is floristic richness, to which a pollen grain richness may correspond.

Since there are many floristic, ecological, and environmental settings within the same city, it follows that the aerobiological situations induced are also numerous. Monitoring should therefore be extended to the entire city, by covering a larger investigated area and positioning more samplers to represent the different urban areas. This will define a more specific correspondence between flora and pollen spectrum at the different stations.

From an examination of the available data, it is suggested that an aerobiological study may lead to interesting data relating to the flora of the city and neighboring areas.

Finally, airborne pollen values referred to the same location may change considerably within a few years. This is clearly observed from a comparison with previous air pollen analyses in Cagliari (Ballero et al., 1987). The data referred to the two periods show differences that can be attributed to edaphic and/or environmental conditions, which have changed in this time interval in the urban area of Cagliari. It is important to base prevention on data that is continuously updated and checked occasionally by accurate detailed samplings.

References

- Arrigoni P.V.: 1968, Fitoclimatologia della Sardegna. *Webbia* **23**, 1–100.
- Ballero M., Piu G. and Cara N.: 1987, La componente pollinica nell'atmosfera di Cagliari. *Aerobiologia* **3**, 61–68.
- Ballero M., Piu G. and Sechi P.: 1985, A pollen calendar for Oristano (central Sardinia) preliminary data. *Boletín da Sociedade Broteriana* **LVIII**(2), 57–62.
- Ballero M. and Ariu A.: 1997, Relazioni tra flora nitrofila e ruderale e concentrazioni aeropolliniche nell'area urbana di Cagliari. *Rendiconti Seminario Facoltà Scienze Università di Cagliari* **67**, 39–46.
- Ballero M., Piu G. and Ariu A.: 2000, The impact of the Botanical Gardens on the aeroplankton of the city of Cagliari. *Aerobiologia, International Journal of Aerobiology* **16**(1), 143–147.
- Ciampolini F. and Cresti M.: 1981, *Atlante dei principali pollini allergenici presenti in Italia*. Università di Siena.
- D'Amato G.: 1981, Allergia respiratoria da pollini e da miceti. Lombardo Ed., Roma.
- Dyakowska J.: 1948, The pollen rain on the sea and on the coast of Greenland. *Bull. Int. Acad. Cracovie (Acad. Pol. Sci.) Ser. B. Sci. Nat.*, 1–25.
- Erdtman G.: 1952, *Pollen Morphology and Plant Taxonomy: Angiospermae*. Almquist & Winchell, Stockholm.
- Feliziani V.: 1986, *I pollini di interesse allergologico. Guida alloro riconoscimento*. Masson Italia Ed., Milano.
- Feliziani V.: 1996, Monitoraggio pollinico in allergologia. *Atti VII Congresso Nazionale A.I.A., Firenze*, 80–82.
- Fiori A.: 1927, *Nuova flora analitica d'Italia*. Tipografia M. Ricci, Firenze.
- Haftsten U.: 1960, Pleistocene development of vegetation and climate in Tristan da Cunha and Gough Island. *Arbok Univ. Bergen Mal. Natyr. Ser.*, n. 20.
- Hirst J.M. and Hurst G.W.: 1967, Long-distance spore transport. Airborne microbes. In: P.H. Gregory and J.L. Monteith (eds.), *Symp. Soc. Gen. Microbiol.* Cambridge University Press, p. 385.
- Hyde H. and Adams K.F.: 1958, *An Atlas of Airborne Pollen Grains*. MacMillan & C., New York.
- Mandrioli P., Comtois P., Dominguez E., Galan C., Isard S. and Syzdek L.: 1998, Sampling: Principles and Techniques. In: P. Mandrioli, P. Comtois and V. Levizzani (eds.), *In Methods in Aerobiology*, cap. 3. 47–12. Pitagora Editrice, Bologna.
- Michel F.B., Seignalet CH. and Cour P.: 1979, Contribution palynologique, allergologique, météorologique et climatologique de l'Etude des flut polliniques entre la Scandinavie et l'Afrique du Nord. Premiers résultats. "Les Pollinoses", Ed. Fisons, 159 pp.
- Polunin N.: 1955, Arctic aeropalynology. Spora observed on sticky slides exposed in various regions in 1950. *Can. J. Bot.*, 33–401.
- Puppi Branzi G.: 1996, Fenologia e previsioni aerobiologiche. *Atti VII Congresso Nazionale A.I.A., Firenze* **36**.
- Singh A.B. and Babu C.R.: 1980, Studies on pollen allergy in Delhi. Diurnal periodicity of common allergenic pollen. *Allergy* **35**, 311.

