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A statistical approach to comparing the results from different aerobiological stations

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The recent increase in the number of aerobiological stations means that it is possible to make comparative studies, not only to ascertain similarities and differences between pollen counts in different places, but also to ascertain the most suitable places for them to be situated and the most adequate distance which should be established between them.

To this end, we present a statistical comparison of the results obtained for the pollen of the ten most abundant taxa, as recorded in the sampling stations of Malaga and Estepona (South of Spain) during 1995–97. The stations are 90 km apart. The variables compared were the following: mean daily concentrations (for each year and the total period studied), the mean concentration of the three years for the same date (trend) and the deviation from this mean (for each year and taken as a whole). The interannual differences within and between stations were taken into account as regards the association, concentration and distribution of the variables.

The results of the tests applied point that significant differences between the two stations were observed for most of the pollen types studied. Despite of this, a positive and significant correlation exists between the mean daily concentrations of the different taxa at the two stations, which is an important finding if we consider the possibility of making reliable predictions for one sampling site based on the data obtained at the other.

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A growing number of aerobiological sampling stations are being installed in population centres for gathering information on the pollen content of the atmosphere. This has led to a substantial increase in comparative studies between different localities. Despite the fact that it is usual to find quantitative and qualitative differences in the concentrations of different taxa, comparative studies have traditionally been made in a descriptive way. No advantages have been taken of statistical tools, which would make it possible to establish whether or not there are differences between different sampling stations (Bagni et al. 1976, Spieksma et al. 1989, Leuschner & Boehm 1981, Goldberg et al. 1988, Caramiello et al. 1991, Leuschner 1991, Hjelmroos & van Hage-Hamsten 1993, Galán et al. 1995, Fornaciari et al. 1996, Frenz et al. 1997, Gottardini & Cristofolini 1997). Furthermore, such studies are essential for establishing whether or not it is necessary to have two sampling stations in close proximity.

In this paper we propose a protocol for statistically comparing the results obtained in different aerobiological stations and, as an example, compare the results obtained for the pollen of the ten most abundant taxa in the stations of Malaga and Estepona (S. Spain) during 1995–97. Both sampling stations are close to the sea and surrounded by mountains, which endows them with special characteristics (Recio et al. 1998). They are approximately 90 km apart.

The climate of the area is dry Mediterranean. The temperatures recorded and the rainfall were similar in both stations during the period studied although there was a slightly less pronounced temperature range in Estepona, possibly because of its greater proximity to the sea. The mean temperature was 18.6°C in Malaga and 17.3°C in Estepona. The mean annual rainfall, during the three years, in both sites was about 850 mm, although the amount of rain falling differed substantially between years, 451.7 mm and 458 mm falling in Malaga and Estepona respectively, in 1995 (a particularly dry year) and 1220.3 mm and 1393.5 mm, respectively, in 1996 (a much wetter year than average). The mountain barriers and the proximity of the Strait of Gibraltar (Fig. 1) mean that the predominant winds were westerly or easterly, bearing to NW or SE in Malaga (because of the Guadalhorce Valley) and westerly/easterly in Estepona. 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 surrounding vegetation showed greater human disturbance in Malaga than in Estepona, the natural vegetation being relegated to small stands of cork-oak, holm-oak and kermes-oak and, in its more degraded stage, to silicicolous scrub and thyme thickets. In many natural places, the natural vegetation has been replaced by repopulations of pine.

MATERIAL AND METHODS

The sampling was made by means of two Hirst type volumetric samplers, one at each station, which were placed approximately 15 m above ground level. Silicone fluid was used as the adhesive substance

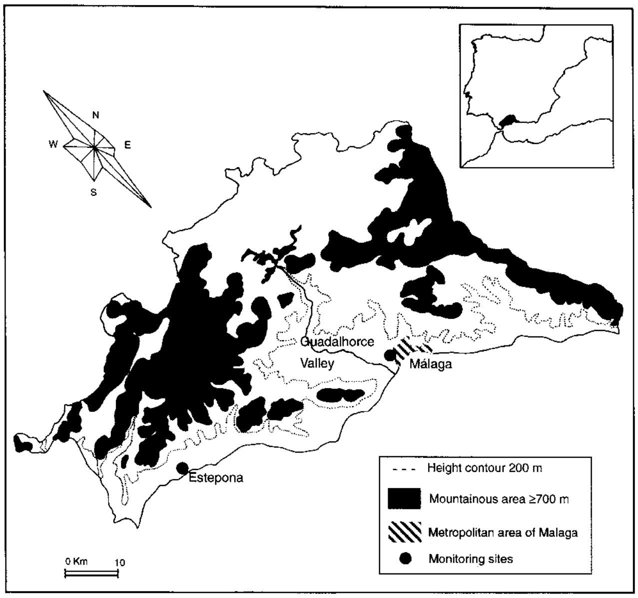

Fig. 1. Location of the two samplers in Malaga and Estepona (southern Spain).

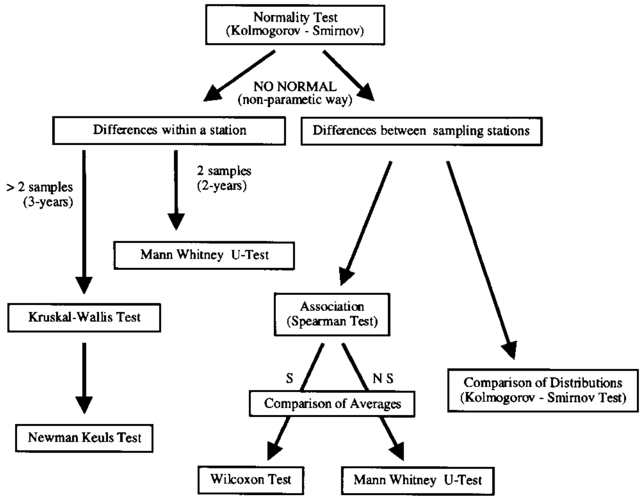

Fig. 2. Statistical protocol used to compare two aerobiological stations. S, significant; NS, non-significant at $\alpha \equiv \geq 95\%$.

and glycerine jelly stained with basic fuchsine as the mounting medium. Pollen counts were made following the method proposed by Domínguez et al. (1991). This consisted of reading four sweeps per preparation at a magnification of ×400, the data being expressed as mean daily concentration. The mean pollen season (MPS) was taken as being the period during which 95% of the total amount of annual pollen of both stations was recorded.

The overlapping MPS between stations was used in order to compare the data obtained for the two stations and the different years. To express the trend of each station, data referring to 29th February were omitted and the data from the first complete month to occur in the MPS to the last were used.

The following variables were compared: mean daily concentrations (for each year and the total period studied), the mean concentration of the three years for the same date (trend) and the deviation from this mean (for each year and taken as a whole). The interannual differences within and between stations were taken into account as regards the association, concentration and distribution of the variables.

After selecting the variables, a normality test (Kolmogorov-Smirnov test for one sample) was applied in order to confirm whether it could reasonably be thought that the obtained values come from a population which has this specific theoretical distribution.

Interannual differences for the same station

When studying the possible similarities and differences existing in the same station and when clear evidence existed against normality, the following steps were followed (Fig. 2):

In order to compare the means obtained for each year, an analysis of variance of a Kruskal-Walis rank classification was made. This is an extremely useful tool when there are more than two independent samples and you want to know if they come from the same population or from populations with the same average values. When the test result was significant, we made an a posteriori test to look for the reasons for the significance found. For this, we used Newman and Keuls' method of pair comparison (looking for significance according to Bonferroni's distribution) which analyses which years show identical averages and which do not. The aim is to determine whether the differences between samples reflect genuine population differences or are simply random variations, similar to those that can be expected between different random samples of the same population. This test is one of the most effective of the non-parametric tests that can be applied in the case of more than two independent samples.

In the case of autumn-winter flowering taxa (Cupressaceae, *Parietaria* and *Urtica*) for which we only had the data from two sampling periods, the Mann-Whitney U-test was applied. This test is used to check whether two independent groups have been taken from the same population and it is one of the most powerful non-parametric tests and a useful alternative to the parametric t-test. In our case, we used it to see whether significant differences existed between the means obtained for each period in the same station when it was only possible to study two periods (Siegel 1970, Martín Andrés & Luna del Castillo 1994, Sokal & Rolhf 1995).

Differences between sampling stations

After ascertaining the behaviour of the taxa in each station, the two stations were compared as described below (Fig. 2):

Association test. – To study the association between pairs of data for the same type of pollen, a Pearson or Spearman correlation test was carried out, depending on whether or not the data fitted a normal distribution curve. This test was intended to show whether two variables were independent or covariant, i.e., varied together. It does not assume that one variable caused the other.

Comparison of averages. – When the variables did not show a normal distribution, Wilcoxon's signed ranks and equal pairs test was applied. This made it possible to check $H_0 \equiv \mu_1 = \mu_2$, independently of the sample size. As it was used as alternative to the parametric test for comparing two means, the hypothesis which is really tested here is whether $H_0 \equiv$ "the two compared populations are identical" or $H_1 \equiv$ "one population tends to give higher values than another". This test considers the relative magnitude and direction of the references. If we add the ranks with a positive sign and those with a negative sign, both totals should be the same according to H_0. However if both totals are very different, we deduce that the average concentration in one sampling station is greater than that of the other, and so H_0 will be rejected.

When there was no significant correlation, the Mann Whitney U-test was used. This is similar to Wilcoxon's test but is used when the samples are independent and there is no association between the pairs of data.

Comparison of distributions. – To compare the distributions of the different pollen types in both sampling sites, the Kolmogorov-Smirnov test for two samples was used. This two-tail test is sensitive to any type of differences between the distributions from which the samples are taken. If the two samples are really taken from the same population, the accumulative distributions of both samples might clearly be expected to be close, since they should only show fortuitous deviations from the population distribution. An excessive spacing out between the two accumulative distributions suggests that the samples are from different populations and so the null hypothesis can be rejected. We shall use this hypothesis to compare the distributions obtained by the two traps (Siegel 1970, Martín Andrés & Luna del Castillo 1994, Sokal & Rolhf 1995).

RESULTS AND DISCUSSION

During the period studied, the ten most predominant pollen types in both sampling stations, as based on the total annual counts, were, in alphabetical order: Chenopodiaceae-Amaranthaceae, Cupressaceae, Myrtaceae, *Olea europaea, Parietaria, Pinus, Plantago,* Poaceae, *Quercus* and *Urtica membranacea* (Table I). It can be seen that Cupressaceae, *Olea europaea, Quercus* and Poaceae were the most abundant pollen types recorded at the two stations, followed by *Urtica membranacea, Pinus, Plantago, Parietaria,* Chenopodiaceae-Amaranthaceae and Myrtaceae in Estepona and *Pinus, Plantago,* Chenopodiaceae-Amaranthaceae, *Casuarina, Parietaria* and Myrtaceae in Malaga. Figure 3 shows the mean concentrations registered during the period studied at both stations. We can appreciate that nitrophilous herbaceous taxa such as Chenopodiaceae-Amaranthaceae, *Plantago* and *Parietaria* have much more influence in the atmosphere of Malaga than in Estepona, probably on account of the vegetation shows a greater human disturbance in Malaga. However, the records of *Urtica membranacea* pollen were much higher at Estepona sampling station. Cupressaceae, Myrtaceae, *Olea europaea*, *Pinus* and *Quercus* pollen also reached higher peaks at Malaga station. For Poaceae the quantities registered were similar.

On the other hand, the same figure also shows graphically the phenology and general behaviour of the different taxa studied, which, in general, were similar, as well as the length of the pollen season and the time in which the higher peaks were detected.

As regards the statistical study, Table II illustrates that most of the variables studied show evidence against normality even when transformed by more traditional methods: square root, logarithms and Moseholm transformation (Moseholm et al. 1987), so that non-parametric techniques were applied.

Table I. *Most relevant ten pollen types in the Estepona and Malaga sampling stations (1995–1997).*

ESTEPONA	% Average	MALAGA	% Average
Cupressaceae	23.83	Cupressaceae	23.95
Olea europaea	15.02	*Olea europaea*	21.74
Quercus	14.98	*Quercus*	10.87
Poaceae	9.38	Poaceae	6.49
Urtica membranacea	7.84	*Pinus*	4.70
Pinus	3.25	*Plantago*	4.45
Plantago	3.20	Chenop.-Amaranth.	3.57
Parietaria	2.25	*Casuarina*	3.44
Chenop.-Amaranth.	1.87	*Parietaria*	2.78
Myrtaceae	1.23	Myrtaceae	1.93

Interannual variations within the same station

As regards interannual variation (Table III), all the taxa except Cupressaceae in Estepona showed clear difference in concentrations during the three years studied. In general, these differences were more pronounced in Malaga for all taxa, excluding *Quercus, Urtica membranacea* and Poaceae, which showed greater differences in Estepona.

If we examine more closely the differences in averages within each station (Table IV) we see that there were significant differences for all the taxa in both stations between 1995 and 1997. However, there were no significant differences between 1996 and 1997 for Chenopodiaceae-Amaranthaceae and *Plantago* in Estepona and *Plantago* and Poaceae in Malaga. On the other hand, *Quercus* pollen showed differences during all the three years in both stations, perhaps due to the distinct weather patterns of the three years in question, 1995 being a very dry year.

Differences between stations

Association test. – When the degree of association between the variables studied in both stations was analysed (Table V), all showed a significant positive degree of correlation, with the exception of the deviations respect to the tendency shown by Myrtaceae in 1996.

In general, all the correlation coefficients were highly significant and above 0.5, emphasising the good correlation between the concentrations registered in both stations. Looking at the concentrations for the whole period, we see that the coefficient is above 0.75 for Poaceae, *Olea europaea, Quercus* and Cupressaceae, which are among the most important taxa from an allergenic point of view in southern Spain.

As regards the mean values for the same date of the three periods studied (trends), the coefficient of correlation was higher than that for the daily means (Table V).

Finally, in the case of the deviations as a whole, the coefficients of correlation were above 0.75 for the pollen of *Olea europaea* but very low for Chenopodiaceae-Amaranthaceae and Myrtaceae.

In general, increased concentrations in one site were matched by increased concentrations in the other, while the deviations were also similar in Malaga and Estepona. Such a finding may be taken as a first step towards predicting the concentrations of pollen in one station from the readings taken in the other.

Comparison of averages. – Despite the strong association between the pollen counts of the two stations for the principal pollen types, clear differences emerged except as regards the mean concentrations of *Quercus*, the overall deviations for

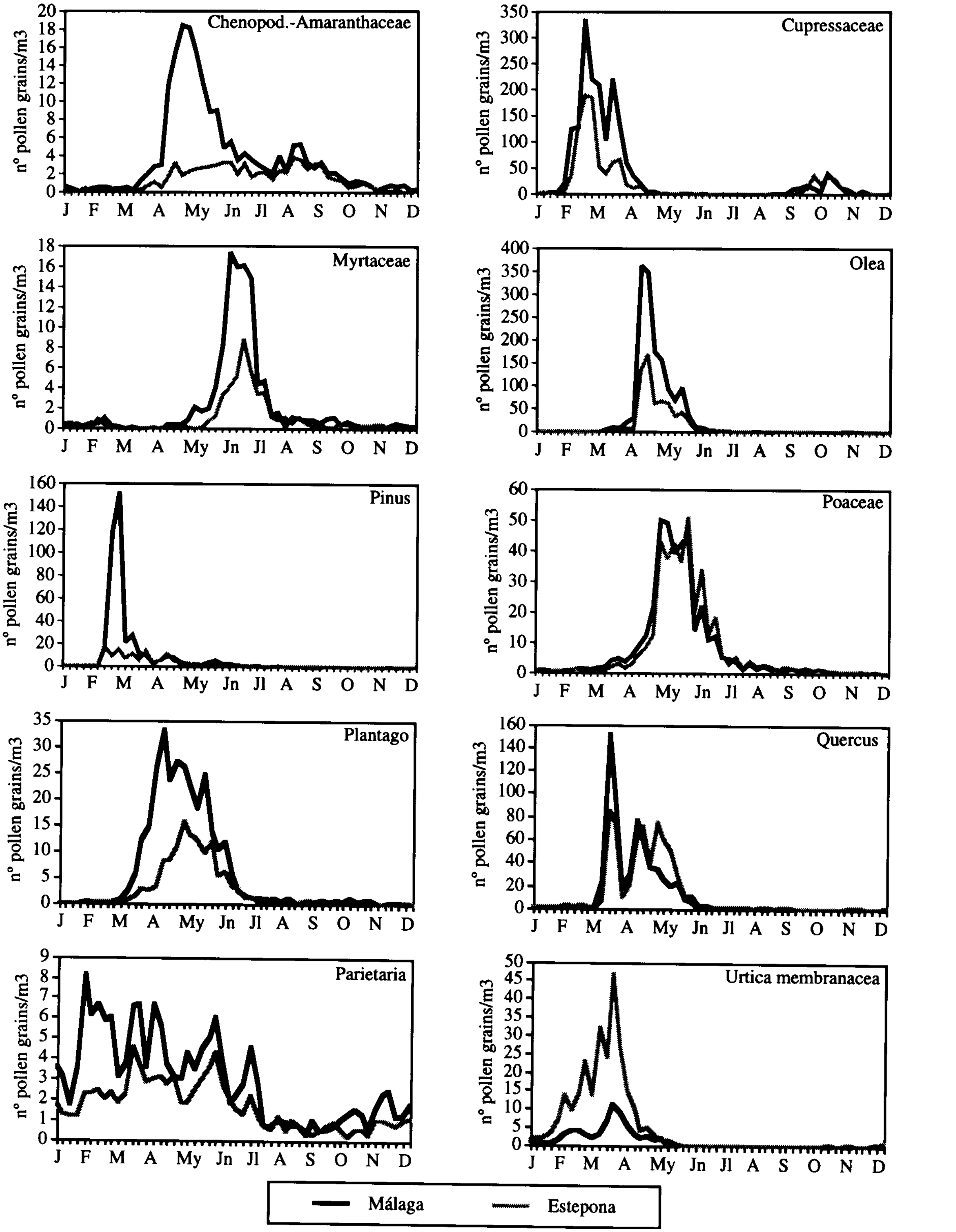

Fig. 3. Graphical representation of the mean weekly concentrations (trend) reached by the different taxa in both stations during the study period.

most taxa and the trend of Poaceae pollen when the concentrations registered in the atmosphere of Estepona and Malaga (Table VI) were analysed.

Because the coefficients of correlation for the deviations in Myrtaceae pollen were not significant during 1996, a Mann Whitney U-test was applied. This showed differences

Table II. *Results of the Kolmogorov-Smirnov normality tests for one sample applied to all the variables used in this study.*

A.

		1995 D. max.	1996 D. max.	1997 D. max.	95/96/97 D. max.	Trend D. max.	Dev. 95 D. max.	Dev. 96 D. max.	Dev. 97 D. max.	Dev. 95–97 D. max.
Chenop.-Amaranth.	Málaga	0.215***	0.233***	0.162**	0.241***	0.239***	0.224***	0.253***	0.164**	0.215***
	Estepona	0.215***	0.235***	0.140*	0.206***	0.186***	0.230***	0.217***	0.198***	0.213***
Myrtaceae	Málaga	0.343***	0.334***	0.288***	0.347***	0.337***	0.322***	0.371***	0.281***	0.319***
	Estepona	0.321***	0.358***	0.284***	0.346***	0.350***	0.291***	0.300***	0.297***	0.278***
Olea europaea	Málaga	0.196*	0.269***	0.282***	0.348***	0.316***	0.271***	0.278***	0.229*	0.259***
	Estepona	0.218**	0.263***	0.283***	0.316***	0.283***	0.226**	0.248***	0.295***	0.240***
Pinus	Málaga	0.309***	0.338***	0.366***	0.411***	0.396***	0.256***	0.357***	0.354***	0.357***
	Estepona	0.304***	0.296***	0.269***	0.294***	0.252***	0.247***	0.257***	0.209**	0.222***
Plantago	Málaga	0.210***	0.158*	0.1 NS	0.215***	0.149**	0.129*	0.174**	0.138*	0.096**
	Estepona	0.248***	0.209***	0.130 NS	0.221***	0.179***	0.157**	0.209***	0.082 NS	0.123***
Poaceae	Málaga	0.326***	0.307***	0.231***	0.329***	0.276***	0.268***	0.299***	0.214***	0.247***
	Estepona	0.310***	0.320***	0.176**	0.317***	0.266***	0.247***	0.272***	0.178**	0.232***
Quercus	Málaga	0.263***	0.317***	0.369***	0.376***	0.330***	0.225***	0.295***	0.360***	0.298***
	Estepona	0.224***	0.264***	0.268***	0.331***	0.278***	0.188**	0.234***	0.229**	0.245***

B.

		95/96 D. max.	96/97 D. max.	95/96/97 D. max.	Trend D. max.	Dev. 95/96 D. max.	Dev. 95/96 D. max.	Dev. 95–97 D. max.
Cupressaceae	Málaga	0.266***	0.298***	0.290***	0.268***	0.180*	0.257***	0.225***
	Estepona	0.310***	0.363***	0.359***	0.344***	0.224***	0.301***	0.261***
Parietaria	Málaga	0.187***	0.209***	0.203***	0.177***	0.168***	0.277***	0.175***
	Estepona	0.226***	0.220***	0.223***	0.221***	0.237***	0.248***	0.247***
U. membranacea	Málaga	0.272***	0.246***	0.288***	0.246***	0.240***	0.231***	0.221***
	Estepona	0.203***	0.211***	0.270***	0.183***	0.206***	0.155***	0.107***

*$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$. NS, non-significant.

Table III. *Results of the Kruskal-Wallis (H) and U-Mann Whitney (Z) tests applied to the different pollen types during the study period.*

	Estepona	Malaga
Chenop.-Amaranth.	H = 19.825***	H = 70.295***
Cupressaceae	Z = − 0.319(NS)	Z = − 2.601**
Myrtaceae	H = 16.715***	H = 45.200***
Olea europaea	H = 28.588***	H = 44.475***
Parietaria	Z = − 2.613**	Z = − 3.750***
Pinus	H = 30.717***	H = 53.139***
Plantago	H = 94.886***	H = 174.018***
Poaceae	H = 165.243***	H = 163.679***
Quercus	H = 83.291***	H = 68.940***
Urtica membranacea	Z = − 9.545***	Z = − 4.247***

**$p \leq 0.01$. ***$p \leq 0.001$. NS, non-significant.

Table IV. *Results of the a posteriori non-parametric analysis of variance test of Newman Keuls when more than two sampling periods are analysed.*

	Estepona			Malaga		
	95 vs 97	96 vs 97	95 vs 96	95 vs 97	96 vs 97	95 vs 96
Chenop.-Amaranth.	4.04**	1.10 NS	3.46**	4.44**	2.42*	8.31**
Myrtaceae	4.12**	4.19**	0.03 NS	6.34**	6.68**	0.34 NS
Olea europaea	2.65*	5.32**	2.58*	4.41**	6.62**	1.97 NS
Pinus	4.71**	5.31**	0.07 NS	6.98**	6.12**	1.12 NS
Plantago	7.77**	1.12 NS	8.70**	10.90**	0.80 NS	11.40**
Poaceae	11.44**	2.68*	9.72**	10.33**	0.71 NS	10.86
Quercus	2.93**	8.71**	5.78**	2.87**	7.99**	5.09**

*$p \leq 0.05$. **$p \leq 0.01$. NS, non-significant.

between the concentrations of this pollen recorded in both stations ($Z = -9.057$, $p \leq 0.0001$).

Comparison of distributions. – When the distributions (annual pollen concentrations, trend and deviations) of the different taxa at both stations were compared (Table VII) any or little differences were found for *Quercus* and Poaceae. In the case of Myrtaceae, *Olea europaea* and *Pinus*, there were not differences for the trend. In the rest of the taxa, differences appeared depending on the year, Chenopodiaceae-Amaranthaceae, *Plantago*, *Parietaria* and *Urtica membranacea* being the pollen types that showed greater differences between both stations, probably due to the fact that they are weeds and, therefore, more influenced by weather conditions.

CONCLUSIONS

During the period 1995–97, on the basis of mean annual quantity of pollen, the ten principal taxa recorded at the stations studied were, in alphabetical order: Chenopodiaceae-Amaranthaceae, Cupressaceae, Myrtaceae, *Olea europaea, Parietaria, Pinus, Plantago,* Poaceae, *Quercus* and *Urtica*

Table V. *Results of the non-parametric correlation analysis (Spearman test) for the different variables studied.*

A.

	1995		1996		1997		95/96/97		Trend		Dev. 95	Dev. 96	Dev. 97	Dev. 95/96/97
	n	r	n	r	n	r	n	r	n	r	r	r	r	r
Chenop.-Amaranth.	222	0.377***	179	0.25***	101	0.415***	502	0.384***	243	0.599***	0.295***	0.171*	0.331***	0.204***
Myrtaceae	190	0.55***	211	0.538***	72	0.801***	473	0.595***	273	0.686***	0.48***	0.02NS	0.677***	0.277***
Olea europaea	57	0.904***	78	0.849***	50	0.823***	185	0.884***	122	0.949***	0.883***	0.842***	0.880***	0.891***
Pinus	119	0.681***	129	0.467***	73	0.672***	321	0.624***	181	0.792***	0.532***	0.427***	0.556***	0.482***
Plantago	131	0.769***	92	0.714***	103	0.266**	326	0.727***	153	0.831***	0.602***	0.663***	0.515***	0.701***
Poaceae	209	0.737***	144	0.800***	97	0.835***	450	0.864***	212	0.860***	0.792***	0.544***	0.739***	0.712***
Quercus	75	0.897***	118	0.769***	64	0.612***	257	0.853***	150	0.891***	0.606***	0.748***	0.542***	0.694***

B.

	1995/96		1996/97		95/96/97		Trend		Dev. 95/96	Dev. 96/97	Dev. 95/96/97
	n	r	n	r	n	r	n	r	r	r	r
Cupressaceae	75	0.832***	179	0.879***	254	0.862***	212	0.876***	0.759***	0.700***	0.714***
Parietaria	248	0.661***	266	0.487***	514	0.576***	304	0.665***	0.534***	0.337***	0.441***
Urtica membranacea	103	0.646***	102	0.337**	205	0.554***	151	0.677***	0.612***	0.474***	0.607***

*p≤ 0.05. **p≤ 0.01. ***p≤ 0.001. NS, non-significant.

Table VI. *Results of the Wilcoxon's signed ranks and equal pairs test applied to the registers obtained for the different pollen types for the two stations.*

A.

	1995	1996	1997	95/96/97	Trend	Dev. 95	Dev. 96	Dev. 97	Dev. 95/96/97
	z	z	z	z	z	z	z	z	z
Chenop.-Amaranth.	− 7.715***	− 9.754***	− 5.672***	− 13.771***	− 10.34***	− 6.098***	− 8.543***	− 6.8***	− 1.493NS
Myrtaceae	− 4.711***	− 4.27***	− 6.076***	− 8.725***	− 7.008***	− 2.401*	− 9.06***	− 4.37***	− 5.529***
Olea europaea	− 5.441***	− 6.313***	− 5.488***	− 9.963***	− 8.310***	− 2.962**	− 0.892 NS	− 4.194***	− 0.311 NS
Pinus	− 2.204*	− 3.403***	− 5.647***	− 6.642***	− 4.483***	− 1.801 NS	− 0.065NS	− 4.702***	− 1.27 NS
Plantago	− 2.66**	− 7.335***	− 7.762***	− 11.119***	− 9.167***	− 9.018***	− 5.559***	− 2.656**	− 0.925 NS
Poaceae	− 3.884***	− 4.328***	− 4.080***	− 2.364*	− 0.701 NS	− 1.316 NS	− 5.173***	− 6.174***	− 0.323 NS
Quercus	− 0.702 NS	− 1.395 NS	− 1.28 NS	− 0.44 NS	− 2.355*	− 1.129 NS	− 2.314*	− 1.000 NS	− 1.471 NS

B.

	95/96	96/97	95/96/97	Trend	Dev. 95/96	Dev. 95/96	Dev. 95/96/97
	z	z	z	z	z	z	z
Cupressaceae	− 5.864***	− 4.844***	− 7.411***	− 6.616***	− 0.085 NS	− 0.771 NS	− 0.493 NS
Parietaria	− 10.130***	− 7.466***	− 12.530***	− 11.200***	− 3.745**	− 0.857 NS	− 2.059*
Urtica membranacea	− 8.549***	− 4.001***	− 9.986***	− 9.421***	− 6.738***	− 7.751***	− 0.202 NS

*p≤ 0.05. **p≤ 0.01. ***p≤ 0.001. NS, non-significant.

membranacea. The length of the pollen season and the time in which the higher peaks were detected were, in general, similar at the two sampling stations.

The results obtained after the statistical protocol proposed were applied, showed clear differences between the results obtained at the two stations for most of the pollen types studied as regards the comparison of averages and comparison of distributions. On the other hand, *Quercus* and Poaceae were the pollen types that fewer differences showed. This entire means that both sampling stations are best kept operational. However, the clear association between the records obtained in both stations, points to the possibility of making reliable forecasts for one sampling site based on the data obtained in the other.

The protocol here described makes possible a thorough comparison of two aerobiological stations independently of the sampling period. The volume of data necessary will naturally depend on the objectives of the individual investigator, although the more data available, the greater the reliability of the results.

The greatest interest of this kind of study is the help given in deciding the geographical distribution of sampling stations so that they are effectively spread over the area to be studied. This will improve the quality of the sampling network and

Table VII. *Results of the Kolmogorov-Smirnov test for two samples used to compare the distributions presented by the different pollen types in both sampling stations.*

A.

	1995 D. max	1996 D. max	1997 D. max	95/96/97 D. max	Trend D. max	Dev. 95 D. max	Dev. 96 D. max	Dev. 97 D. max	Dev. 95–97 D. max
Chenop-Amaranth.	0.234***	0.458***	0.307***	0.321***	0.329***	0.279***	0.413***	0.455***	0.179***
Myrtaceae	0.132 NS	0.128 NS	0.250*	0.146 NS	0.099 NS	0.068 NS	0.351***	0.194 NS	0.161***
Olea europaea	0.211 NS	0.256**	0.300*	0.216***	0.139 NS	0.228 NS	0.103 NS	0.280*	0.103 NS
Pinus	0.084 NS	0.186*	0.315***	0.153***	0.088 NS	0.143 NS	0.102 NS	0.247*	0.072 NS
Plantago	0.107 NS	0.380***	0.456***	0.255***	0.353***	0.382***	0.283***	0.311***	0.196***
Poaceae	0.100 NS	0.118 NS	0.186 NS	0.060 NS	0.080 NS	0.062 NS	0.160*	0.216*	0.031 NS
Quercus	0.080 NS	0.110 NS	0.172 NS	0.058 NS	0.080 NS	0.200 NS	0.128 NS	0.188 NS	0.078 NS

B.

	95/96 D. max	96/97 D. max	95/96/97 D. max	Trend D. max	Dev. 95/96 D. max	Dev. 95/96 D. max	Dev. 95/96/97 D. max
Cupressaceae	0.280**	0.128 NS	0.161**	0.146*	0.189 NS	0.078 NS	0.103 NS
Parietaria	0.278***	0.237***	0.257***	0.263***	0.190***	0.105 NS	0.127***
Urtica membranacea	0.544***	0.216*	0.337***	0.404***	0.392***	0.451***	0.235***

*$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$. NS, non-significant.

facilitate the work of researchers since stations providing redundant information can be eliminated.

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REFERENCES

Bagni, N., Charpin, H., Davies R. R., Nolard, N. & Stix, E. 1976. City spore concentrations in the European Economic Community (ECC). I. Grass pollen, 1973. – Clinical Allergy 6: 61–68.

Caramiello, R., Polini, V., Siniscalco, C. & Ferrando, R. 1991. Confronton aerosporologico tra una zona urbana (Torino) ed una collinaire extraurbana (Cravanzana, Cuneo). – Informatore Botanico Italiano 21: 337–346.

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.

Fornaciari, M., Bricchi, E., Frenguelli, G. & Romano, B. 1996. The results of 2-year pollen monitoring of an urban network in Perugia, Central Italy. – Aerobiologia 12(4): 219–227.

Frenz, D. A., Melcher, S. E., Murray, L. W. & Sand, R. E. 1997. A comparison of total pollen counts obtained 5.6 km apart. – Aerobiologia 13(3): 205–208.

Galán, C., Emberlin, J., Domínguez, E., Bryant, R. H. & Villamandos, F. 1995. A comparative analysis of daily variations in the Gramineae pollen counts at Córdoba, Spain and London, UK. – Grana 34: 189–198.

Goldberg, C., Buch, H., Moseholm, I. & Weeke, E. R. 1988. Airborne pollen records in Denmark, 1977–1986. – Grana 27: 209–217.

Gottardini, E. & Cristofolini, F. 1997. Spring airborne pollen data in two sites in Trentino (Northern Italy): a comparison with meteorological data. – Aerobiologia 13(3): 199–204.

Hjelmroos, M. & van Hage-Hamsten, M. 1993. Birch pollen dispersal on the Baltic island, Gotland. – Grana Suppl. 2: 75–79.

Leuschner, R. M. 1991. Comparison of airborne pollen levels in Switzerland at four recording stations in Davos, Lucerne, Nyon and Basel during 1989. – International Journal of Biometeorology 35: 71–75.

Leuschner, R. M. & Boehm, G. 1981. Pollen and inorganic particles in the air for climatically very different places in Switzerland. – Grana 20: 161–167.

Martín Andrés, A. & Luna del Castillo, J. D. 1994. Bioestadística para las ciencias de la salud. – Norma, Madrid.

Moseholm, L., Weeke, E. R. & Petersen, B. N. 1987. Forecast of pollen concentrations of Poaceae (Grasses) in the air by time series analysis. – Pollen et Spores 29(2–3): 305–322.

Recio, M., Cabezudo, B., Trigo, M. M. & Toro, F. J. 1998. Pollen calendar of Malaga (Southern Spain), 1991–1995. – Aerobiologia 14: 101–107.

Siegel, S. 1970. Estadística no paramétrica aplicada a las ciencias de la conducta. – Edit. Trillas, Mexico.

Sokal, R. & Rohlf, F. J. 1995. Biometry. The principes and practice of statistics in biological research. – W. H. Freeman & Co., New York.

Spieksma, F. Th. M., Frenguelli, G., Nikkels, H., Mincigrucci, G., Smithuis, L. O. M. J., Bricchi, E., Dankaart, W. & Romano, B. 1989. Comparative study of airborne pollen concentrations in Central Italy and The Netherlands (1982–1985). Emphasis on *Alnus*, Poaceae, and *Artemisia*. – Grana 28: 25–36.