

Comparison between categorical pollen data obtained by Hirst and Cour sampling methods

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Abstract

Two methods of aerobiological collection, the Burkard (Hirst-based) and the Cour, were compared using data from pollen collected at Bellaterra (Barcelona, Spain) between 1994 and 1996. Results for three pollen taxa of allergenic relevance (Urticaceae, Poaceae and *Olea*) are presented. This study confirmed the difficulty of finding a reliable conversion formula between these sampling methods, as has been found by several other authors.

An alternative statistical analysis was carried out using categorical data, the pollen concentration data being first converted into an ordinal scale with five levels based on local records. Our analysis shows that both methods provide essentially the same information.

Introduction

In aerobiological science, many sampling methods have been developed. The Hirst method (Hirst, 1952) has become the accepted standard method used in Europe. However, other sampling methods are still used; our research is based on pollen data obtained using a Burkard sampler (based on the Hirst method) and a Cour (1974) sampler.

In the last ten years, some effort has gone towards comparing sampling methods (Larsson et al., 1983; Belmonte et al., 1988; Durand and Comtois, 1989; Gagnon and Comtois, 1992; Dechamp, 1993; Tomás et al., 1997). All used pollen concentration data, sometimes after a mathematical transformation. Tomás et al. (1997), in particular, found a highly significant correlation between the Burkard and Cour methods.

This paper is concerned with the comparison of data obtained by means of the Hirst and the Cour sampling methods. Both methods have weak and strong points, but as our comparison is purely statistical, i.e. restricted to the data, we will not discuss here which is the best. More specifically, our aim is to investigate the feasibility of predicting Burkard counts from Cour counts, and to compare categorical

data obtained from these counts. To obtain the categorical data, we defined five classes for each pollen type, transforming the pollen concentrations into an ordinal scale.

The data analysed were obtained over a three-year period (1994–1996) at a sampling station at the *Universitat Autònoma de Barcelona* (Bellaterra, Spain), where a Burkard sampler and a Cour sampler operated simultaneously.

Materials and methods

The Burkard and the Cour samplers used in this study were set up 8.6 m apart on a 30 m high roof-top at the *Universitat Autònoma de Barcelona* at the site of Bellaterra (see Figure 1). Bellaterra (41° 34' N, 02°06' E, 245 m above sea level) is 15 km from Barcelona and in the middle of a plain, the '*Depressió Pre-litoral Catalana*'. It is surrounded by gently-sloping mountains, with Tibidabo (512 m) and La Mola (1095 m) being the nearest peaks. The climate is Mediterranean, with a mean annual precipitation of 611 mm, and a mean annual temperature of 15.2°C (Benet, 1986).

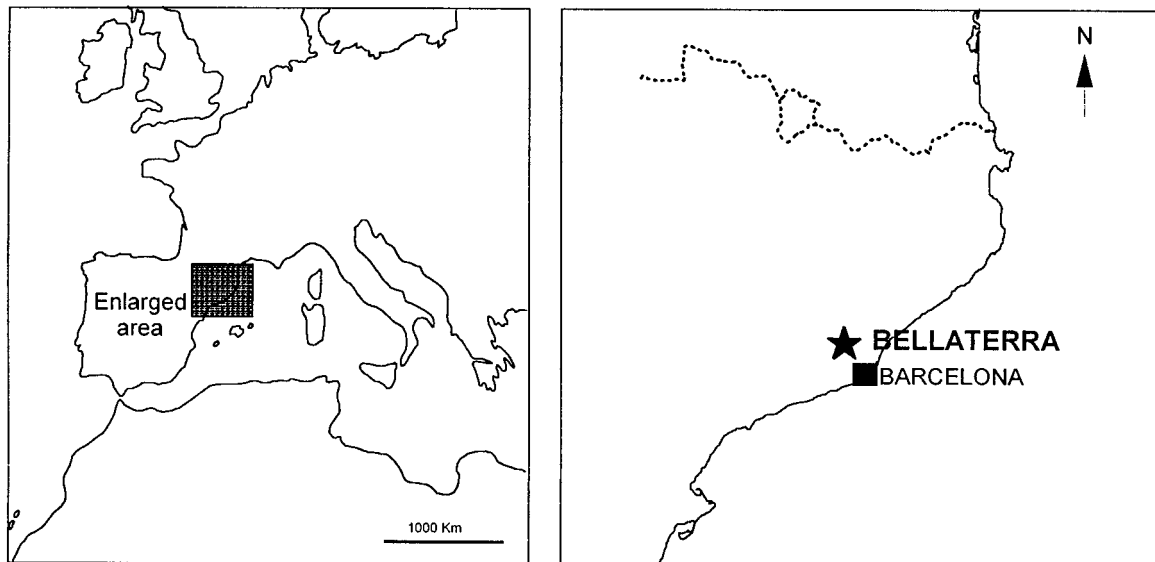


Figure 1. Location of the pollen monitoring sampling site.

Being located under the same meteorological conditions, both samplers were expected to catch the same amount of pollen. The university campus is a semi-urban environment, with ruderal vegetation and ornamental species growing nearby. Other external influences must also be considered: a) the proximity of cultivated land, and b) the vegetation of the surrounding mountains, a littoral oak wood community (*Quercetum ilicis galloprovinciale*) affected by degradation and pine reafforestation.

The Cour sampler traps air-borne particles in a filter composed of five layers of siliconed gauze, with a surface area of 400 cm². The filter is disposed vertically on a vane mechanism, and a wind run anemometer, located near the sampler, measures the volume of air passing through the filter during the period of exposure, usually one week. The filter is then removed and brought to the laboratory for extensive physical and chemical treatment, before the pollen is analysed. This treatment, developed by Cour (1974), and modified by Belmonte (1988), involves acetolysis (Erdtman, 1960) and immersion of the pollen sediment in a semi-liquid medium. These steps contribute to a better identification of pollen grains. The pollen is analysed by a method proposed by Cambon (1981), and validated by Gros (1984).

The Burkard sampler, based on the Hirst method (Hirst, 1952), is an electrical wind-vane apparatus that sucks in a constant volume of air. The air impacts

on a film impregnated with a silicone solution, which retains the pollen grains. The film is then mounted on a drum that rotates in such a way that the film exposed is replaced continuously, at a speed of 2 mm per hour. At the end of the week, the film is separated from the drum, cut into seven parts, each part corresponding to one day, and mounted on a slide. The Hirst method allows the sweeping of the slides without previous laboratory treatment. In the analysis of the Burkard samples, the recommendations of the Spanish Aerobiological Network ('Red Española de Aerobiología', REA) (Domínguez, 1995) were followed.

The results of the pollen analysis were converted into mean weekly pollen concentrations, given as daily pollen per cubic metre of air (daily P/m³). The conversion formula is specific for each method. A total of 10 pollen types were included in the study. In the choice of pollen types, we considered several criteria, such as allergenic power, pollen size, pollination dynamics throughout the year, and the significance of the pollen producer plant in the environment. Our study focused on three pollen types, selected because they are the most allergenic ones in the Mediterranean area: Urticaceae (*Parietaria*), Poaceae and *Olea*. The characteristics of these pollen types are summarized in Table 1.

The two samplers were subject to comparison based on: a) weekly mean pollen concentrations (continuous data), and b) categorical data obtained by

Table 1. Comparison of characteristics of the three pollen types studied.

Taxon	Allergenicity	Pollen size	Pollination period	Environment/use	Composition of the pollen taxa
Urticaceae (mostly <i>Parietaria</i>)	Very high	Small	All the year round	Ruderal species	Two genera and several species, mostly <i>Parietaria officinalis</i> ssp. <i>judaica</i>
Poaceae	High	Medium to big	Spring–summer	Natural landscape and cultures	Numerous genera and species
<i>Olea</i>	High	Medium	End of spring	Cultivated and ornamental plants	One species: <i>Olea europea</i>

Table 2. Categories and ordinal scales established for pollen concentrations in this study.

Category	Ordinal scale	Arboreous plants	Herb plants
Null	0	$0 < P/m^3 < 1$	$P/m^3 = 0$
Low	1	$1 < P/m^3 < 20$	$0 < P/m^3 < 5$
Medium	2	$20 < P/m^3 < 50$	$5 < P/m^3 < 20$
High	3	$50 < P/m^3 < 100$	$20 < P/m^3 < 30$
Very high	4	$P/m^3 > 100$	$P/m^3 > 30$

transforming the concentrations into an ordinal, 0–4 scale. The statistical analysis was performed with SYSTAT. For each pollen type, the continuous data consisted of three yearly series and a three-year series for each sampling method. The categorical data consisted of one series (three years) for each method.

For the continuous data, the factors for converting Cour to Burkard pollen concentrations were obtained by calculating the least squares estimates of the parameter of a linear regression model without constant, in which Cour was taken as the independent variable and Burkard as the dependent variable. The linear (Pearson) and non-parametric correlations (Spearman and Kendall) were derived using SYSTAT. Any statistical package would suffice, and information about these statistics can be found in any biostatistics textbook, e.g. Sokal and Rohlf (1987).

The categories for the ordinal scale were defined especially for this study, on the basis of the records of the Bellaterra station, which includes ten years of Cour data (1988–1997), and four years of Burkard data (1994–1997). The classification is based on the experience of the research group, and would be different under different biogeographical and climatic conditions. Table 2 shows the ordinal scales defined for arboreous plants (*Olea* in this paper) and for herb plants (Poaceae and Urticaceae).

For the categorical data, the usual chi squared test for contingency tables was used, and also a chi squared

test for linear association of ordinal variables. Technical details about this test can be found in any book on categorical data analysis, e.g. Agresti (1996).

Results and discussion

Line charts for the three pollen types are presented in Figures 2, 3, and 4, with the continuous scale on the left and the ordinal scale on the right. For Urticaceae, Burkard gave higher values, but the trends were quite similar. Nevertheless, we found zero value in the Cour series, in weeks for which the Burkard value was relatively high. For Poaceae, Cour gave higher values, except for 1995. This difference found between pollen types is consistent with Poaceae having big pollen grains and Urticaceae small pollen grains. It has already been noted (Hirst, 1953) that particles of different size are trapped with different efficiency. For *Olea*, Burkard gave higher values, but, except for a few weeks, both pollen concentrations fell into the null class.

The conversion factors and correlations for the continuous data are presented in Table 3, with 95% confidence limits for factor estimates also being included. Such confidence limits and significance levels can only be taken as an indication, as they are exact only under certain statistical assumptions (normality for confidence limits and linear correlations and randomness for non-parametric correlations). As all correlations are highly significant ($p < 0.0001$), we can reasonably conclude that there is a correlation between the Cour and Burkard data. This is not surprising, because both are measurements of the same thing.

The conversion factors present relevant differences from one year to another, particularly for Poaceae. Moreover, if the usual comparison tests (under normality assumptions) are applied, most of these differences are significant at the 95% level. Since the specific factor for a year cannot be known in advance, no application can be found for these

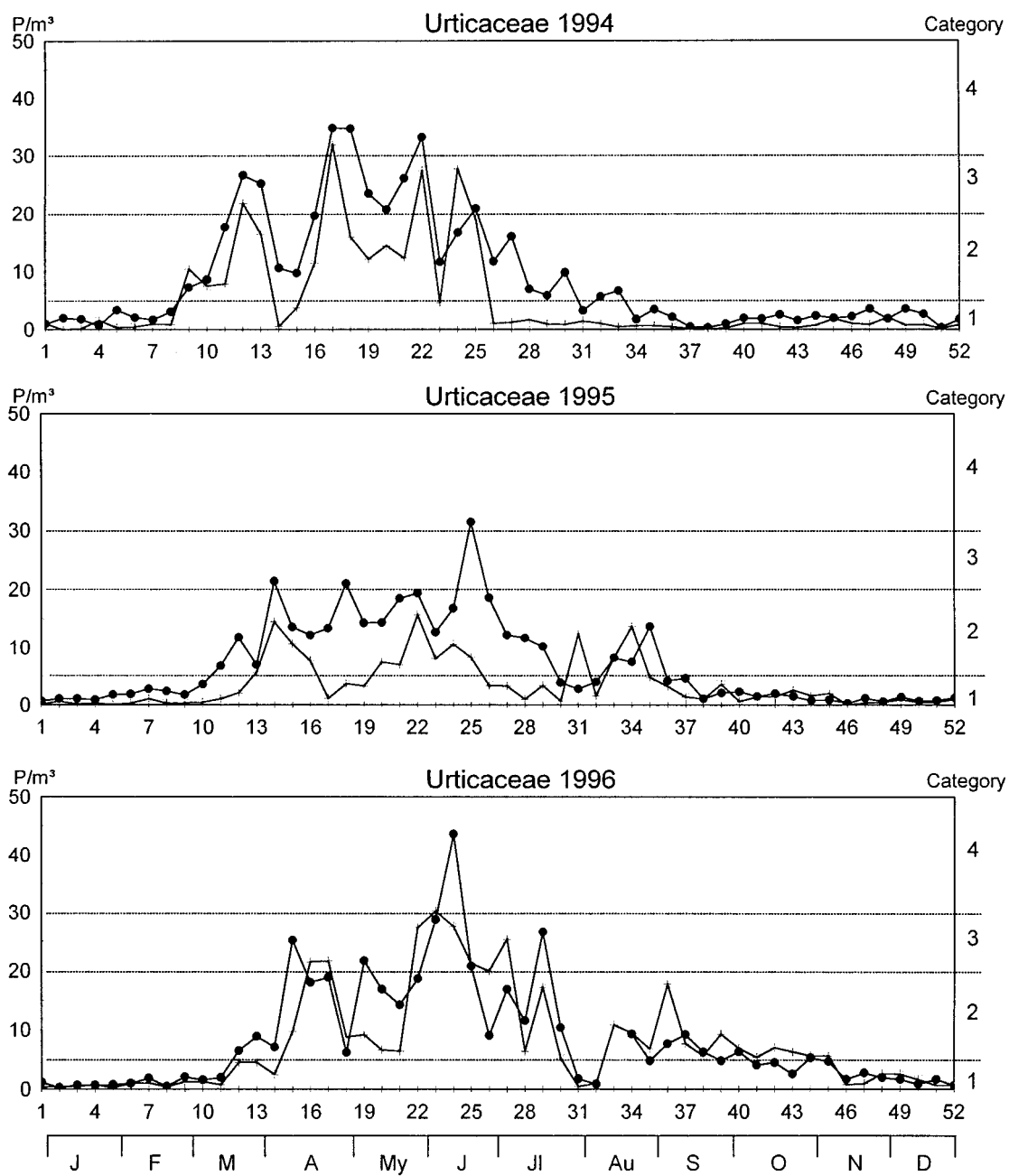


Figure 2. Annual variations of the Urticaceae mean weekly pollen concentration in the air of Bellaterra during the study period. Burkard series are represented by lines and circles and Cour series by lines and asterisks. The values on the right y-axis and the horizontal lines correspond to the categories established in Table 2.

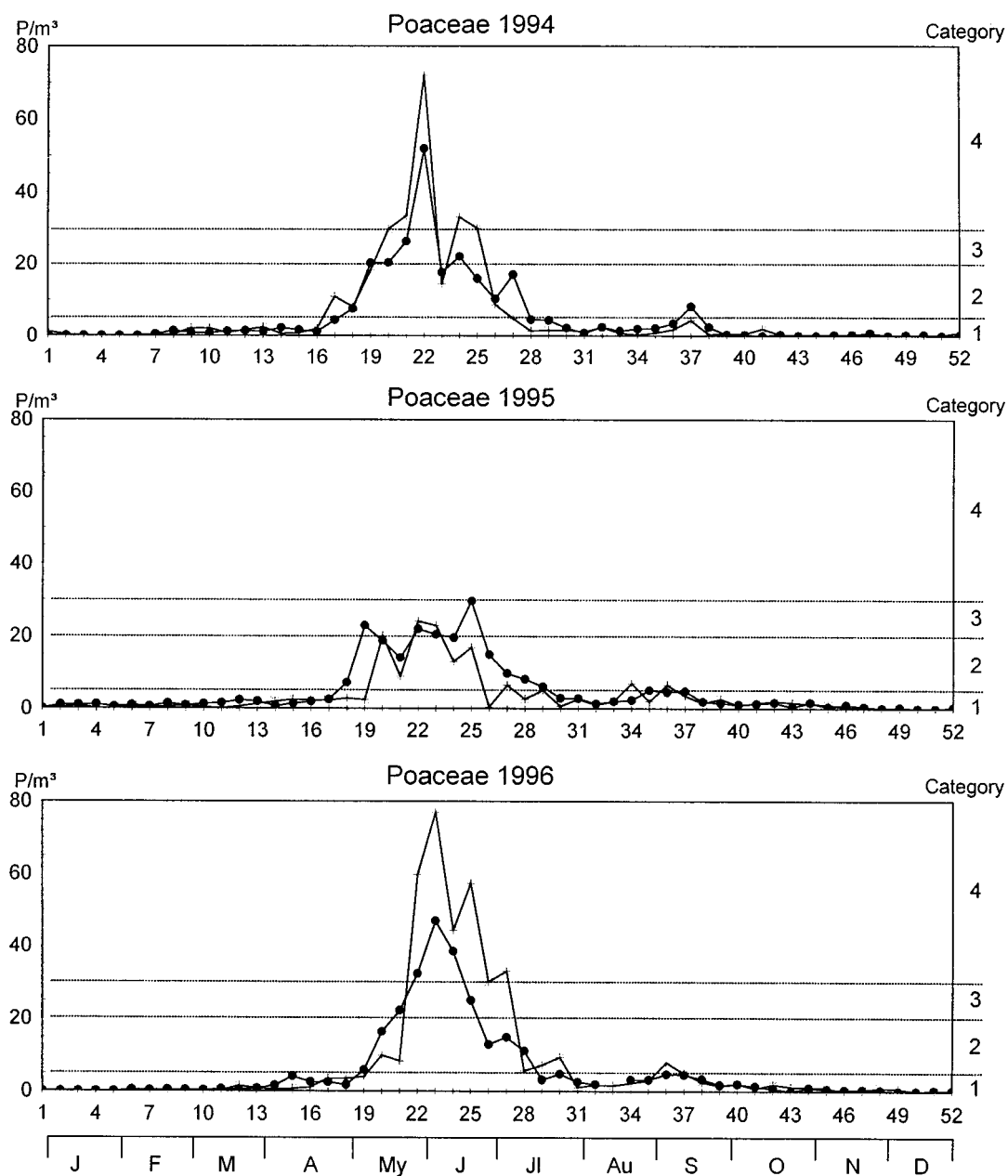


Figure 3. Annual variations of the Poaceae mean weekly pollen concentration in the air of Bellaterra during the study period. Burkard series are represented by lines and circles and Cour series by lines and asterisks. The values on the right y-axis and the horizontal lines correspond to the categories established in Table 2.

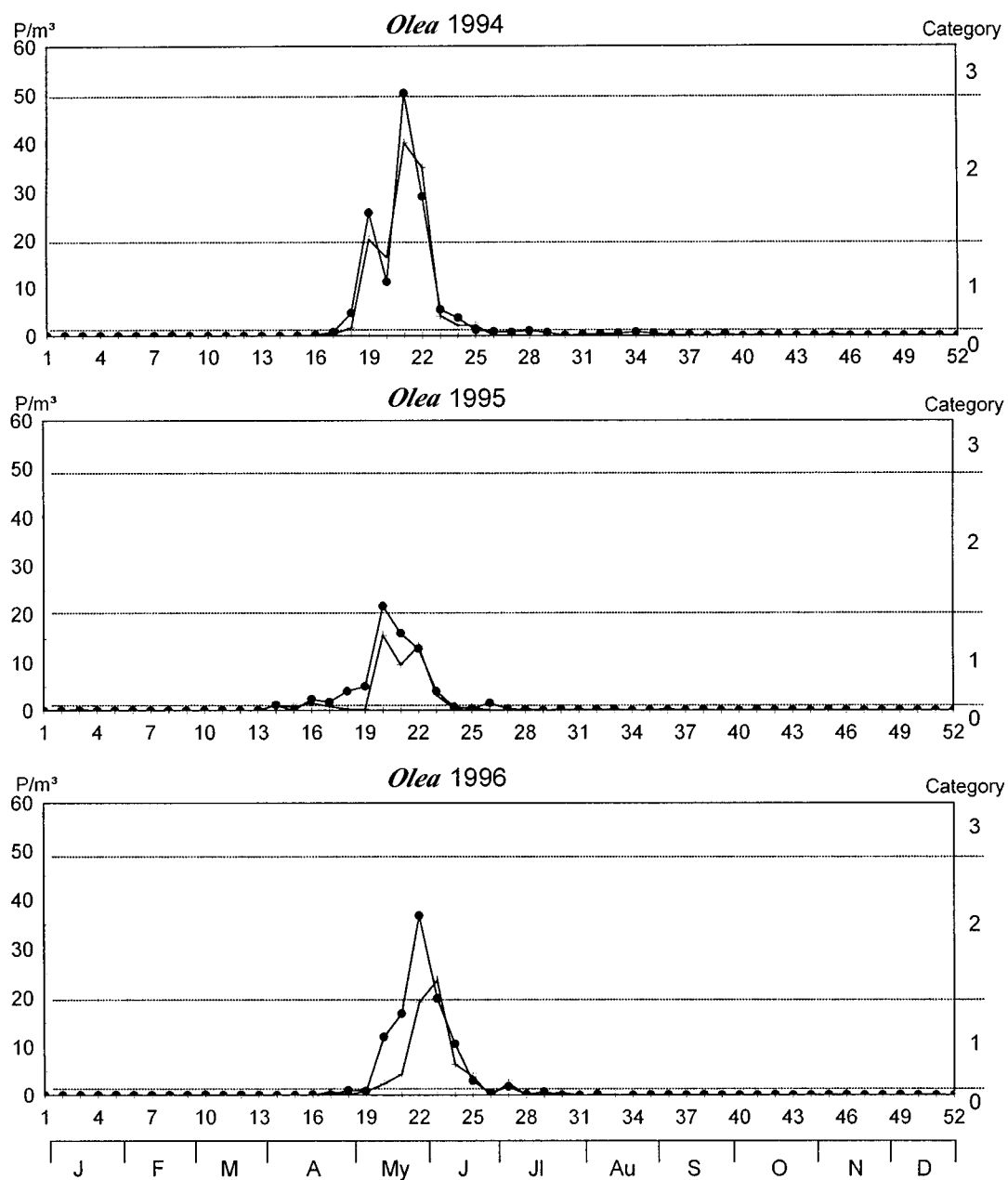


Figure 4. Annual variations of the *Olea* mean weekly pollen concentration in the air of Bellaterra during the study period. Burkard series are represented by lines and circles and Cour series by lines and asterisks. The values on the right y-axis and the horizontal lines correspond to the categories established in Table 2.

Table 3. Conversion factors for the prediction of Burkard from Cour pollen concentrations, and correlations. The factors are least squares estimates for the parameter of a linear regression model without constant term. Significance levels for correlations are lower than 0.0001.

	Conversion factor	95% confidence limits	Pearson correlation	Spearman correlation	Kendall correlation
<i>Urticaceae</i>					
94	1.25	(1.09, 1.41)	0.87	0.74	0.58
95	1.49	(1.14, 1.75)	0.64	0.76	0.56
96	0.99	(0.87, 1.13)	0.82	0.89	0.70
3 years	1.15	(1.05, 1.25)	0.79	0.79	0.60
<i>Poaceae</i>					
94	0.74	(0.68, 0.79)	0.96	0.79	0.63
95	1.12	(0.94, 1.30)	0.81	0.79	0.62
96	0.59	(0.53, 0.65)	0.93	0.89	0.75
3 years	0.68	(0.63, 0.73)	0.89	0.83	0.66
<i>Olea</i>					
94	1.06	(1.00, 1.13)	0.97	0.60	0.54
95	1.28	(1.18, 1.39)	0.96	0.66	0.57
96	1.34	(1.16, 1.53)	0.88	0.50	0.56
3 years	1.21	(1.13, 1.30)	0.92	0.57	0.52

factors, except for filling in gaps in a pollen data series, where both methods are running in parallel at the same place.

Similar results were obtained by Gagnon and Comtois (1992) who compared data from three different samplers (Rotorod, Hirst and Durham) for *Ambrosia*, and concluded that there was no reliable conversion. Belmonte et al. (1988) also attempted to derive conversion factors for modified Durham (Belmonte, 1988) and Cour samplers, for *Urticaceae*, *Poaceae*, and three other pollen types; they found a great variation among the factors for different pollen types.

The conversion factors obtained in this study are greater than 1 for *Urticaceae* and *Olea*, but lower than 1 for *Poaceae*, except in 1995. Moreover, for *Urticaceae* and *Poaceae*, annual differences in the estimates are quite similar, suggesting that changes in the measurement process may occur from year to year. The interpretation of the conversion factors for *Olea* is not simple, since two-thirds of the mean weekly concentrations obtained fell in the null category for both sampling methods, due to its short pollination period.

Linear correlation (Pearson) can be used to assess the prediction of Burkard data from Cour data by means of a linear equation. The best results were for

Olea. The results for *Urticaceae* and *Poaceae* were quite satisfactory, except in 1995.

Linear correlation is sometimes used to test statistical independence but, for pollen data, the rank (Spearman) correlation is usually preferred, because normality is not assumed. The interpretation of the Kendall correlation is similar to that of the Spearman correlation. As they are based on the ordering of the data, not on the numbers themselves, non-parametric correlations are not sensible to peak values, which are common in pollen data. For *Olea*, non-parametric correlations are affected by the great quantity of null data.

Larsson et al. (1983) compared data obtained by means of two Burkard traps, 3 m apart, computing rank correlations for several taxa. They observed that the taxa with higher pollen concentration presented a high correlation (this also happened in this study), but not conversely, and suggested that other factors may influence the mathematical relationship between both types of data. Belmonte et al. (1988) found higher Spearman correlations between Cour and modified Durham data, for *Urticaceae* and *Poaceae*, possibly because the two methods compared are based on the same principle. Tomás et al. (1997) obtained Spearman correlations between Cour and Burkard data for 16 pollen types, and for pollen totals. Their corre-

Table 4. Contingency tables for the three pollen types. Rows correspond to Burkard and columns to Cour categories. Significance levels for chi squared tests are lower than 0.0001.

	Null	Low	Medium	High	Very high	Totals
Urticaceae						
Null						
Low	2	76	8			86
Medium		21	24	6		51
High		1	9	2	1	13
Very high		1	2	1	1	5
Totals	2	99	43	9	2	155
Poaceae						
Null	8	16				24
Low	8	85	6			99
Medium		6	9		2	17
High		1	3	3	3	10
Very high		1			4	5
Totals	16	109	18	3	9	155
Olea						
Null	127	2				129
Low	5	15	1			21
Medium		2	2			4
High			1			1
Very high						
Totals	132	19	4			155

lations are slightly lower than those of Table 3 for Urticaceae and Poaceae, but still significant ($p < 0.001$). Nevertheless, the Spearman correlation given in their paper for *Olea* (0.900) is very high, far from the values of Table 3. The differences between the results in the two papers could be attributed to the different proportion of null pollen data from Sevilla and Bellaterra.

To diagnose a situation and to provide a rough evaluation of allergenic risks can be more useful than to have an exact value of pollen concentration. Keeping this principle in mind, pollen concentrations may be transformed into categorical data, and the relationship between both sampling methods analysed using contingency tables. A contingency table for the three pollen types is presented in Table 4.

The significance levels in the chi squared tests for independence and linear association are less than 0.0001 for the three sections in Table 4, in accordance with the correlation analysis. Moreover, the contingency tables show that, once the pollen concentrations

have been converted to categorical data, both methods provide essentially the same information. Indeed, we have coincidence in 66.5% of cases of Urticaceae (the diagonal in the first section of Table 4), in 70.3% for Poaceae, and 93.0% for *Olea*.

It seems that the problem of the converting Cour data to Burkard data could be addressed, not by looking for conversion factors or other mathematical devices, but for simple rules of categorization. As the mean levels for different methods do not coincide, the concentration ranges for the categorization need not be the same for both methods. They also could be based on allergenic thresholds, which again could be specific for each method.

Although a fair coincidence of Cour and Burkard data is achieved by using categorical data instead of continuous values (see Figures 2 to 4 and Table 4), there are still some differences. A first source of error can be due to the methods themselves. Larsson et al. (1983) suggested various reasons for the differences found in their study between two Burkard traps 3 m apart, for example, the non-uniform distribution of pollen grains in the air, and imperfections in the aerodynamics of the samplers.

In our study, meteorological data have been revised for pairs of pollen values showing relevant differences. No explanation for these differences, in terms of precipitation, wind run, and temperature, has been found. Gagnon and Comtois (1992) also concluded that there was no influence of meteorological variables on the differences between Burkard, Durham, and Rotorod pollen data.

The only likely explanation for the differences observed would be in the laboratory processing of the Cour samples. Great accuracy is required because final data depend on the volume measurements resulting from this phase. Pollen sediment volumes corresponding to 1995 samples were considerably lower than volumes obtained during 1994 and 1996.

Some of the published results do not agree with ours nor with others discussed. For example, with Gramineae and *Ambrosia*, Dechamp (1993) concluded that Cour and Hirst data from samplers separated by a distance of 10 km were not comparable. On the other hand, Domínguez (1994) compared data from two Hirst samplers (Burkard and Lanzoni), obtaining non-significant differences, except for some taxa (Poaceae and Urticaceae) in periods of maximum pollination.

Conclusions

The first conclusion of this study is that the two sampling methods considered provide essentially the same information, in spite of the fact that the mean weekly pollen concentrations have different magnitudes, and that the change in magnitude depends on the taxon. Moreover, the conversion of Cour data into Burkard data cannot be done by means of a single factor. This difficulty has been previously discussed for several sampling methods, including those studied in this paper.

This study also provides an argument for the categorization of pollen data. It is the authors' opinion that, to simplify interpretation and to avoid controversy over sampling methods, pollen data should be presented in an ordinal scale. The categorization should be specific for each method, and should be related to allergenicity thresholds. These thresholds should also be specific for each sampling method.

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