

Evaluation of the efficiency of the Coriolis air sampler for pollen detection in South Europe

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Abstract The Coriolis δ air sampler is a new volumetric air sampler, dedicated to outdoor monitoring of airborne biological particles, including pollen and spores. In the present work, the performance of the Coriolis in the collection of pollen grains was evaluated in comparison with a Hirst spore trap, the most frequently used trap in aerobiological studies, in two cities of South Europe, Evora (Portugal) and Córdoba (Spain). Both concentration values are compared, and statistical analysis was carried out. The present study indicated that, in general, pollen counts for all taxa detected with the Hirst trap were higher than those detected with the Coriolis δ in both cities. In Córdoba, significant differences were detected for all taxa except for *Cupressus*, *Olea* and *Pinus*, while in Evora significant differences were noted for all except *Pinus* and Poaceae. Differences were particularly marked in species flowering during April and May. In spite of these differences, Spearman correlation test results showed that the relationship between Hirst and Coriolis curves was always positive and significant

($p > 0.01$). Regards to the number of detected taxa, the results showed greater diversity for the Hirst sampler in both cities.

Keywords Pollen · Hirst · Coriolis · Air sampler · Allergen

1 Introduction

Within the framework of the MONALISA project (Monitoring Network of Allergens by Immuno-Sampling), part of the LIFE-ENVIRONMENT Program, a new approach was developed for the analysis of airborne particles using recent methodology based on the cyclone process. The new Coriolis δ cyclonic air sampler developed by Bertin Technologies (France) was tested during this project. This sampler works on the basis of a principle described by Decker et al. (1969), and trap dimensions are based on the geometrics of Stairmand cyclones (Leith and Licht 1972).

The main aim of the project was to demonstrate the use of this cyclonic air sampler, in association with immunological analysis methods, and to validate a new approach for airborne pollen monitoring by online antigenic/allergenic measurement. Bertin Technologies has developed a liquid cyclonic high-volume air sampler for the collection and identification of airborne bio-particles including microorganisms such as bacteria and fungi, as well as pollen grains. This

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technology is based on a cyclone-type device that selects and captures airborne particles and instantly transfers them into a liquid sample. Liquid samples enable both visual and immunological analysis of biological particles. The performance of the Coriolis δ for collecting airborne pollen grains was compared here with that of a conventional Hirst spore trap (Hirst 1952), one of the traps most widely used to measure outdoor airborne pollen. Pollen data obtained using Coriolis δ and Hirst traps were compared in two southern European cities, Córdoba (Spain) and Évora (Portugal), in the course of 2007.

Pollen data from both cities, situated 450 km apart, were counted daily. The most abundant pollen types were analysed: *Cupressus*, *Pinus*, *Platanus*, *Quercus*, Poaceae, *Olea europaea*, *Urtica urens*-*Parietaria* and *Urtica membranacea*. All these pollen types, except for *Quercus* and *Pinus*, are an established cause of allergy in southern Europe (D'Amato et al. 2007). In the study cities, the main causes of pollinosis are *Olea* and Poaceae, both of which give rise to seasonal allergic rhinitis and asthma in a high percentage of the population (Sánchez Mesa et al. 2005).

Although a previous study was performed in France (Carvalho et al. 2008), we present this work in order to investigate the validity of the Coriolis sampler for the first time in southern Europe, where in both studied sites it was placed 2 m away from Hirst traps; data obtained from the two samplers, operating simultaneously during the same period, were compared. This sampling strategy allowed statistical comparisons of particle counts and analysis of quantitative and qualitative differences in the pollen spectra detected by the two samplers.

2 Materials and methods

The Coriolis δ air sampler designed by Bertin Technologies (France) is a continuous air sampler for outdoor monitoring of airborne spores and pollen grains (Fig. 1). This high-volume sampler is based on patented Coriolis technology and delivers a liquid sample: air is drawn into a conical vial in a whirling motion, using suction; particles are pulled against the wall due to centrifugal force. Airborne particles are separated from the air and collected in a liquid medium (Fig. 2). The sample obtained is directly



Fig. 1 Coriolis sampler

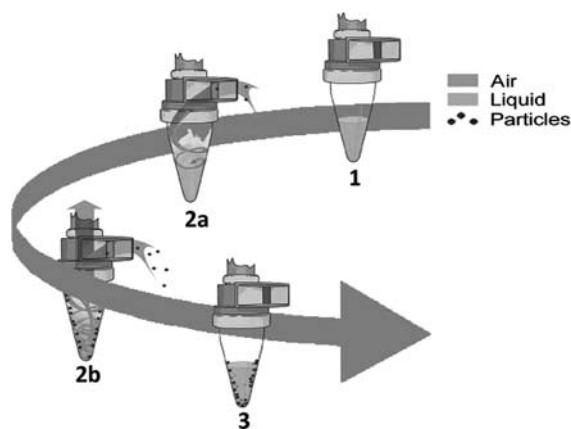


Fig. 2 Operating principle of Coriolis. 1. Before aspiration. Cone ready to use with appropriate collection liquid. 2a. During aspiration. Vortex beginning. Air and particles come into the cone forming the vortex. 2b. During the vortex. Aspirated particles are centrifuged with the liquid on the cyclone's surface. 3. After aspiration. Particles are concentrated in the liquid

compatible with all types of biological analysis (including epifluorescence microscopy, immunoassay, PCR assay, flow or solid phase cytometry and standard culture methods).

This paper presents some of the results obtained during 2007 in the cities of Córdoba (southern Spain) and Évora (central Portugal). Córdoba is a medium-sized city located in southwest of Spain, with 350,000 inhabitants and light industrial development. The land is mainly devoted to cereals and olive groves. The climate is Mediterranean with a touch of continentality; the annual average temperature is 17.6°C and total

annual rainfall is 536 mm. Évora is a small city with 60,000 inhabitants, located in southeastern Portugal. The city is located essentially in a rural area where oak plantations, vineyards and olive trees are the core of the local economy. The climate is influenced by the Atlantic Ocean. The average annual temperature is 15.8°C and the annual rainfall 686 mm.

Aerobiological samples were collected over 2007 using a Hirst volumetric collector (Hirst 1952), (Burkard® Spore Trap) and a Coriolis δ trap. The traps were placed 2 m apart operating simultaneously (from 10:00 a.m. to 16:00 p.m.) during the same period. The counting method for Hirst samplings was that recommended by the Spanish Aerobiological Network (Galán et al. 2007). For Coriolis δ samplings, the counting method was that by Carvalho et al. (2008). For the present study, an air flow rate of 200 l/min was selected for sampling using the Coriolis δ equipment in the fixed mode, adding 0.5 at 1 ml/min of water to the cone, depending on weather. A plastic cone was used to collect liquid. Injected liquid was water + triton (0.005%). Counts for the various pollen types obtained with the Coriolis δ were compared with those recorded using the Hirst-type spore trap, in both cases analysed under a light microscope. Pollen Index was expressed as the sum of daily pollen concentrations during a year.

The (nonparametric) Wilcoxon W test was performed to compare medians rather than means, i.e. to determine whether differences between the medians obtained using the two methods were significant or not significant. Results were considered significant at $p < 0.05$. The (nonparametric) Spearman correlation test was performed to compare daily variations in pollen curves from Hirst and Coriolis samplers. Statistical analysis was carried out using the SPSS 8.0 software package.

3 Results

Visual analysis of airborne pollen grains indicated that, in general, pollen counts for all taxa detected with the Hirst trap were higher than those detected with the Coriolis δ in both cities, except in the case of *Pinus*, higher with Coriolis, and *Quercus* with values very similar (Table 1). This difference was particularly marked in species flowering during

Table 1 Pollen index recorded during the sampling period in both cities with both samplers, Coriolis (C) and Hirst (H)

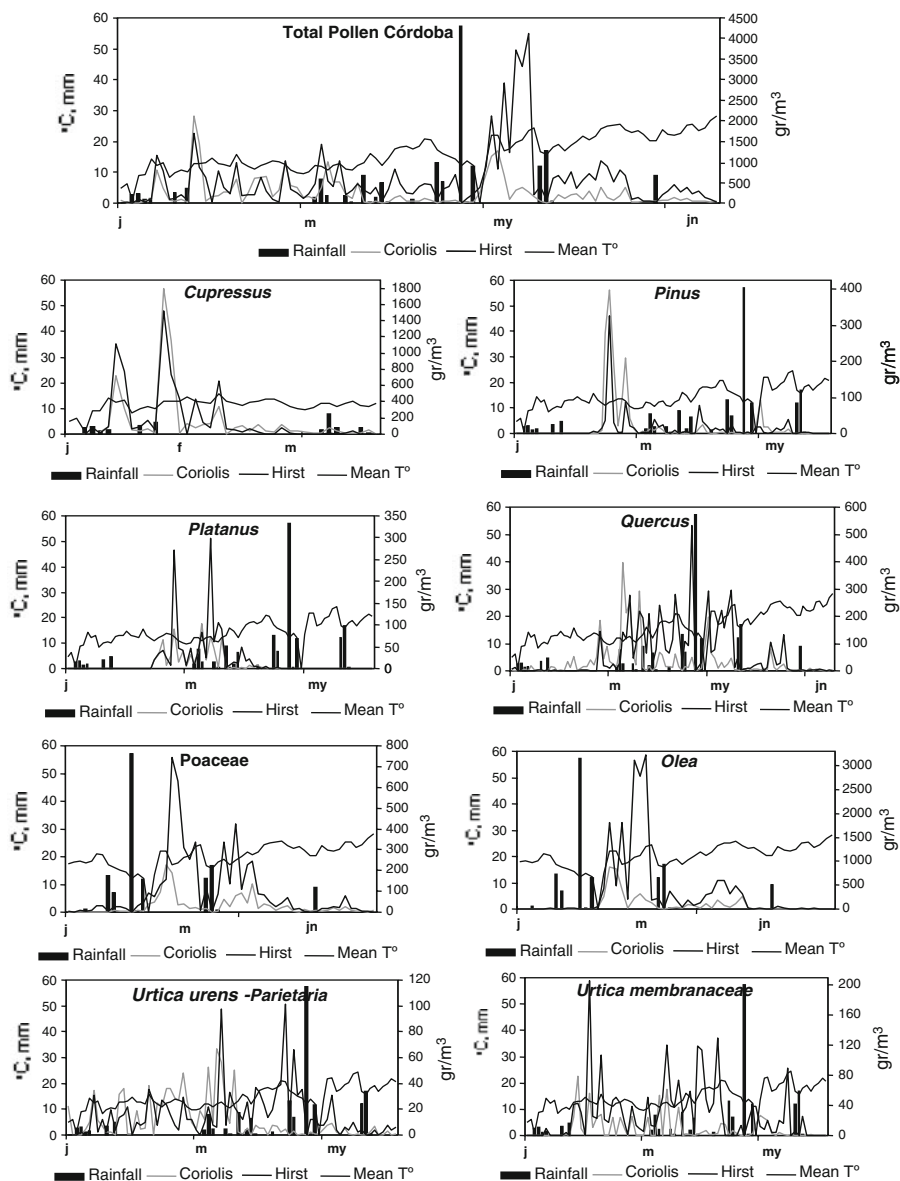
Taxa	Samplers	Córdoba	Evora
<i>Cupressus</i>	H	7,000	11,641
	C	6,001	9,292
<i>Olea</i>	H	18,488	8,445
	C	4,566	1,121
<i>Pinus</i>	H	1,083	1,351
	C	1,598	1,622
<i>Platanus</i>	H	1,388	9,687
	C	730	8,779
Poaceae	H	5,361	25,777
	C	1,711	6,349
<i>Quercus</i>	H	5,878	19,083
	C	3,137	18,890
<i>Urtica urens</i> - <i>Parietaria</i>	H	1,264	1,602
	C	1,006	714
<i>Urtica membranaceae</i>	H	2,226	8,316
	C	653	3,930
Total Pollen	H	54,248	99,085
	C	23,997	56,505

April and May. However, similar pollen curve trends were observed (Fig. 3). Statistical comparison using the W test (Table 2) showed that total pollen counts in both cities differed significantly as a function of trap type. In Córdoba, significant differences were detected for all taxa except *Cupressus*, *Olea* and *Pinus*, while in Evora, significant differences were noted for all except *Pinus* and Poaceae (Table 3).

To study sampler efficiency, the temporal distribution of pollen counts was plotted for the two traps (Fig. 3). The graphs showed similar trends and curves with peaks on the same, although the counts recorded by Coriolis declined during spring. From late April, the Coriolis sampler detected lower counts. Nevertheless, Spearman test results showed that the correlation between Hirst and Coriolis data was always positive and significant ($p > 0.01$) (Table 4).

Comparison of the number of different pollen types detected by the two samplers showed greater diversity for the Hirst sampler. In Cordoba, the Hirst sampler detected 35 pollen types, compared with 18 for the Coriolis sampler. In Evora, the figures were 37 for the Hirst sampler and 16 for the Coriolis sampler.

Fig. 3 **a** Temporal distribution in 2007 of pollen concentrations (grains/m³) for the Hirst and Coriolis samplers in Córdoba. **b** Temporal distribution in 2007 of pollen concentrations (grains/m³) for the Hirst and Coriolis samplers in Évora

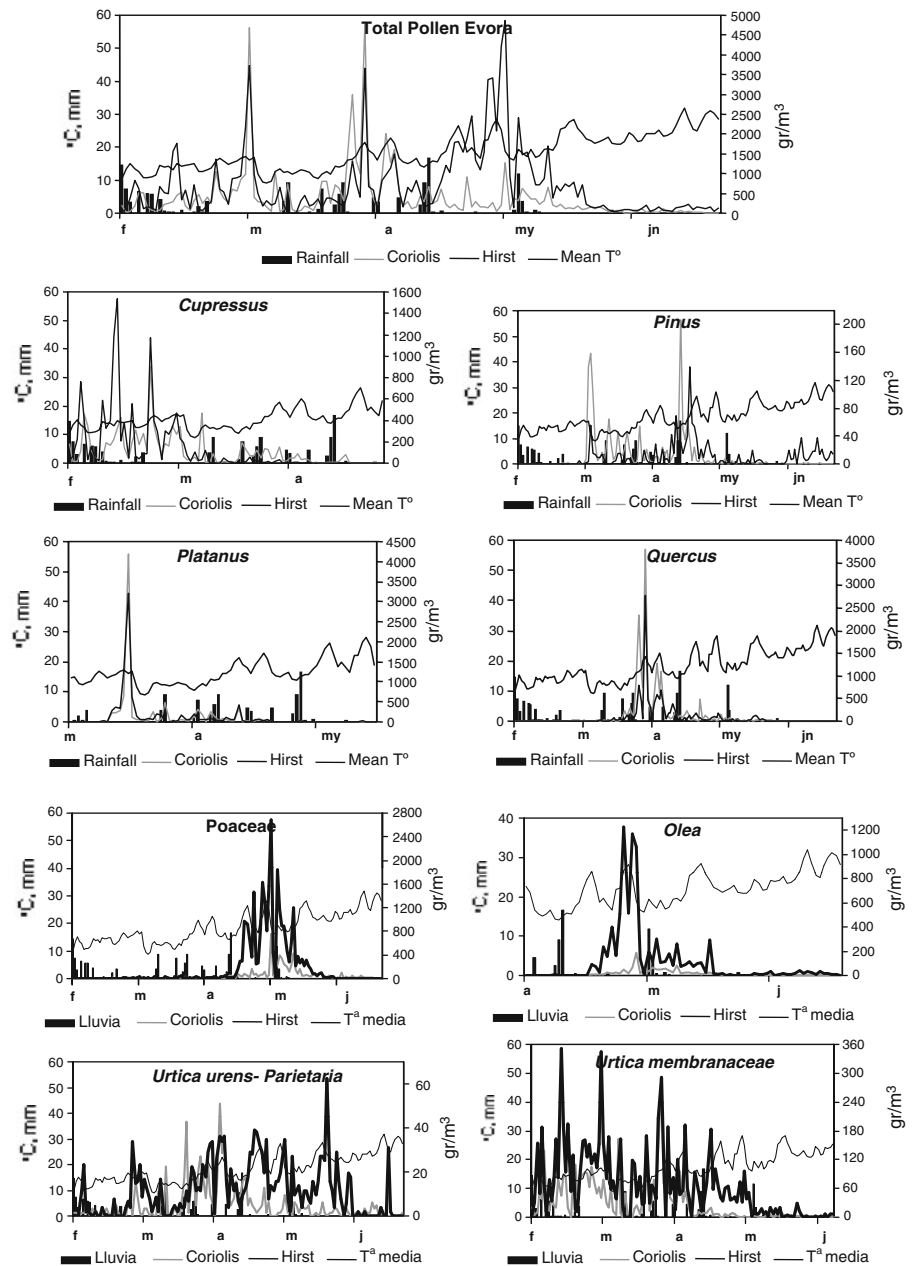


4 Discussion

The pollen-sampling efficiency of the Coriolis δ sampler was compared with that of the Hirst spore trap as a reference method in aerobiology (Hirst 1952), in a study performed in two cities in the Iberian Peninsula, Córdoba (Spain) and Évora (Portugal). Sánchez Mesa et al. (2005) have reported that the main causes of pollinosis in both cities are *Poaceae* and *Olea*. Both pollen types were detected in high concentrations by the two samplers tested.

Comparison of the pollen grain counts recorded by the two samplers showed comparable temporal distributions, and statistical analysis confirmed the positive correlation of pollen curves. Although previous studies of Coriolis efficiency report acceptable results for both small and large particles (Carvalho et al. 2008), the results obtained here indicate significant differences in the amounts of pollen detected: the Hirst trap recorded higher pollen counts in both cities studied, especially for spring-flowering taxa. Nevertheless, no significant differences were

Fig. 3 continued



detected for *Cupressus*, *Olea* and *Pinus* in Córdoba and for *Pinus* and *Poaceae* in Evora, which could be explained in part because the high size of these pollen grains which would facilitate the absorption by the cyclonic force from the cone walls. These results joined to the big differences recorded in small pollen grains such as *Urticaceae* would suggest some losses from the cone by factors not yet explained. All these findings contrast with the results reported by

Carvalho et al. (2008) in Lyon (France), which pointed to the greater efficiency of the Coriolis sampler compared to the Hirst trap; indeed, pollen counts for all taxa were found to be higher using the Coriolis sampler. Moreover, whereas the Hirst trap detected a greater diversity of pollen types in the present study, the Coriolis sampler yielded greater diversity in the Lyon study by Carvalho et al. (2008). These contrasting findings may be due in part to

Table 2 Wilcoxon test results in (a) Córdoba (b) Évora

Taxón	H < C	H > C	H = C	Total	Z	2-Tail P
(a)						
<i>Cupressus</i>	29	28	42	99	−0.258	0.796
<i>Olea</i>	33	45	21	99	−1.572	0.116
<i>Pinus</i>	22	28	49	99	−1.366	0.172
<i>Platanus</i>	8	23	68	99	−2.469	0.014
Poaceae	29	56	14	99	−2.364	0.018
<i>Quercus</i>	35	56	8	99	−1.991	0.046
<i>Urtica urens-Parietaria</i>	34	55	10	99	−3.545	0.000
<i>Urtica membranacea</i>	12	57	30	99	−5.839	0.000
Total Pollen	23	75	1	99	−6.440	0.000
(b)						
<i>Cupressus</i>	55	43	43	141	−2.369	0.018
<i>Olea</i>	11	59	71	141	−6.189	0.000
<i>Pinus</i>	46	56	39	141	−1.437	0.151
<i>Platanus</i>	23	69	49	141	−4.704	0.000
Poaceae	55	78	8	141	−1.733	0.083
<i>Quercus</i>	74	54	13	141	−2.314	0.021
<i>Urtica urens-Parietaria</i>	35	86	20	141	−5.514	0.000
<i>Urtica membranacea</i>	31	99	11	141	−6.292	0.000
Total Pollen	40	101	0	141	−5.694	0.000

H Hirst sampler, C Coriolis sampler. Results are regarded significant at $p < 0.05$

Table 3 Spearman rank correlation test between Hirst and Coriolis pollen data and meteorological variables in (a) Córdoba (b) Évora

	Mean T°		Rainfall		Humidity	
	Hirst	Coriolis	Hirst	Coriolis	Hirst	Coriolis
(a)						
<i>Cupressus</i>	0.851**	0.700*	−0.171	−0.574	−0.766**	−0.343
<i>Olea</i>	0.596*	−0.121	−0.799**	−0.498	0.205	−0.656*
<i>Pinus</i>	−0.600	−0.667	−0.354	−0.544	−0.036	0.000
<i>Platanus</i>	−0.050	0.080	−0.069	0.294	−0.202	0.295
Poaceae	0.413**	−0.208	−0.205	−0.147	0.010	−0.302*
<i>Quercus</i>	0.317*	0.016	0.205	0.080	−0.135	−0.401*
<i>Urtica urens-Parietaria</i>	0.407**	0.223	−0.177	0.058	−0.487	−0.163
<i>Urtica membranaceae</i>	0.127	1.00**	−0.315	−0.632	−0.293	−0.800
(b)						
<i>Cupressus</i>	0.644*	0.298	−0.480	−0.574	−0.134	−0.343
<i>Olea</i>	0.505*	0.427*	−0.508*	−0.498	−0.503*	−0.656*
<i>Pinus</i>	0.000	−0.358*	−0.161	−0.544	−0.037	0.000
<i>Platanus</i>	0.311	0.395	—	0.294	0.190	0.295
Poaceae	0.674**	0.689**	−0.421**	−0.147	−0.442**	−0.302*
<i>Quercus</i>	0.207	0.345*	−0.308*	0.080	−0.288*	−0.401*
<i>Urtica urens-Parietaria</i>	0.703**	−0.157	−0.372**	0.058	−0.478**	−0.163
<i>Urtica membranaceae</i>	0.564**	0.360**	−0.473**	−0.632	−0.450*	−0.800

(* Signification to 95%. ** Signification to 99%)

Table 4 Spearman correlation between Hirst and Coriolis pollen curves

Pollen type	Córdoba	Évora
<i>Cupressus</i>	0.760**	0.789**
<i>Olea</i>	0.761**	0.738**
<i>Pinus</i>	0.792**	0.442**
<i>Platanus</i>	0.937**	0.603**
<i>Poaceae</i>	0.711**	0.736**
<i>Quercus</i>	0.564**	0.773**
<i>Urtica urens-Parietaria</i>	0.461**	0.385**
<i>Urtica membranaceae</i>	0.565**	0.656**
Total pollen	0.638**	0.528**

* Signification to 95%; ** Signification to 99%

differences in weather conditions between France and the southern Iberian Peninsula; higher temperatures in the latter, overall during late spring and summer might lead a decrease in pollen detection by the Coriolis sampler, which would account in these periods for lower counts of taxa such as *Olea* or *Poaceae*. Nevertheless, a clear advantage of the Coriolis δ sampler is that it uses an innovative method, delivering a liquid sample into a single vial. This enables analysis by several techniques including visual analysis, serological assay (ELISA) and even PCR. ELISA analysis of the airborne allergen load cannot be ignored by either aerobiologists or allergists. Although it was shown some years ago that the proteins responsible for pollinosis are released from pollen particles of different sizes (Rantio-Lehtimäki et al. 1994), recent studies suggest that allergy-prompting proteins appear in the atmosphere before the pollen season starts and remain for several weeks after the pollen season is over (De Linares et al. 2007; Gómez-Domenech et al. 2008).

The results obtained here suggest that further research is required to enhance air-quality assessment capacity, taking advantage of the ability of the Coriolis sampler to provide pollen and spore data together with information on allergenicity levels in

the air by combining visual and serological assay methods.

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