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Pollen calendar of Malaga (Southern Spain), 1991–1995

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Abstract

A pollen calendar has been constructed for Malaga (Southern Spain) based on the data obtained during 5 years (1991–95) using a Burkard spore trap set up approximately 1 km west of the city. The calendar only reflects taxa which showed a 10-day mean pollen concentration equal to or greater than 1 grain of pollen/m^3 of air. Twenty nine taxa are included, of which the three commonest (*Olea europaea*, Cupressaceae and *Quercus*) represent approximately 54% of the total annual count and the following four (Chenopodiaceae-Amaranthaceae, Gramineae, Urticaceae and *Plantago*) represent 21.3%. The greatest diversity of pollen types occurs during Spring and the highest concentrations from February to June, when approximately 85% of the total annual pollen is registered. Several peaks occur during the year principally due to Cupressaceae in February, *Quercus* in April, *Olea europaea* in May and *Casuarina* in October, although substantial quantities of Urticaceae, Chenopodiaceae-Amaranthaceae, *Plantago* and Gramineae are also detected in April and May. The pollination of important allergy-producing taxa such as olive and grass takes place earlier in Malaga than in cities more inland, so that the data presented here may be useful in predicting the beginning of the pollination season of these localities. © 1998 Elsevier Science Ireland Ltd. All rights reserved.

Keywords: Pollen; Calendar; Malaga; Spain

1. Introduction

To obtain information on the air pollen content in Malaga, a very popular tourist resort, the Plant Biology Department of Malaga University in collaboration with the Spanish Aerobiological Network (REA) set up a Burkard spore trap in the University Campus in May 1991, since then continuous readings have been made. As regards pollen diversity, its quantity and seasonal distribution, several papers have been published (Cabezudo et al., 1994; Recio et al., 1995) although we decided to take samples over a longer period (at least 5 years) before constructing a pollen calendar for Malaga.

Due to the close relation between pollen quantity and quality of a given area and the climate, we first describe the geographical situation and general climatic characteristics of Malaga. For a greater understanding of the results obtained we study the climate's behaviour during the sampling period.

1.1. Geographical situation and predominant vegetation

The city of Malaga lies in the south of the Iberian Peninsula on the shores of the Mediterranean Sea (36° 47′ N, 4° 19′ W). It sits on the alluvial plains of the rivers Guadalhorce and Guadalmedina, extending eastwards along a narrow coastal strip which is hemmed in by mountains very close to the sea.

As in any urban area, the most significant aspects of the flora are the deterioration of the natural vegetation, an important component of ornamental plants and an increase of weeds. The city is close to plantations of olives, citrus, almond, vine, sugar cane, and typical 'huertas' or small-holdings, growing a variety of products. The natural vegetation has been relegated to small stands of cork-oak, holm-oak and kermes-oak and, in

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its more degraded stage, to silicicolous scrub and thyme thickets. In many places the natural vegetation has been replaced by repopulations of pine, which favour pasture land.

1.2. Climatology

Malaga has a Coastal Mediterranean climate with dry Summers and mild Winters. The mean annual temperature is 18°C, January being the coldest month and August the hottest. The annual average rainfall is 575 mm, the rain falling principally in Autumn (October–December) and Winter (January–March). The rain is frequently torrential, so that in a matter of hours quantities of water similar to the monthly average can fall.

There are very few cloudy days (average 57.9 p.a.), its 3000 h of sunshine making it one of the sunniest places in the Iberian Peninsula. This fact, together with the aforementioned temperature regime, influences the local flora and brings forward the flowering season compared with that of other inland sites.

The city is almost completely surrounded by mountains, which cause a special wind regime. As in other coastal localities nearby with a similar setting, the predominant winds are easterly and westerly (Fig. 1). Northerly winds take on a NW direction, coming through the Guadalhorce 'gap' and constituting the locally denominated 'terral' winds. The wind direction plays an important role in the airborne pollen content since south-easterly winds blowing off the sea partially clean the atmosphere, sweeping the pollen towards the interior. Those from the north-west, on the other hand, are capable of bringing with them large quantities of pollen from distant inland sites.

Relative humidity in Malaga is always high although it varies with the temperature, rainfall (presence or absence) and wind direction. This parameter is, as is to be expected, closely related to rainfall and indirectly with temperature. The fact that humidity remains high throughout the year is due to the nearby presence of the sea. However, it falls when there are strong NW winds

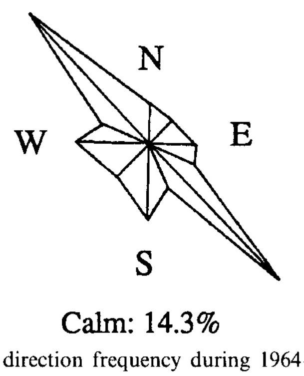

Fig. 1. Wind direction frequency during 1964–1983 at Malaga-Airport.

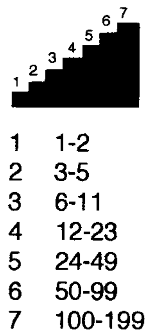

Fig. 2. Ten-day mean pollen count classes depicted by column growth heights in pictorial calendar.

which bring dry air from the interior, as occurs mainly in Spring and Summer when the temperatures are high. When winds blow from the SE (off the sea), relative humidity increases.

2. Materials and methods

Sampling was carried out by means of Hirst's volumetric method (Hirst, 1952) using a 7-day recording Burkard® spore trap on the top of the Medicine Faculty of University of Malaga, approximately 15 m above ground level. The faculty is situated 1 km west of the city in an open area with no nearby buildings to interfere with air circulation. The trap works continuously and aspirates a constant air flow of 10 l per min.

To count the different pollen types, four longitudinal scans per slide were made using a lens × 40 (0.45 mm microscopic field) according to the method proposed by Domínguez et al. (1991). The pollen concentrations are expressed as number of pollen grains/m^3 of air, the mean daily values being used for the tables and graphs.

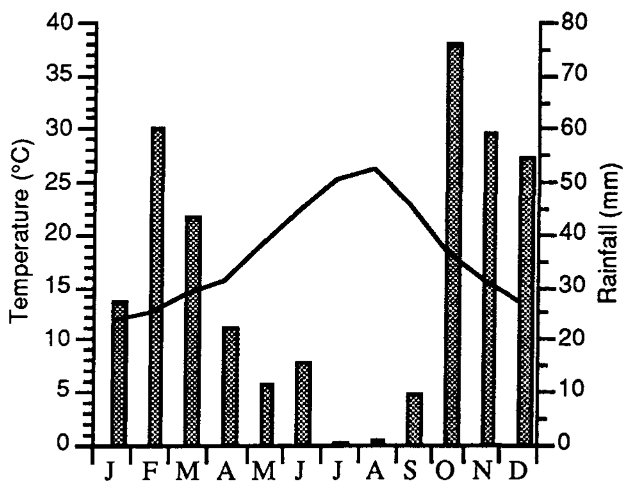

Fig. 3. Average values of monthly mean temperatures and total rainfall during the sampling years (1991–95).

Table 1
Monthly and annual rainfalls (R) and mean temperatures (T) recorded by Malaga-Airport meteorological station during the sampling years

		January	February	March	April	May	June	July	August	September	October	November	December	Annual
1991	R	19.9	83.9	93.5	27.5	0.4	0.9	0	0	27.9	120.8	65.8	29.6	470.2
	T	11.6	11.2	14.5	14.6	17.8	22.6	25.5	25.7	24.3	17.5	14.3	13.1	17.7
1992	R	23.7	34.1	20.2	23.7	0.4	65.5	1.8	0	13.3	111.8	12.1	22.3	328.9
	T	11.2	11.8	13.9	16.7	19.9	21.3	24.5	26.6	22.3	17.5	15.5	13.4	17.8
1993	R	51.3	44.2	64.1	25.6	43.7	0	0	0	1.2	121.1	79.3	1	431.5
	T	10.8	11.9	13.6	15.3	18.1	22.5	24.4	25.9	23.4	17.2	14.8	12.6	17.5
1994	R	31.4	131.9	6.7	33.4	11.6	0.2	0	3.3	5.5	24.2	51.7	0	299.9
	T	11.8	12.5	14.7	15.9	19.5	22.6	26.3	26.7	22.5	19.5	16.7	14.1	18.5
1995	R	10.9	6.9	32.8	2	0.3	12.2	0.3	0	0	0.6	87.2	218.9	372.1
	T	13.4	15.2	15.2	16	20.4	22.7	26.1	26.9	22.2	20.2	17.4	14.4	19.2

R is expressed in mm and T in °C.

Table 2
Annual sums of average daily pollen concentrations (No. pollen grains/m³ of air) of each taxon and total pollens, during each of the complete sampling year

Taxon	1992	1993	1994	1995	Mean (92–95)	% (Mean 92–95)
Olea europaea	4481	8924	6637	4166	6052	23.7
Cupressaceae	4888	7347	3973	3128	4834	18.93
Quercus	1925	3071	3204	3246	2861.5	11.2
Chen.-Amar.	1492	2539	1693	819	1635.8	6.4
Gramineae	1249	1595	2098	906	1462	5.72
Urticaceae	906	1242	1531	1078	1189.3	4.65
Plantago	1104	1521	1683	399	1176.8	4.6
Pinaceae	633	1285	619	999	884	3.46
Casuarina	277	786	716	750	632.3	2.47
Myrtaceae	533	512	613	534	548	2.15
Rumex	279	364	472	131	311.5	1.21
Platanus	197	278	161	284	230	0.9
Artemisia	529	190	104	93	229	0.9
Mercurialis	231	243	202	208	221	0.86
Asteraceae*	233	238	266	91	207	0.81
Palmae	180	99	167	319	191.3	0.75
Cyperaceae	228	221	153	68	167.5	0.65
Populus	121	36	101	108	91.5	0.24
Apiaceae	87	109	129	30	88.8	0.35
Ericaceae	31	139	38	147	88.8	0 35
Ricinus	139	42	80	81	85.5	0 33
Parkinsonia	78	71	75	102	81.5	0.32
Pistacia	73	100	109	27	77 3	0.3
Echium	47	130	65	47	72.3	0 28
Castanea	33	57	93	89	68	0.27
Typha	53	45	69	59	56.5	0.22
Morus	61	39	33	55	47	0.18
Fraxinus	7	22	41	104	43 5	0.17
Cannabis	10	17	30	21	19.5	0.08
Ligustrum	30	16	21	8	18.8	0.07
Ulmus	10	11	14	18	13.3	0.05
Alnus	10	4	17	11	10.5	0.04
Salix	15	3	12	6	9	0.03
Total	22 522	31 631	28 255	19 750	25 539.5	100

The last two columns show the mean value for 1992–95 and the annual mean percentage of each taxon compared with total pollens.
* Except *Artemisia*

The pollen calendar was constructed following Spieksma's model (1991), which transforms 10-day mean pollen concentrations into a series of classes represented in pictogram form by columns of growing height (Fig. 2). Hence, the pollen concentration values used in the calendar are the mean of ten consecutive days, each 10-day period corresponding approximately to a third of a month. Since sampling began on 10 May 1991, the calendar values from January to the first 10 days of May correspond to the mean of four years (1992–95), while all other values correspond to the mean of five years (1991–95). The order of the taxa in the pollen calendar follows the order in which the maximum peaks appear. Only those taxa are included which show a minimum 10-day mean of 1 pollen grain/m³.

The meteorological data used are those of Malaga-Airport, which is situated 5 km to the south of the sampling site and were provided by the Meteorological Centre of Eastern Andalusia.

3. Results and discussion

3.1. Climatology

In general, the rainfall pattern during the 5 years of the study was similar with two rainy periods (one in Winter and one in Autumn) and a dry period during the Summer. However, the Autumn of 1994 and Winter of 1995 were exceptionally dry (Table 1).

The annual mean temperatures were similar to those of the previous 40 years. The year 1993 was the coldest one of those studied (mean 17.5°C) and 1995 the warmest (mean 19.2°C) (Table 1). The development of temperature and rainfall during the year is shown in

Fig. 3, in which the characteristic dry Summer period can also be observed.

3.2. Pollen calendar

The mean annual pollen count during 1992–95 was 25540 pollen grains/m³ of air, the lowest number being recorded in 1995 and the highest in 1993 (Table 2). Fig. 4 shows how the total quantity of pollen collected during a year is related with the rainfall recorded from the Autumn of the previous year to the Spring of the year in question.

On the basis of the mean annual total quantity of pollen for 1992–95, the 15 principal taxa are: *Olea europaea*, Cupressaceae, *Quercus*, Chenopodiaceae-Amaranthaceae, Gramineae, Urticaceae, *Plantago*, Pinaceae, *Casuarina*, Myrtaceae, *Rumex*, *Platanus*, *Artemisia*, *Mercurialis* and Asteraceae (except *Artemisia*) (Table 2). The first three taxa (*Olea europaea*, Cupressaceae and *Quercus*) are responsible for approximately 54% of the annual total and so any change in the quantities recorded for them will have a substantial effect on the total annual count. During 1995 the total quantity of olive and Cupressaceae pollen was less than the average, the same occurring during 1992 with olive and *Quercus*. This is reflected in the lower annual total for these 2 years.

In addition, there are four groups of pollen grains basically corresponding to weeds (Chenopodiaceae-Amaranthaceae, Gramineae, Urticaceae and *Plantago*), which make up 21.3% of the annual total and which also strongly influence the overall results. The total pollen of this group was substantially lower in 1995 (Table 2) since the scarcity of rain during the Autumn of 1994 and Winter–Spring of 1995 (Fig. 4) affected

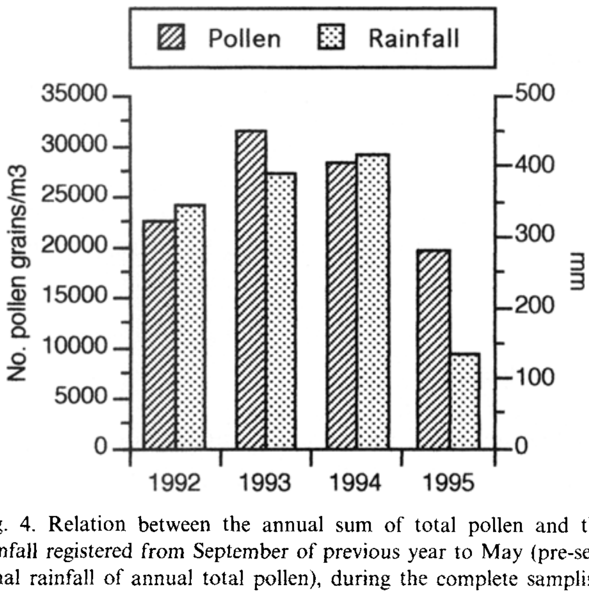

Fig. 4. Relation between the annual sum of total pollen and the rainfall registered from September of previous year to May (pre-seasonal rainfall of annual total pollen), during the complete sampling years.

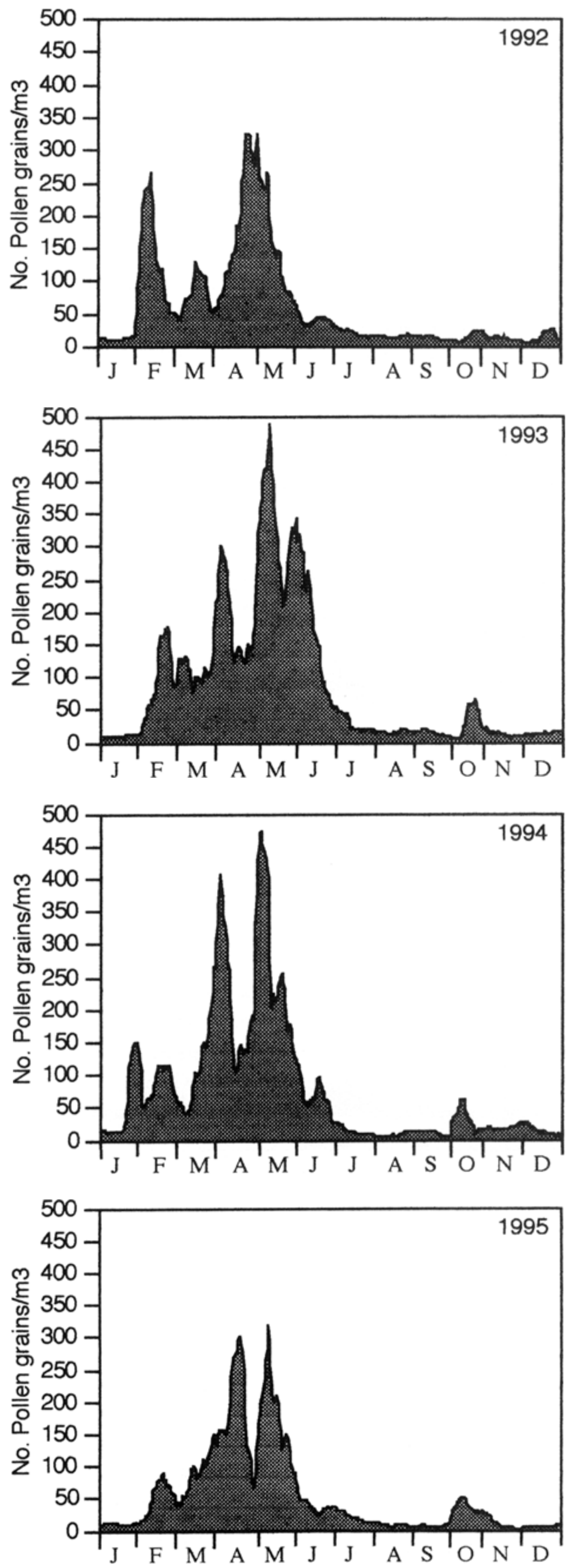

Fig. 5. Running means (10 days) of total pollen during each of complete sampling years.

their growth and flowering, and therefore pollen production.

Fig. 5 shows the development of the annual total pollen concentration during the years studied. The behaviour is fairly similar with the greatest concentrations always occurring from February to June (both inclusive), when 85.4% of the annual total pollen count is recorded and the highest concentrations occur in April and May. The lowest concentrations occur during the period from July to January (14.6% of annual total).

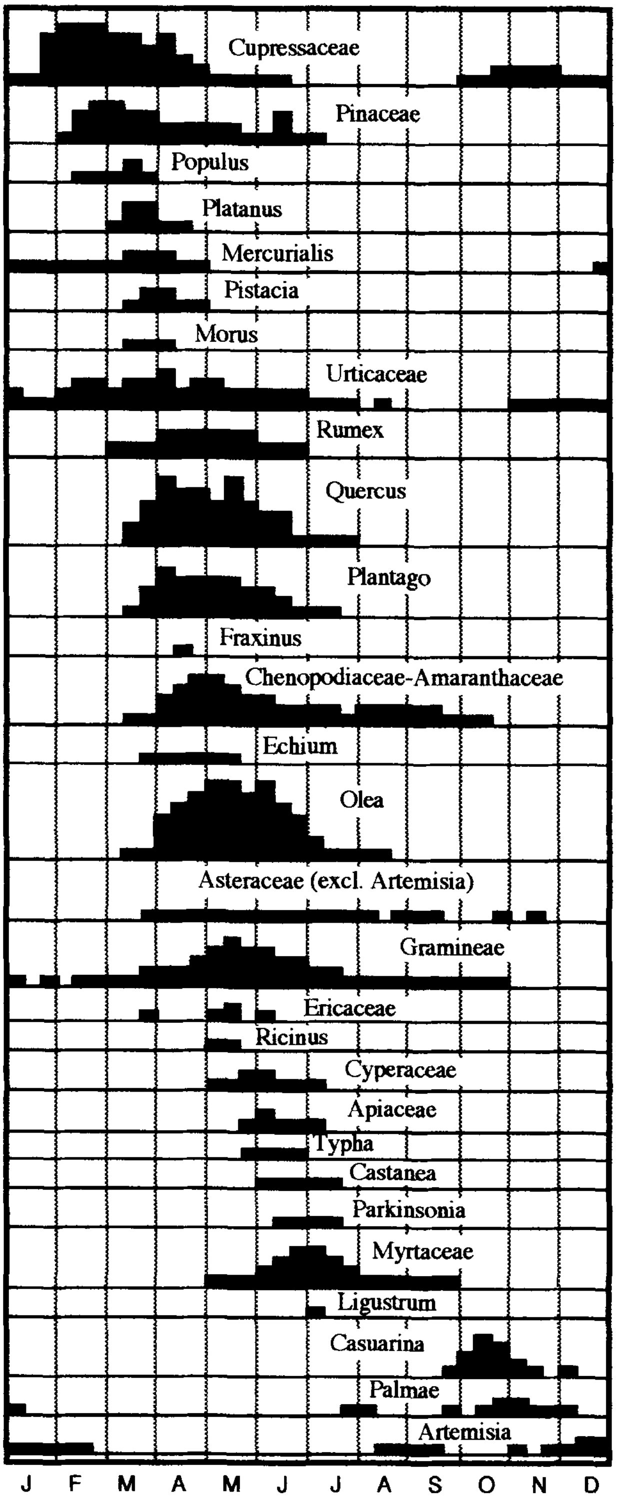

Fig. 6. Pollen calendar for Malaga, using data from May 1991–December 1995.

The same peaks occur every year (Fig. 5) and are principally due to Cupressaceae in February, *Quercus* in April, *Olea europaea* in May and *Casuarina* in October, although substantial quantities of pollen from Urticaceae, Chenopodiaceae-Amaranthaceae, *Plantago* and Gramineae are also detected in April and May (Fig. 6).

Generally speaking, airborne pollen develops in a similar way to that in other places in the South of Spain such as Córdoba (Domínguez et al., 1984), Sevilla (González Romano et al., 1992) and Huelva (González Minero and Candau, 1995), and other Mediterranean sites in Europe (Spieksma, 1991; Nilsson and Spieksma, 1992). It should be noted that the pollination season of some taxa such as olive and grass in Malaga starts earlier than in Córdoba (Galán et al., 1989; Domínguez et al., 1993), Granada (Díaz de la Guardia et al., 1993, 1995) and Sevilla (González Romano et al., 1992). This information may be useful in predicting the beginning of pollen dispersion of these species in these inland sites.

As already stated, the pollen calendar (Fig. 6) only refers to taxa which show a 10-day mean pollen count equal to or higher than 1 pollen grain/m^3. Twenty nine taxa are therefore included in the calendar, all of which with the exception of *Parkinsonia* (which is cited for the first time as an airborne pollen) are regularly included in pollen calendars of other southern European sites. All the pollen types can cause allergic reactions in sensitive individuals so that it would seem advisable to include them in the standard pollen reaction tests. It should not be forgotten that other pollen grains have not been included in the calendar because they appear in very low concentrations (*Alnus*, *Ulmus* and *Salix* during the Winter, and *Betula*, *Cannabis*, Brassicaceae, Fabaceae, Rosaceae, Lamiaceae, Rhamnaceae, etc. during the Spring). Many of these are entomophilous and others are transported from long distances by the wind.

4. Conclusions

1. During 1992–95 a mean annual total of 25 540 pollen grains/m^3 of air were recorded in Malaga. These correspond to a great diversity of pollen grains since approximately 93% of the total is made up by 33 taxa. The 15 most common pollen types in order of annual frequency and taking the mean

values of these years studied are: *Olea europaea*, Cupressaceae, *Quercus*, Chenopodiaceae-Amaranthaceae, Gramineae, Urticaceae, *Plantago*, Pinaceae, *Casuarina*, Myrtaceae, *Rumex*, *Platanus*, *Artemisia*, *Mercurialis* and Asteraceae (except *Artemisia*).

2. The greatest pollen concentrations occur from February to June (both inclusive), when approximately 85.4% of the annual total is recorded, and the highest concentrations occur in April and May. The lowest concentrations occur from July to January (14.6% of the annual total).
3. The peaks which occur over the years studied are principally due to Cupressaceae in February, *Quercus* in April, *Olea europaea* in May, and *Casuarina* in October, although substantial quantities of pollen from Urticaceae, Chenopodiaceae-Amaranthaceae, *Plantago* and Gramineae are also detected in April and May.
4. The quantity of pollen collected during 1 year is related with the rainfall occurring from the Autumn of the preceding year to the Spring of the year in question.

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