

Risk of pollen allergy in Nerja (southern Spain): a pollen calendar

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Abstract An aeropalynological study was carried out in the atmosphere of the city of Nerja (southern Spain) during a period of 4 years (2000–2003), using a Hirst type volumetric pollen trap. An annual pollen index of 59,750 grains, on average, was obtained with 80–85% of the total pollen recorded from February to May, with *Pinus*, *Olea*, Urticaceae, Cupressaceae, *Quercus* and Poaceae being the principal pollen producers in abundance order. A total of 29 pollen types that reached a 10-day mean equal to or greater than 1 grain of pollen per m³ of air is reflected in a pollen calendar. The results were compared with those obtained for nearby localities and a correlation analysis was made between the daily fluctuations of the main pollen types and total pollen, and meteorological parameters (temperature, rainfall and hours of sun). The daily, monthly and annual values reached by the most important pollen types from an allergenic point of view (*Olea*, Urticaceae and Poaceae) confirms Nerja as a high-risk locality for the residents and the numerous tourists who visit the area.

Keywords Nerja · Southern Spain · Pollen calendar · Aerobiology

1 Introduction

The province of Malaga (southern Spain) is one of the most popular tourist resorts in Europe. It is especially known for its coast, the “Costa del Sol”, in which Nerja constitutes an important city, situated 60 km eastwards from the provincial capital. Near the Nerja urban centre is located one of the biggest and most visited caves in the world, the “Cueva de Nerja”, which receives more than half a million visitors every year.

As knowledge of the atmospheric pollen content is considered very useful in the diagnosis and treatment of pollinosis, aerobiological studies have previously been carried out in several localities of the province of Malaga: in the capital (Recio et al. 1998), in the western coast (Recio et al. 2006) and inlands (Trigo et al. 1999, 2000). This, however, is the first study developed in the eastern coast. The station at Nerja forms part of the Spanish Aerobiology Network (REA) and covers information from a wide territory situated between the coastal aerobiological stations of Malaga and Motril, this last in the province of Granada. The aim of this work is to present a study of the atmospheric pollen content of the locality by elaboration of a pollen calendar as well as to show the annual behaviour presented by the different pollen types in order to assess the allergenic potential of this zone of the Costa del Sol. Finally, we will compare the results obtained with other nearby station and its relationship with meteorological parameters will be analyzed.

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2 Materials and methods

Nerja (36°45' N, 3°50' O) lies in the south of the Iberian Peninsula. It is bounded to the north by a mountain chain of calcareous rocks (Sierra de Almijara), running NW-SE and terminating in high cliffs over the sea. To the west run the alluvial plains of the rivers Chillar and Vélez, while the Mediterranean Sea limits its southern border (Fig. 1).

The surroundings of the station are populated by natural vegetation adapted to the special ecological conditions of the zone (poorly developed calcareous soils, high temperatures and low rainfall). The arboreal stratum is dominated by repopulations of *Pinus halepensis* Miller, the most characteristic bushes being *Buxus balearica* Lam. (Boj), *Maytenus senegalensis* (Lam.) Exell, *Cneorum tricoccom* L., *Quercus coccifera* L., *Pistacia lentiscus* L., *Chamaerops humilis* L. and *Juniperus oxycedrus* L. In the herbaceous stratum several species of grass, *Chenopodium*, *Amaranthus*, *Plantago*, *Parietaria* and *Artemisia* are frequent (Nieto et al. 1991;

Cabezudo et al. 2005). Near the sea, tropical fruits, especially avocado, and horticultural plants are frequently cultivated. The many ornamental plants in the parks and gardens bordering the aerobiological station, particularly casuarina, cypresses, palms and pines, also play their part in a study such as this.

Bioclimatically, Nerja lies within the thermomediterranean belt, with a dry ombroclimate (Rivas Martínez 1987). Winters are mild and frost-free (Fig. 2) and the annual mean temperature is 18.5°C, January being the coldest month (mean, 13.2°C) and August the warmest (mean, 25.4°C). The annual rainfall is 442.2 mm, as average, falling mostly in autumn (October–December) and winter (January–March). There is less rain in spring, while the summer is long and dry (Fig. 2). As regards wind, although variable in direction, the predominant blows from the mountains (north), while the south wind blows off the sea; periods of calm are infrequent (14.4%). Another characteristic of importance is the number of hours of sunshine—about 3,000 h per year—and the practical absence of days without sun.

The study is based on the atmospheric pollen records obtained from 15 February 2000 to 31 December 2003, using a Hirst type volumetric trap (Hirst 1952), a Burkard seven-day recorder, placed near the gardens adjoining Nerja Cave. The sampler was situated in an open area, on a cement post 2 m

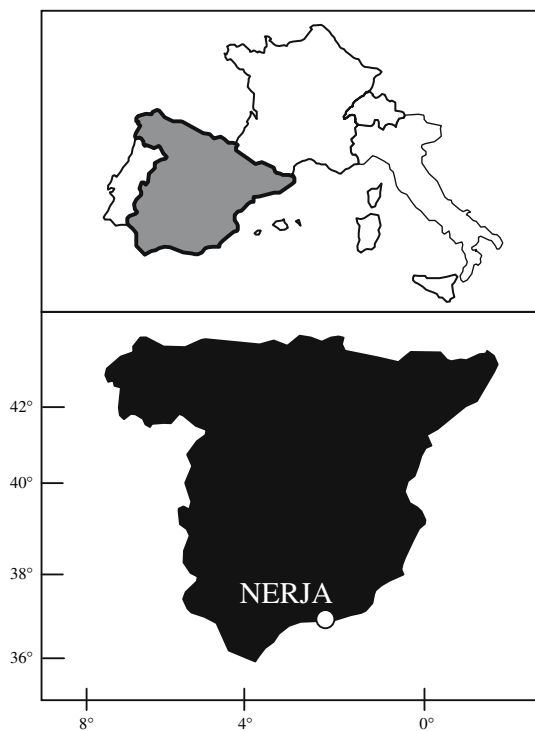


Fig. 1 Localisation and geographical coordinates of Nerja

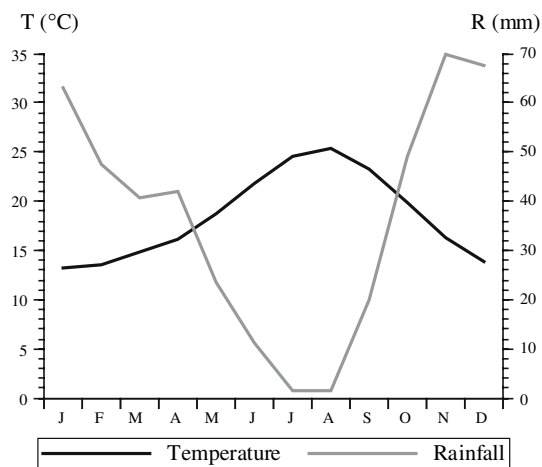


Fig. 2 Ombroclimatic diagram for monthly values of mean temperature and total rainfall during the years 1964–2003

above the ground level, on the slope of a hill, over the level of the city. The sampler operated continuously aspirating a constant flow of 10 l per minute. After exposure, the Melinex[®] tape, impregnated with silicone fluid was cut into 24 h fragments (48 mm) and mounted on slides using glycerine jelly stained with fuchsine. 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 400 \times , according to the methodology proposed by the REA (Domínguez et al. 1991). The pollen concentrations are expressed as the number of pollen grains/m³ of air, the mean daily values being used for the elaboration of tables and graphs.

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 in which the cumulative daily count reached 2.5% of the annual figure (from Jan 1st) and finishing the day in which 97.5% of the annual total had been included.

The pollen calendar was constructed by following Spiekma's model (Spiekma 1991), which transforms 10-day mean pollen concentrations into a series of classes according to Stix and Ferretti (1974) and represents them in a 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 equal to or greater than 1 pollen grain/m³ of air were included.

To statistically confirm possible relationships between daily pollen concentrations and the different meteorological parameters, such as rainfall, temperature (maximum, minimum and mean), and sunshine, the Spearman correlation coefficients were calculated. For this, we used the pre-peak period daily data of the main pollen seasons (Table 3) of the most abundant taxa for the years 2001–2003.

The climatic data were provided by the La Mayora meteorological station, situated 18 km west from the aerobiological sampling station (Cueva de Nerja), which was chosen because it was the closest one and possessed a great number of reliable data covering not only the study period (2000–2003) but also all the years since 1964.

3 Results

3.1 Climatology

During the 4 years studied, the mean annual temperature was close to the average (18.5°C), although a little lower the first year (18.1°C) and slightly higher during the subsequent 3 years (18.7, 18.7 and 18.8°C, respectively), reflecting a gradual increase during the 4 years of the study (2000–2003). During the same period, rainfall was slightly higher than average (442.2 mm), except in 2001 and, as in the case of the mean temperature, there was a slight tendency for the annual rainfall to increase: 459.2 mm (2000), 396.5 mm (2001), 503 mm (2002) and 548.7 mm (2003).

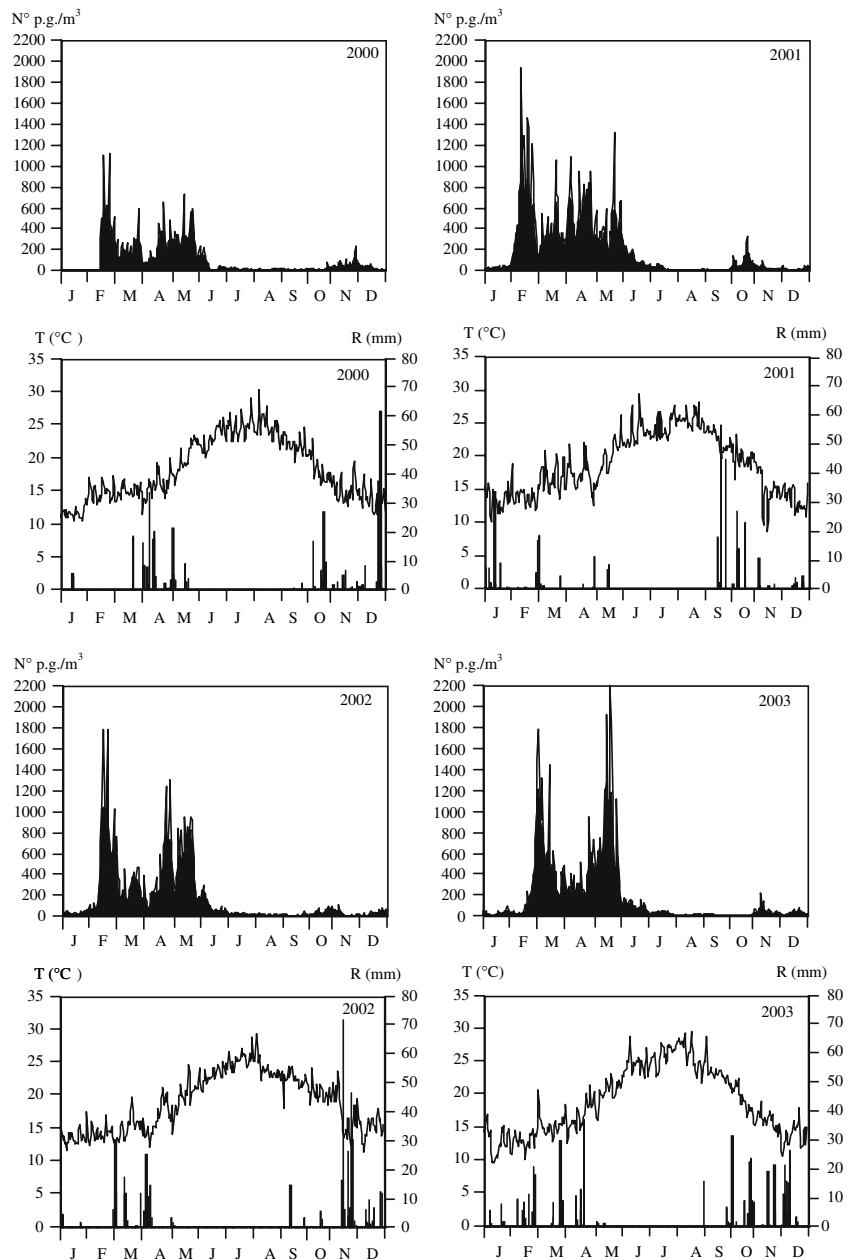
Although the daily values of both meteorological parameters (temperature and rainfall) registered during the 4 years of the study varied from day to day, the general trend during each year was largely similar: rainfall irregularly distributed from autumn to spring, being more abundant in the former, and the lowest temperatures being registered in January (10–15°C), after which they gradually rise to reach a maximum in August (25–30°C) before falling off again until the end of the year, as can be seen in the ombroclimatic diagram (Figs. 2, 3).

3.2 Pollen content

The mean annual pollen index obtained in Nerja during the period studied (2001–2003) was 59750 (Table 1). The lowest value was recorded in 2000 with an incomplete count of the 33,664 (15 February–31 December) and the highest in 2001 with a value of 62,053.

During the years studied, the highest pollen counts were always recorded from February to May (Table 1, Fig. 3), a period in which 80–85% of the total annual pollen was collected. However, the month in which the highest quantities of pollen were recorded varied from year to year: in 2001 the highest score was detected in February (16,769 pg/m³; 27% of annual total), while in 2002 and 2003 it was in May, with 17,156 pg/m³ (29.7%) and 21,753 pg/m³ (36.6%), respectively. Another important difference is that in February 2003 only 4.5% of the annual total was recorded, which is very low compared with the

Fig. 3 Daily values of mean temperature, total rainfall and total pollen concentration (line: daily mean values; black area: five days running mean) during the years studied



corresponding values for the same month in other years (25–27%). The months with the lowest quantities of pollen were always August and September (also October in 2003), when the percentage did not reach 1% of the annual total.

As the year progressed, several pollen peaks were detected, principally due, with little differences from year to year to *Pinus* and Cupressaceae in February–March, *Quercus* in April, *Olea* and Poaceae in May

and Urticaceae from March to May (Figs. 3, 4). From the end of May onwards the daily pollen counts fall significantly and no new peaks appear until October–November, but much less pronounced. This small peak detected is due to the pollination of some autumn-flowering species such as some Cupressaceae, *Casuarina* and *Artemisia*. From February to May mean daily concentrations sometimes exceed 1,000 pg/m^3 . The historic maximum for the period

Table 1 Monthly and annual values (total and percentages) of total pollen during the years studied

	2000		2001		2002		2003		Average (2000–2003)	
	Total	%	Total	%	Total	%	Total	%	Total	%
January	–	–	888	1.4	1,066	1.8	875	1.5	943	1.6
February	<i>6,501</i>	–	16,769	27.0	14,561	25.2	2,668	4.5	11,333	18.9
March	6,111	–	9,821	15.8	8,374	14.5	17,544	29.5	10,463	19.9
April	5,162	–	15,000	24.2	8,613	14.9	8,151	13.7	9,232	17.6
May	9,434	–	9,564	15.4	17,156	29.7	21,753	36.6	14,477	27.2
June	2,151	–	5,044	8.1	3,258	5.6	4,143	7.0	3,649	6.9
July	635	–	981	1.6	863	1.5	1,242	2.1	930	1.7
August	357	–	205	0.3	510	0.9	341	0.6	353	0.6
September	353	–	270	0.4	466	0.8	393	0.7	371	0.6
October	462	–	2,139	3.4	1,158	2.0	102	0.2	965	1.9
November	1,708	–	789	1.3	748	1.3	1,425	2.4	1,168	1.7
December	860	–	583	0.9	929	1.6	857	1.4	807	1.3
Sum	<i>33,734</i>	–	62,053	100.0	57,702	100.0	59,494	100.0	59,750	100.0

In italics: incomplete values because sampling began in February 2000

studied being reached on 24th May 2003, when a daily mean of 2,200 pg/m³ was recorded.

The taxa with a higher influence in the atmosphere of Nerja are *Pinus*, *Olea*, Urticaceae, Cupressaceae, *Quercus* and Poaceae, that jointly represent, as average, 89.01% of the total, with substantial fluctuations from year to year regarding annual quantities, dates of beginning and end of the MPS, season length and daily maximum values (Fig. 4, Tables 2, 3). Although the different scales for each pollen type must be taken into account, the maximum daily values are reached by arboreal species (*Pinus*, *Olea*, *Quercus* and Cupressaceae), while the herbaceous plants (Urticaceae and Poaceae) show the lowest maxima. The highest daily register reached in Nerja by the different pollen types correspond to *Pinus* (1,669 pg/m³), followed by *Olea* (1,345 pg/m³), *Quercus* (745 pg/m³), Cupressaceae (709 pg/m³), Poaceae (578 pg/m³) and Urticaceae (373 pg/m³). We have also calculated the number of days of different levels of risk of allergy diseases caused by the pollen of these taxa (Table 3). For that, it has been considered as “moderately allergenic levels” those between 25 and 50 pg/m³ in the case of herbaceous taxa and between 50 and 100 pg/m³ in the case of arboreal taxa, and as “highly allergenic levels” those >50 pg/m³ and >100 pg/m³ for herbaceous and arboreal taxa, respectively. Note that in Neja it is not unusual to

find daily atmospheric concentrations of *Pinus* and *Olea* pollen higher than of 1,000 pg/m³.

In general, the pollination periods of the arboreal taxa (*Pinus*, *Olea* and *Quercus*) are shorter than those of the herbaceous ones (Urticaceae and Poaceae) (Fig. 4). Cupressaceae has two pollination periods, one in February–March and the other, of lower intensity, in October–November, each one corresponding to the flowering season of different species (basically *Cupressus sempervirens* L. in winter, *Juniperus oxycedrus* L. in late winter and early spring, and *Cupressus arizonica* E.L. Greene in autumn). Urticaceae has a long MPS, beginning in autumn (October) and finishing in summer, corresponding to three species: *Urtica dioica* L., *Urtica membranacea* Poir. and *Parietaria judaica* L. Poaceae also shows long pollination periods since many species of this family occur in the area.

When daily pollen counts are compared with temperature and rainfall records (Fig. 3), it is clear that most peaks coincide with increases in temperature, while decreased pollen counts coincide with falling temperatures and rainfall, at least during the periods in which atmospheric pollen is at its highest (February–May and October–November). To confirm this association, we calculated the Spearman correlation coefficient between the daily mean total pollen concentrations and these meteorological parameters during pre-peak periods of each taxa for all the years

Fig. 4 Five days running mean (black area) and maximum daily mean (line) values during the years studied (2000–2003) reached by the six most abundant pollen types. Note the different scales

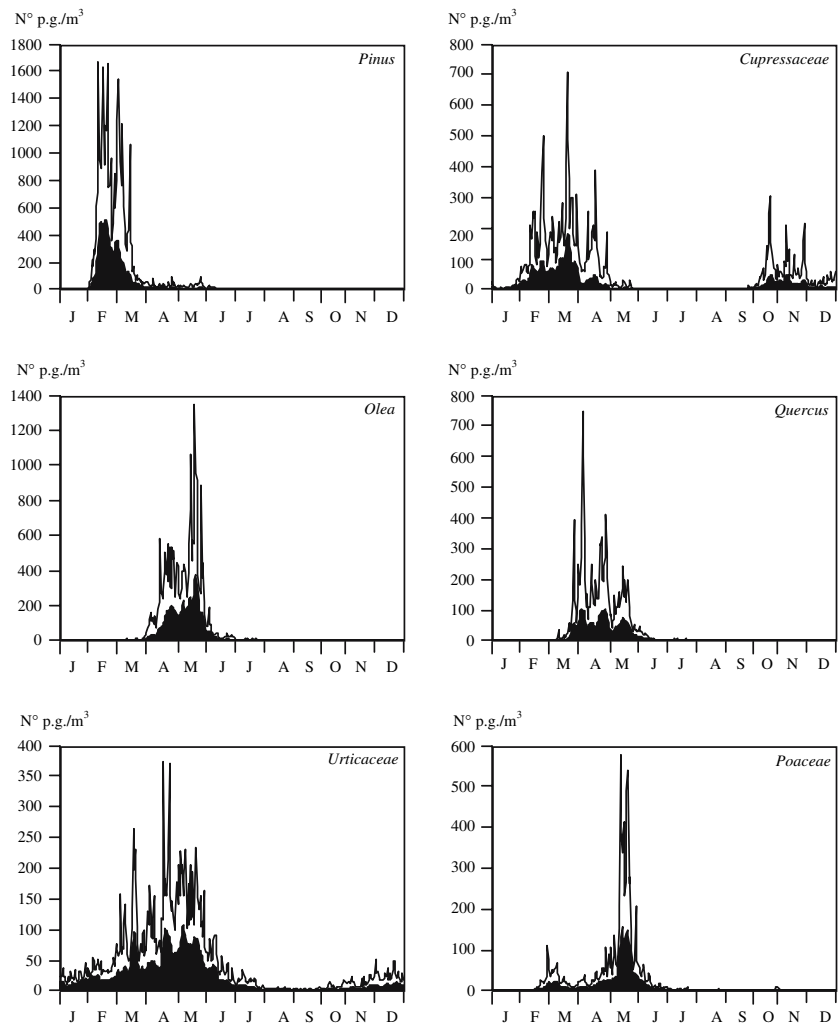


Table 2 Annual total counts of the main pollen types in the atmosphere of Nerja during the years studied

Year	<i>Pinus</i>	<i>Olea</i>	Urticaceae	Cupressaceae	<i>Quercus</i>	Poaceae
2000	<i>6,520</i>	<i>5,480</i>	<i>7,263</i>	<i>4,408</i>	<i>1,766</i>	<i>2,570</i>
2001	14,016	12,894	9,284	9,934	5,828	3,030
2002	15,815	8,675	8,766	5,491	6,675	5,178
2003	15,061	14,148	7,107	9,481	3,475	4,713
Average (2001–2003)	14,964	11,906	8,386	8,302	5,326	4,307
% of total pollen	25.04	19.93	14.03	13.89	8.91	7.21

Data for 2000 are in italics due to sampling began on 15th February

studied. The result (Table 4), points to positive significant values for the correlation coefficient between total pollen and temperature and sunshine hours, while the correlations with rainfall were, although not significant, negative, probably because

of the very few days of rain registered. Similar results were obtained for the pollen of Poaceae, *Quercus*, Cupressaceae and Urticaceae. For *Olea*, on the other hand, correlations were positive and significant with minimum temperature and rainfall only at 95%

Table 3 Characteristics of the main pollen season for the most important taxa: start and ending dates, length, maximum daily value and its date, and number of days with daily pollen concentration over an allergenically significant value (levelsconsidered: “moderate”: ≥ 25 pg/m³ in herbs and ≥ 50 pg/m³ in trees; “high”: ≥ 50 pg/m³ in herbs and ≥ 100 pg/m³ in trees)

		2001	2002	2003
<i>Pinus</i>	Pollen season	5 Feb–14 May	12 Feb–2 May	21 Feb–30 May
	Season length	99	80	99
	Daily maximum value (Date)	1,669 (11 Feb)	1,662 (21 Feb)	1,537 (4 Mar)
	No. days 50–100 pg/m ³	7	10	13
	No. days 100–1,000 pg/m ³	24	22	26
	No. days >1,000 pg/m ³	4	4	4
<i>Olea</i>	Pollen season	5 Apr–17 Jun	25 Apr–12 Jun	27 Apr–3 Jul
	Season length	74	49	68
	Daily maximum value (Date)	920 (26 May)	519 (2 May)	1,345 (24 May)
	No. days 50–100 pg/m ³	12	12	9
	No. days 100–1,000 pg/m ³	40	25	30
	No. days >1,000 pg/m ³	0	0	2
Urticaceae	Pollen season	15 Jan–1 Dec	25 Jan–20 Nov	13 Jan–20 Dec
	Season length	320	300	342
	Daily maximum value (Date)	233 (22 Mar, 25 May)	373 (21 Apr)	193 (10 May)
	No. days 25–50 pg/m ³	54	49	49
	No. days 50–100 pg/m ³	56	44	43
	No. days >100 pg/m ³	21	19	10
Cupressaceae	Pollen season	2 Feb–8 Nov	31 Jan–26 Dec	5 Feb–26 Nov
	Season length	280	330	295
	Daily maximum value (Date)	709 (22 Mar)	298 (26, 27 Mar)	409 (21 Mar)
	No. days 50–100 pg/m ³	21	19	22
	No. days >100 pg/m ³	29	8	32
	<i>Quercus</i>	Pollen season	23 Mar–1 Jun	3 Apr–21 Jun
Season length		71	80	115
Daily maximum value (Date)		745 (8 Apr)	414 (2 May)	242 (20 May)
No. days 50–100 pg/m ³		13	12	14
No. days >100 pg/m ³		15	25	8
Poaceae		Pollen season	10 Mar–30 Oct	27 Feb–11 Jul
	Season length	235	135	113
	Daily maximum value (Date)	207 (3 Jun)	415 (21 May)	578 (17 May)
	No. days 25–50 pg/m ³	30	28	12
	No. days 50–100 pg/m ³	11	23	16
	No. days >100 pg/m ³	4	12	9

probability. In the case of *Pinus*, positive significant correlation coefficients were only obtained with maximum temperature and sunshine hours.

Finally, we present the atmospheric pollen calendar for Nerja (Fig. 5). By only including taxa reaching a ten-day mean of 1 pg/m³, the calendar comprises 29 pollen types. The different taxa are ordered as a function of the length of pollination and the moment

at which their maximum peaks appear. The scale is exponential, so that each step doubles, approximately, the previous (Fig. 6). The atmosphere in Nerja is characterised as follows: in January and February the pollen of deciduous trees, such as *Alnus*, *Ulmus*, *Fraxinus* and *Populus*, but also of *Artemisia*, *Mercurialis*, *Ricinus* and Chenopodiaceae-Amaranthaceae are registered in low concentrations, while the highest

Table 4 Spearman's test coefficients obtained between the daily values of the main meteorological parameters and daily mean pollen concentrations of the six most abundant pollen

types and the total pollen during the pre-peak periods (significant values in bold: *95%, **99%, ***99.9%)

	Rainfall	Maximum temperature	Minimum temperature	Mean temperature	Sun hours
<i>Pinus</i>	-0.005	0.392*	0.149	0.247	0.448*
<i>Olea</i>	0.245*	0.471***	0.253*	0.399***	0.239*
Urticaceae	-0.072	0.769***	0.364***	0.651***	0.532***
Cupressaceae	0.002	0.472***	0.398***	0.552***	0.265**
<i>Quercus</i>	-0.113	0.528***	0.361***	0.481***	0.376***
Poaceae	-0.000	0.534***	0.366***	0.494***	0.432***
Total pollen	-0.059	0.432***	0.176***	0.341***	0.339***

concentrations correspond to Urticaceae, Cupressaceae and *Pinus* (these last two reaching high levels in February). In March (late winter), the high levels of Cupressaceae and *Pinus* continue, while the pollens of *Platanus* and *Pistacia* begin to be detected and the Poaceae pollen reach moderately high levels. The atmospheric pollens of Urticaceae start to reach high levels in March and continue high until June. The greatest diversity of pollen types is always detected in the months of spring, which is when *Quercus* and *Plantago* reach their highest levels (April), while *Olea* and Poaceae show their peaks in May. During June, while the pollen concentrations of many taxa decrease, the pollen of summer-flowering taxa (Cyperaceae, Apiaceae, *Eucalyptus*, *Cannabis* and *Castanea*) begin to appear, although always in low concentrations. At the end of summer, in August and September, the pollen of *Artemisia* is detected and, at the end of September, the typically autumnal *Casuarina* is noted. At the same time, the already mentioned second peak of Cupressaceae and an increase in Urticaceae pollen are detected. As can be seen, most pollen types present in the atmosphere of Nerja show a long MPS (long-tailed curves) that last several months, some even being present throughout or, at least, during most of the year (Urticaceae in the former case and Chenopodiaceae-Amaranthaceae, Poaceae and Cupressaceae in the latter).

4 Discussion

Regarding the mean annual total of pollen registered in Nerja (index 59,750), the figure is higher than the approximately 35,000 corresponding to the provincial capital of Malaga (60 km to the west) and that of

Almeria (150 km to the east), which is also situated on the Mediterranean coast and almost at the same latitude of 36°50'N (Recio et al. 1998; Ruíz García et al. 1998).

Knowledge of the daily, weekly, monthly and annual pollen levels is important for allergologists and allergy sufferers alike. The possible causes of variations in atmospheric levels of pollen, their statistical analysis and the construction of prognostic models are also important. It is widely accepted by aerobiologists that one of the causes for a fall in pollen concentrations is the washing effect of rainfall (the solid particles in the air being carried away by drops water due to the effect of gravity). This, for example, would explain the lower total pollen counts recorded during February and October 2003 compared with other years since rainfall was unusually heavy in these two months (84.3 and 134 mm, respectively). Of note, too, is the substantial increase in the concentrations of olive pollen, one of the principal causes of respiratory allergies in Mediterranean Europe (D'Amato and Lobefalo 1989), recorded in 2001 and 2003 compared with the evenly numbered years (Table 2). The same behaviour was also observed in Malaga (Recio et al. 1996, 1997), and other Spanish localities (Díaz de la Guardia et al. 1999). This phenomenon of "alternating production" is well attested and has been described by other authors, such as Macchia et al. (1987, 1991) and Domínguez et al. (1993). The reason is that, although olive flowers every year, one year it dedicates more energy to increasing its vegetal biomass (new leaves and branches) and the following to reproduction, producing more flowers and, consequently, more pollen.

Regarding the pollen calendar, a comparison with the results obtained in Malaga (Recio et al. 1998)

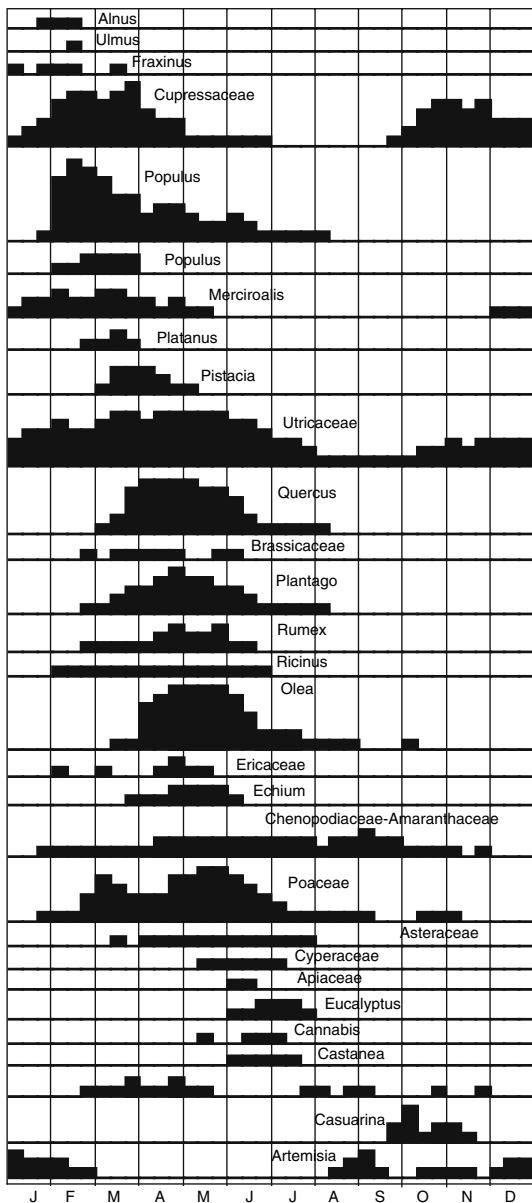


Fig. 5 Pollen calendar for Nerja, using data from February 2000 to December 2003 and following Spieksma’s models (1991)

(available on the Web site <http://webdeptos.uma.es/BiolVeg/02Aer/00Haer/CalMalaga.html>) shows that the results are similar but with a few significant differences. In Nerja, for example, greater quantities of *Pinus* and *Urticaceae*, and less of *Platanus*, *Olea*, *Chenopodiaceae-Amaranthaceae* and *Eucalyptus* are evident. Similarly, although not to the same extent, higher concentrations of *Artemisia* and *Pistacia* were

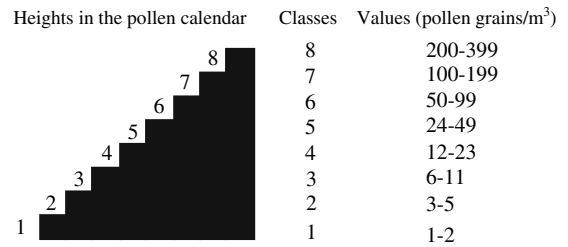


Fig. 6 Classes and pollen concentration values represented in the calendar graph

recorded in Nerja since the natural populations of the species of both genera are much closer to the Nerja station than to Malaga capital. The natural populations of *Artemisia barrelieri* Besser, *Artemisia herba-alba* Asso and *Artemisia campestris* L. are characteristic of the arid south-east of the Iberian Peninsula and Nerja is much more arid than Malaga but less so than Almeria, Chirivel and Murcia, where the pollen concentrations of *Artemisia* are higher (Munuera et al. 1998, 2002; Cariñanos et al. 2000; Sabariego et al. 2002). Another important difference is that the MPS of some taxa, such as *Pinus*, *Pistacia*, *Plantago*, *Rumex* and *Poaceae*, begins earlier in Nerja than in Malaga, probably due to the milder climate of this area that it is said to possess “the best climate of Europe”. However, the maximum peaks of most pollen types occur simultaneously in both aerobiological stations and the only significant difference is that for *Poaceae*, since a first peak is registered at the beginning of March in Nerja, followed by another in May. Lastly, the pollen of *Parkinsonia*, an ornamental tree present in Malaga, is not registered in sufficient quantities in Nerja to be included in the pollen calendar (10-day mean ≥ 1 pg/m³).

The most abundant pollen in Nerja is *Pinus*, with a mean annual total of almost 15,000 pg/m³, the highest of all the aerobiological stations of the REA. If we consider that in Vigo (NE Spain), where pine pollen concentrations are also high but lower than those detected in Nerja (Jato et al. 2000; Rodríguez Rajo et al. 2004), there are patients, including mono-sensitive patients (Marcos et al. 2001), who react positively to skin prick-tests for this taxon, we think it highly probable that cases of pine allergy exist in February or March in Nerja. For this reason, we think that allergologists should include pine pollen extracts in standard skin tests, at least in the case of people who have shown allergic symptoms and are known to

have visited Nerja in these two months. As affirmed by Fountain and Conford (1991), Freeman (1993) and Jato et al. (2000), allergy to *Pinus* deserves to be studied in a greater depth and Nerja is clearly a place where it is highly likely that allergies to this pollen type occur.

Finally, allergies to the pollen of Urticaceae have been demonstrated in Malaga by García González (1994), particularly in rural areas. Nerja is a locality that includes a rural area that has not been previously studied from an allergological point of view. The results obtained for the pollen of this taxon, together with its known allergenicity (D'Amato and Spiekma, 1991; D'Amato et al. 1991, 1992), strongly suggest that cases of allergy exist. Indeed, some gardeners working in the Nerja cave complex, have stated that they suffer from allergy-respiratory symptoms and we think that species of this family, such as *Urtica membranacea* Poir. and *Parietaria judaica* L., are probably responsible.

5 Conclusions

The pollen calendar for Nerja is typically Mediterranean, with a large variety of taxa, many of which show a long MPS (with long tails), which may last practically all year. The calendar is similar to that of Malaga, although higher concentrations are recorded for *Pinus*, Urticaceae, *Artemisia* and *Pistacia*, and lower concentrations for *Olea*, *Platanus*, Chenopodiaceae-Amaranthaceae and *Eucalyptus*.

Analysis and comparison of daily, monthly and annual values, which reach allergologically relevant levels in the case of *Olea*, Urticaceae and Poaceae, show that Nerja is a high risk locality for potential allergy sufferers among residents and visitors. *Pinus*, particularly, should be taken into consideration because of the high concentrations of this pollen recorded in February and March.

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References

- Andersen, T. (1991). A model to predict the beginning of the pollen season. *Grana*, 30, 269–275.
- Cabezudo, B., Pérez Latorre, A., Navas Fernández, D., Gavira, O., & Cabalero, G. (2005). Contribución al conocimiento de la flora del Parque Natural de las Sierras Tejeda, Almijara y Alhama (Málaga-Granada, España). *Acta Botanica Malacitana*, 30, 55–110.
- Cariñanos, P., Galán, C., Alcázar, P., & Domínguez, E. (2000). Allergenic pollen in the subdesert areas of the Iberian Peninsula. *Journal Investigational of Allergology and Clinical Immunology*, 10, 242–247.
- D'Amato, G., & Lobefalo, G. (1989). Allergenic pollen in the southern Mediterranean area. *Journal of Allergy and Clinical Immunol.*, 83, 116–122.
- D'Amato, G., & Spiekma, F. Th. M. (1991). Allergenic pollen in Europe. *Grana*, 30, 67–70.
- D'Amato, G., Ruffilli, A., & Ortolani, C. (1991). Allergenic significance of *Parietaria* (Pellitory-of-the-wall) pollen. In G. D'Amato, F. Th. M. Spiekma, & S. Bonini (Eds.), *Allergenic pollen and pollinosis in Europe* (pp. 113–118). Oxford: Blackwell Sci. Publ.
- D'Amato, G., Ruffilli, A., Sacerdoti, G., & Bonini, S. (1992). *Parietaria* pollinosis: A review. *Allergy*, 47, 443–449.
- Díaz de la Guardia, C., Galán, C., Domínguez, E., Alba, F., Ruíz, L., Sabariego, S., Recio, M., Fernández-González, D., Méndez, J., Vendrell, M., & Gutiérrez Bustillo, M. (1999). Variations in the main pollen season of *Olea europaea* L. at selected sites in the Iberian Peninsula. *Polen*, 10, 103–113.
- Domínguez, E., Galán, C., Villamandos, F., & Infante, F. (1991). Handling and evaluation of the data from the aerobiological sampling. *Monografías REA-EAN*, 1, 1–18.
- Domínguez, E., Infante, F., Galán, C., Guerra, F., & Villamandos, F. (1993). Variations in the concentrations of airborne *Olea* pollen and associated pollinosis in Córdoba (Spain): A study of the 10-year period 1982–1991. *Journal of Investigational Allergology and Clinical Immunology*, 3, 121–129.
- Fountain, D. W., & Conford, C. A. (1991). Aerobiology and allergenicity of *Pinus radiata* pollen in New Zealand. *Grana*, 30, 71–75.
- Freeman, G. L. (1993). Pine pollen allergy in Northern Arizona. *Annals of Allergy*, 70, 491–495.
- García González, J. J. (1994). *Calendario polínico de la ciudad de Málaga: prevalencia de tests cutáneos*. PhD Thesis, Department of Biochemistry and Molecular Biology, Faculty of Medicine, University of Malaga.
- Hirst, J. M. (1952). An automatic volumetric spore trap. *Annals of Applied Biology*, 39, 257–265.
- Jato, V., Rodríguez-Rajo, F. J., & Seijo, M. C. (2000). *Pinus* pollen in the atmosphere of Vigo and its relationship to meteorological factors. *International Journal of Biometeorology*, 43, 147–153.
- Macchia, L., Aliani, M., Caiaffa, M. F., Carbonara, A. M., Gatti, E., Iacobelli, A., Strada, S., Casella, G., & Tursi, A. (1987). Monitoring of atmospheric conditions and forecast of olive pollen season. In G. Boehm, & R. M. Leuschner (Eds.), *Advances in Aerobiology*. Proc. 3rd Int. Conf. Aerobiol. Birkhäuser, Basel, Switzerland.
- Macchia, L., Caiaffa, M. F., D'Amato, G., & Tursi, A. (1991). Allergenic significance of *Oleaceae* pollen. In G. D'Amato, F. Th. M. Spiekma, & S. Bonini (Eds.),

- Allergenic pollen and pollinosis in Europe* (pp. 87–93). Oxford: Blackwell Sci. Publ.
- Marcos, C., Rodríguez-Rajo, F. J., Luna, I., Jato, V., & González, R. (2001). Pine pollen aerobiology and clinical sensitization in Northwest Spain. *Annals of Allergy and Asthma Immunology*, *86*, 39–42.
- Munuera, M., Garrión, J., & García-Sellés, J. (1998). Winter blooming of *Artemisia*. A 2-year survey in Murcia. *Aerobiologia*, *14*, 109–116.
- Munuera, M., Garrión, J., & Navarro, C. (2002). Seasonal fluctuations of the airborne pollen spectrum in Murcia (SE Spain). *Aerobiologia*, *18*, 141–151.
- Nieto, J. M., Trigo, M. M., Salvo, E., Sánchez, P., & Cabezudo, B. (1991). Consideraciones botánicas sobre la Cueva de Nerja. In F. Carrasco Cantos, & F. Marín Girón (Eds.), *Investigación Biológica y Edafológica Cueva de Nerja (Málaga)*. Málaga: DIALAR, Patronato de la Cueva de Nerja.
- Recio, M., Cabezudo, B., Trigo, M. M., & Toro, F. J. (1996). *Olea europaea* L. pollen in the atmosphere of Málaga (S. Spain) and its relationship with meteorological parameters. *Grana*, *35*, 308–313.
- Recio, M., Cabezudo, B., Trigo, M. M., & Toro, F. J. (1997). Accumulative air temperature as a predicting parameter for daily airborne olive pollen (*Olea europaea* L.) during the pre-peak period in Málaga (Western Mediterranean area). *Grana*, *36*, 44–48.
- Recio, M., Cabezudo, B., Trigo, M. M., & Toro, F. J. (1998). Pollen calendar of Malaga (Southern Spain), 1991–1995. *Aerobiologia*, *14*, 101–107.
- Recio, M., Trigo, M. M., Toro, F. J., Docampo, S., García-González, J. J., & Cabezudo, B. (2006). A three-year aeropalynological study in Estepona (southern Spain). *Annals of Agricultural Environ Med*, *13*, 201–207.
- Rivas Martínez, S. (1987). *Memoria del mapa de series de vegetación de España*. Madrid: ICONA.
- Rodríguez Rajo, F. J., Iglesias, I., & Jato, V. (2004). Allergenic airborne pollen monitoring of Vigo (NW Spain) in 1995–2001. *Grana*, *43*, 164–173.
- Ruiz García, L., Díaz de la Guardia, C., & Mota, J. F. (1998). Analysis of airborne pollen in the town of Almeria (South-East Spain), 1995–1996. *Aerobiologia*, *14*, 281–284.
- Sabariego, S., Díaz de la Guardia, C., Alba, F., & Mota, J. F. (2002). Aerobiología en Andalucía: Estación de Almería (2000–2001). *Rea*, *7*, 33–38.
- Spieksma, F. Th. M. (1991). Regional european pollen calendars. In G. D'Amato, F. Th. M. Spieksma, & S. Bonini (Eds.), *Allergenic pollen and pollinosis in Europe* (pp. 49–65). Oxford: Blackwell Sci. Publ.
- Stix, E., & Ferretti, M. L. (1974). Pollen calendars of three locations in Western Germany. In J. Charpin, R. Surinych, & A. W. Frankland (Eds.), *Atlas European des Pollens Allergisants* (pp. 85–94). Paris: Sandoz.
- Trigo, M. M., Recio, M., Docampo, S., & Cabezudo, B. (1999). Aerobiología en Andalucía: Estación de Antequera (1998). *Rea*, *5*, 51–54.
- Trigo, M. M., Toro, F. J., Recio, M., Docampo, S., & Cabezudo, B. (2000). Aerobiología en Andalucía: Estación de Antequera (1999). *Rea*, *6*, 47–50.