

AIRBORNE POLLEN CALENDAR OF CAXIAS DO SUL (RIO GRANDE DO SUL, BRAZIL), 2001-2002

Contenido polínico de la atmósfera de Caxias do Sul (Rio Grande do Sul, Brasil) 2001-2002

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RESUMEN: El análisis de la concentración de polen en la atmósfera de Caxias do Sul fue realizado durante los años 2001 y 2002 usando un captador volumétrico de succión tipo Hirst. Durante el periodo de estudio se han identificado 40 tipos polínicos diferentes. Los 18 siguientes constituyen el 97% del contenido de polen total y el calendario polínico: *Amaranthus*, *Araucaria*, Asteraceae, *Carya*, Cupressaceae, Cyperaceae, *Ligustrum*, Melastomataceae, *Mimosa scabrella*, *Myrsine*, Myrtaceae, Pinaceae, *Plantago*, Poaceae, *Ricinus*, *Rumex*, *Sorocea* y Urticaceae. Las mayores concentraciones polínicas se registran durante los meses de invierno y primavera.

PALABRAS CLAVE: aeropalinología, calendario polínico, Caxias do Sul, Brazil.

SUMMARY: The pollen concentration in the atmosphere of Caxias do Sul was studied using the volumetric suction Hirst-type sampler (*Burkard*® model), during 2001 and 2002. During the study period, 40 pollen types were identified and 18 of these were selected to compose the Pollen Calendar: *Amaranthus*, *Araucaria*, Asteraceae, *Carya*, Cupressaceae,

Cyperaceae, *Ligustrum*, Melastomataceae, *Mimosa scabrella*, *Myrsine*, Myrtaceae, Pinaceae, *Plantago*, Poaceae, *Ricinus*, *Rumex*, *Sorocea* and Urticaceae, which account for 97% of the total pollen content. Clearly distinct pollen seasons were observed, with the highest concentrations of pollen grains in winter and spring.

KEY WORDS: aeropalynology, pollen calendar, Caxias do Sul, Brazil.

INTRODUCTION

The city of Caxias do Sul is located between 51°17' West and 29°16' South (Fig. 1), at an altitude between 760 and 800 m above sea level and a physical area of 1,588.4 km². The population is about 396,261 habitants.

The city has a Tropical Pluvial bioclimate (RIVAS-MARTÍNEZ *et al.*, 2002). As for the meteorological factors, the annual mean temperature is about 15.9 °C, the annual mean precipitation is 1,821 mm/year and the relative humidity ranges from 75% to 85%.

In Caxias do Sul there are three distinct types of vegetation: the mixed shadow forest, the savanna and the deciduous forest. The mixed shadow forest, also known as Araucaria forest, is the largest formation of the study zone, and is characterized by the presence mainly of *Araucaria angustifolia*, as well as *Campomanesia xanthocarpa*, *Ilex paraguariensis*, *Nectandra lanceolata*, *Ocotea porosa*, *Schinus terebinthifolius*, *Sebastiania commersoniana*, *Sorocea bonplandii*, among others. The savanna tends to undergo an invasion by the Araucaria forest because of the high rate of rainfall, and is mainly characterized by the presence of species of Poaceae and Asteraceae. In the deciduous forest

we find *Parapiptadenia rigida*, *Luehea divaricata*, *Myrocarpus frondosus*, *Cabralea canjerana*, *Patagonula americana*, which tend to invade the Araucaria forest.

The main species of trees in the streets of this city are *Acer palmatum*, *Allophylus edulis*, *Brunfelsia uniflora*, *Cupressus lusitanica*, *Cryptomeria japonica*, *Eugenia uniflora*, *Jacaranda mimosifolia*, *Lagerstroemia indica*, *Ligustrum japonicum*, *Platanus occidentalis*, *Tabebuia chysotricha*, *Tibouchina sellowiana*, among others.

Therefore, the observation of the main species' pollen season present in the study area is important from a biological perspective as well as from the point of view of health, since many species may contain allergenic properties that may cause allergic symptoms in the population.

The main aim of this study is to establish the pollen calendar of the study zone to obtain information about the pollen concentration of this region in different seasons of the year and the periods of highest allergenic potential for the people sensitive to pollinosis, which represent approximately 4.8% of the population of the city of Caxias do Sul (VIEIRA & NEGREIROS, 1989).

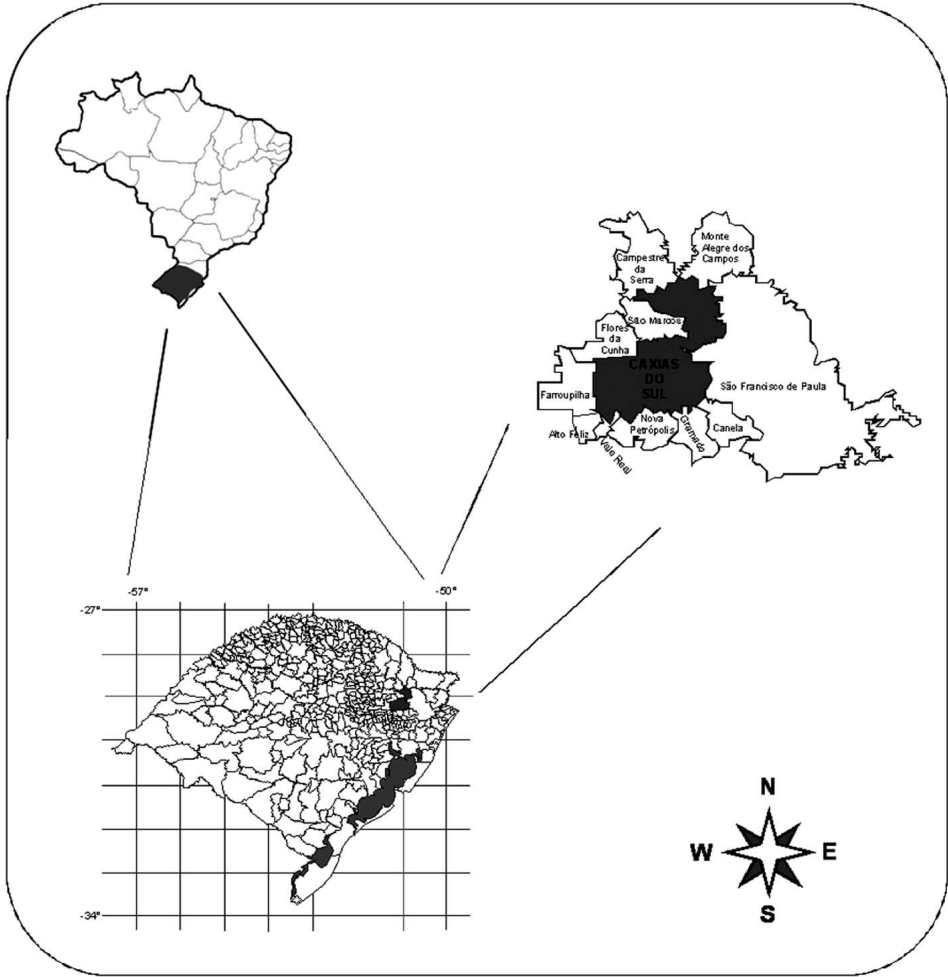


FIGURE 1. Location of Caxias do Sul city in Rio Grande do Sul, Brazil.

MATERIALS AND METHODS

The pollen monitoring in the city of Caxias do Sul was performed from January 1st 2001 to December 31st 2002.

To obtain the airborne pollen samples a Hirst type (HIRST, 1952) volumetric sampler (*Burkard*®) was used, placed on the top of the roof of the University Hospital, in a urban perimeter, about 20 m above ground level, in

an open space without nearby obstacles that could interrupt the air current.

The sampler keeps a constant entrance of air of 10L/min, which falls upon a capturing surface (melinex ribbon) with silicon, where the airborne particles, including the pollen grains, are fixed. This ribbon is replaced once a week and then cut into seven pieces corresponding to the seven days of the week. Later, the slides were analyzed with a *Leica DMLS* optical microscope following DOMÍNGUEZ VILCHES *et al.* (1992). The pollen concentration was expressed as the average number of pollen grains per day per cubic meter of air.

The pollen identification was based on a reference collection made with fresh or herbarium material of the region, in addition to specialized bibliography (BARHT & BARBOSA, 1972; BARHT, 1976; GRANT SMITH, 1984, 1986; VALDÉS *et al.*, 1987; MOORE *et al.*, 1991; PIRE *et al.*, 1998; BARHT & PINTO DA CRUZ, 2000).

The 18 pollen types with percentages of 0.5% or more in relation to the total in anyone of the two years of study were selected to compose the Pollen Calendar.

RESULTS

In this study 40 pollen types were identified in the total of 30,469 pollen grains registered. The highest concentrations were registered in 2001, totalizing 16,221 pollen grains. In 2002, 14,248 pollen grains were totalized. Considering the total pollen content, the tree/shrub group represented 76.76% and the

herbaceous group 23.22% (among them, 19.07% corresponded to Poaceae pollen type).

During the two study years, the presence of pollen grains in the atmosphere of Caxias do Sul was observed every week (Fig. 2). The summer (January) began in both years with an average weekly concentration lower than 45 grains of pollen. After that, this value decreased until weeks 12 or 13 (March). A small increase in the pollen concentration in the atmosphere occurred in week 16 (April), and the concentration then decreased again, registering the lowest concentration of the period between weeks 18 and 26 (May and June). The amount of pollen increased during the winter (July and August), between weeks 31 and 35. From weeks 36 to 39 a small reduction was observed, and when the spring began (October), the pollen concentration in the atmosphere increased, registering the highest mean concentration of the study period (weeks 40 and 44). Between weeks 45 and 48 (November), the pollen concentration decreased slightly and in the last weeks of the year, the pollen quantities decreased again, coinciding with the end of the spring (December) and beginning of the summer (Fig. 2).

The 18 pollen types which presented the highest incidence of pollen grains in the atmosphere of Caxias do Sul and constitute the Pollen Calendar corresponded to 97% of the total pollen content. The order of importance is the following: Poaceae, *Mimosa scabrella*, Urticaceae, Myrtaceae, Cupressaceae, *Myrsine*, *Sorocea*, Pinaceae, Astera-ceae, *Ricinus*, Cyperaceae, *Araucaria*,

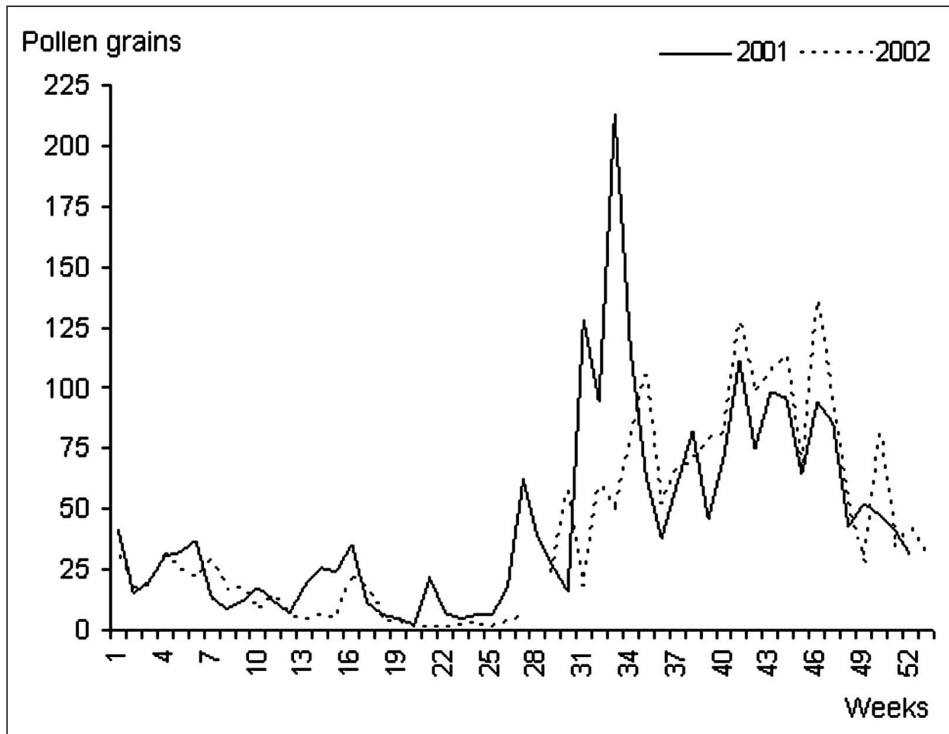


FIGURE 2. Average weekly pollen concentration during the years 2001 and 2002.

Plantago, *Ligustrum*, Melastomataceae, *Amaranthus*, *Rumex* and *Carya* (Fig. 3).

Poaceae pollen type was registered in all months, practically every week, in the two years of the study, presenting the highest incidence in the spring and summer, being weeks 41 and 47, in 2001, the peaks. The annual total number was higher in 2001 (3,269 pollen grains) than in 2002 (2,543 pollen grains). It occupied the first place in the spectrum of atmospheric pollen of the city (Tab. 1, Fig. 4).

The highest incidence of *Mimosa scabrella* occurred in the winter, with the highest concentrations observed in weeks 31 to 35 (August) in both years. The total number of pollen grains varied considerably between 2001 and 2002, being almost twice higher in the first year. It occupied the second place in the city's pollen spectrum (Tab. 1, Fig. 4).

The highest pollen concentrations of Urticaceae were found during the spring and summer in the period of study. The highest quantities of this pollen type were registered in the weeks between

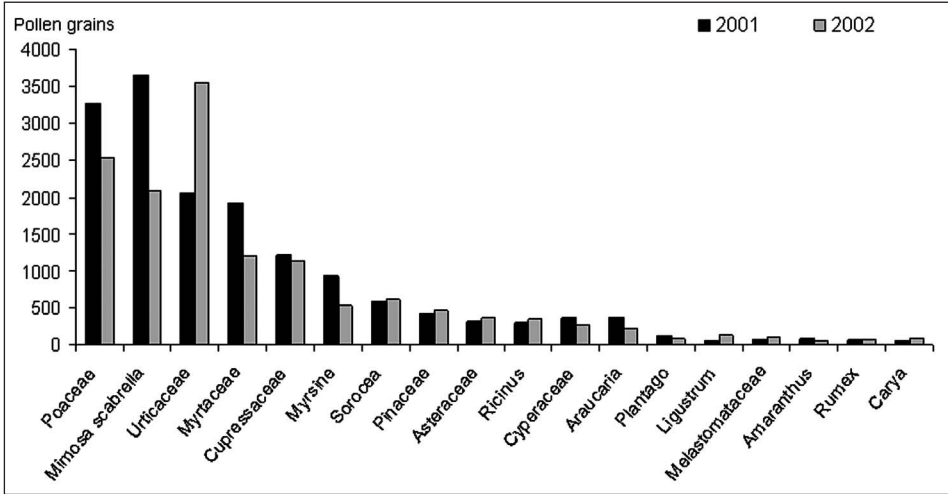


FIGURE 3. The pollen concentration of the 18 pollen types the higher incidence in atmosphere of Caxias do Sul (2001-2002).

44 and 46 in 2001 and between 41 and 47 in 2002. In the second study year, the annual total number was significantly higher (Tab. 1, Fig. 4).

The pollen type Myrtaceae was found in the atmosphere of Caxias do Sul during nearly the whole year, with the highest pollen concentrations between weeks 37 and 44. In both study years, the peak occurred in week 40, and the annual total number in 2001 was higher than in 2002 (Tab. 1, Fig. 4).

The pollen type Cupressaceae has a winter nature, and occurred in its highest concentration between weeks 27 and 33 (July and August). The annual total number was very similar in the two years, but the maximum was registered in different weeks (Tab. 1, Fig. 4).

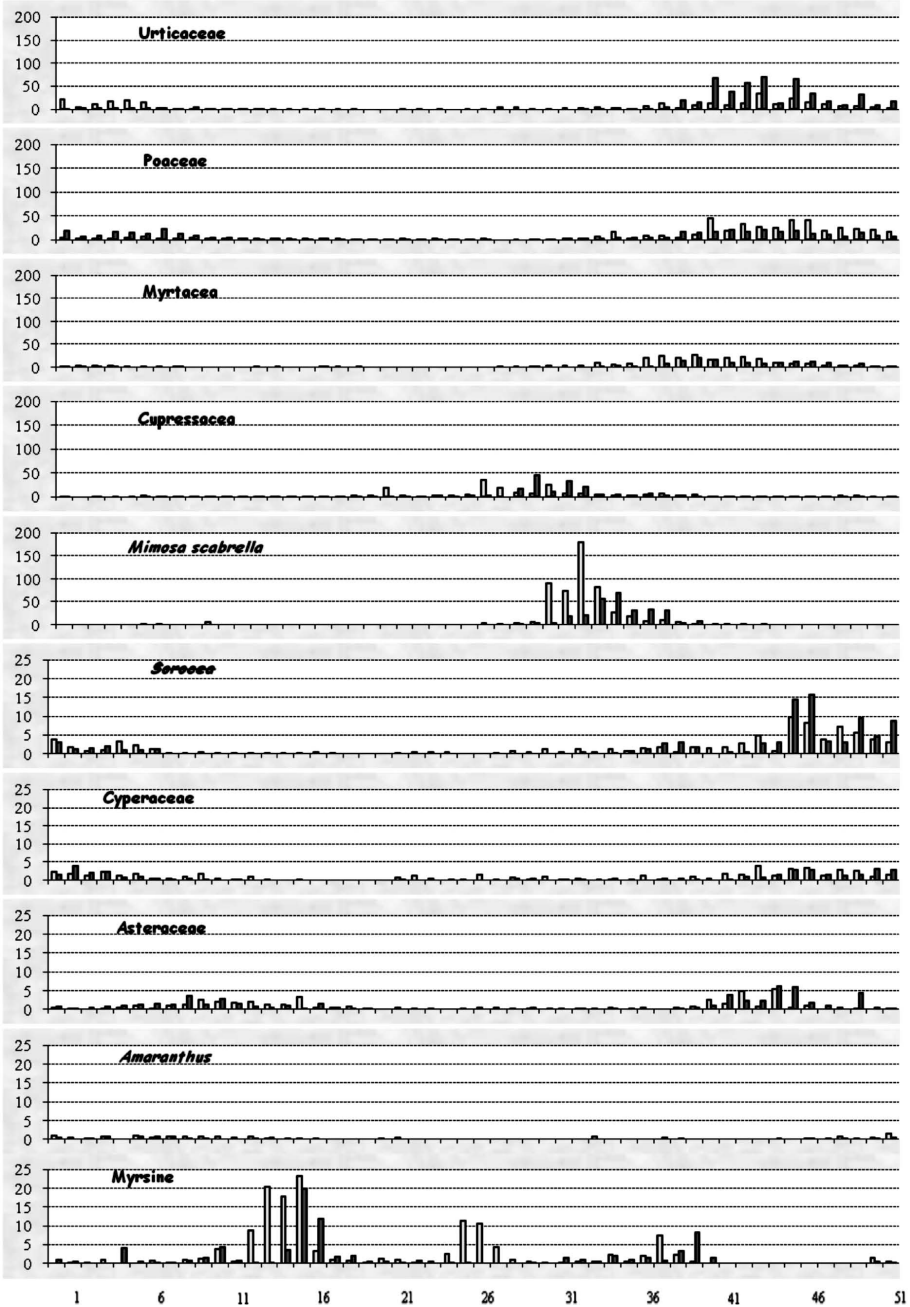
The *Myrsine* pollen type occurred in the atmosphere of the city with many oscillations, being more constant in the autumn. The annual total number of the two years was much higher in 2001, and the highest pollen concentration was registered in weeks 14 to 16 in 2001 and 16 and 17 in 2002 (Tab. 1, Fig. 4).

The pollen type *Sorocea* was found mainly in the spring and summer and the highest concentrations were registered in weeks 46 and 47 in both study years. The annual total number was higher in 2002 than 2001 (Tab. 1, Fig. 4).

The pollen type Pinaceae was found in its highest concentrations in the winter, in weeks 27 to 37. This pollen type did not present a significant difference between the annual concentration in 2001 and 2002 (Tab. 1, Fig. 4).

Taxa	Year	Total pollen collected	Peak day	Concentration in a peak day	Peak month
<i>Amaranthus</i>	2001	90	27/12	5	Mar
	2002	49	10/02	2	Feb
<i>Araucaria</i>	2001	361	14/10	35	Oct
	2002	208	13/10	35	Oct
Asteraceae	2001	313	08/11	20	Oct
	2002	361	13/11	20	Nov
<i>Carya</i>	2001	44	11/11	5	Nov
	2002	83	12/11	8	Nov
Cupressaceae	2001	1215	26/05	75	Jul
	2002	1132	25/07	198	Jul
Cyperaceae	2001	362	30/10	10	Nov
	2002	268	29/12	9	Jan
<i>Ligustrum</i>	2001	53	01/01	14	Jan
	2002	126	16/03	12	Oct
Melastomataceae	2001	70	26/09	5	Sep
	2002	98	30/12	6	Dec
<i>Mimosa scabrella</i>	2001	3656	17/08	399	Aug
	2002	2087	28/08	179	Aug
<i>Myrsine</i>	2001	937	22/04	56	Apr
	2002	539	16/04	64	Apr
Myrtaceae	2001	1930	23/09	65	Oct
	2002	1190	03/10	50	Oct
Pinaceae	2001	410	18/08	28	Aug
	2002	464	27/08	39	Aug
<i>Plantago</i>	2001	113	27/11	4	Nov
	2002	88	17/12	5	Oct
Poaceae	2001	3269	08/10	104	Nov
	2002	2543	14/02	55	Nov
<i>Ricinus</i>	2001	296	22/10	28	Oct
	2002	346	07/11	20	Sep
<i>Rumex</i>	2001	67	03/10	4	Oct
	2002	71	13/10	4	Oct
<i>Sorocea</i>	2001	577	17/11	32	Dec
	2002	613	19/11	33	Nov
Urticaceae	2001	2066	03/11	92	Nov
	2002	3554	28/11	259	Oct

TABLE 1. Values characterizing pollen of 18 selected pollen types in Caxias do Sul in 2001-2002.



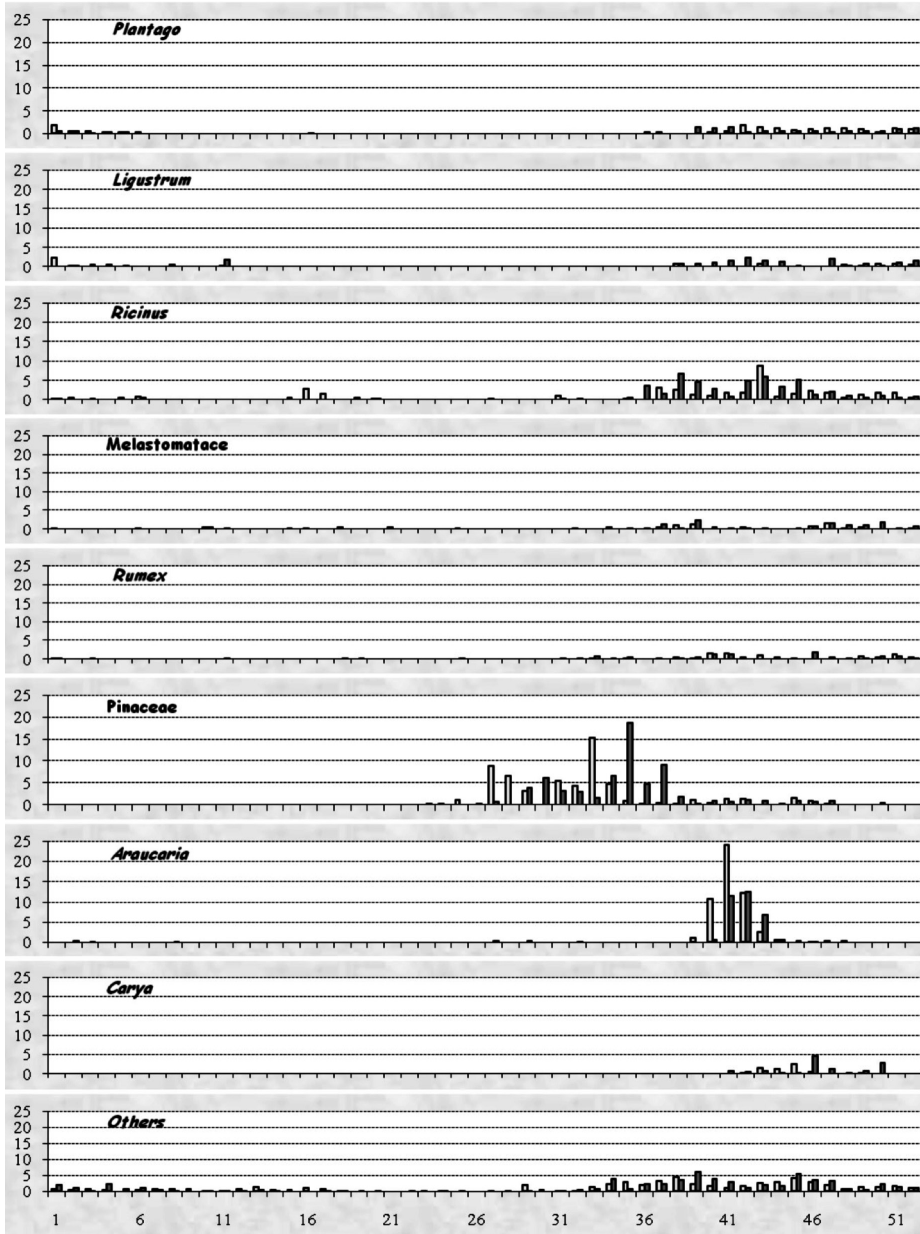


FIGURE 4. Pollen calendar of the city of Caxias do Sul, 2001-2002. . . 2001 2002

The pollen of the Asteraceae family was found in the atmosphere practically during the whole year. The highest pollen concentration of this family occurred in the spring and in the end of the summer, in weeks 43 and 45 in 2001 and in weeks 45 and 46 in 2002. The annual total number was similar in both study years (Tab. 1, Fig. 4).

The *Ricinus* pollen type presented its highest concentrations in the end of the winter and in the spring, in weeks 43 of 2001 and 38 of 2002 (Tab. 1, Fig. 4).

The Cyperaceae family is present in the city pollen spectrum during nearly the whole year. The highest concentrations were registered between weeks 44 and 47 in 2001 and in weeks 2, 46, 47, 51 and 52 in 2002. The highest concentration of this pollen type was registered in 2001 (Tab. 1, Fig. 4).

The *Araucaria* pollen had its highest incidence in the city atmosphere in 2001, with the highest concentrations between weeks 40 and 43 (October) in both study years. The presence of these pollen grains in the atmosphere is limited to a very short period (Tab. 1, Fig. 4).

Plantago presented its highest pollen concentration mainly in the spring and summer, with the highest concentrations in weeks 1 and 42 in 2001, and 39 to 41 in 2002. The difference in the annual total number in the two years of study was not significant (Tab. 1, Fig. 4).

The pollen type *Ligustrum* was registered in the spring and summer, and the highest incidence of this pollen type in 2001 occurred in the first week, and in 2002 in weeks 41 to 44. The pollen number registered in 2002 was twice as high as in 2001 (Tab. 1, Fig. 4).

The Melastomataceae family presented low concentrations during the study period. The maximum concentration was registered in week 47 in 2001 and in weeks 39 and 50 in 2002, and the difference in the annual total number was not significant (Tab. 1, Fig. 4).

The *Amaranthus* pollen type did not present important concentrations during the two study years. It presented a pollination period during spring and summer, and the mean of pollen grains registered in the period was from low to moderate. The maximum concentration in 2001 occurred in weeks 1, 6, 13 and 52, and in 2002 in week 8 (Tab. 1, Fig. 4).

The permanence of the *Rumex* pollen type in the atmosphere of Caxias do Sul was mainly during the spring, with a low incidence. The annual total number was similar in both study years, with the highest incidence in weeks 40 and 41 in 2001, and in week 46 in 2002 (Tab. 1, Fig. 4).

The *Carya* pollen season began around week 41 and lasted until week 50. In the second study year, the annual total number was twice the one in the first. Week 46 in 2002 registered the highest concentration of this pollen type (Tab. 1, Fig. 4).

Other pollen types not included in Table 1 presented small atmospheric concentrations of less than 0.5% of the annual total pollen and their annual total concentrations were between 20 and 70 grains of pollen. These are: Meliaceae, *Podocarpus*, Iridaceae, *Castanea*, *Acacia*, Verbenaceae, *Platanus*, Brassicaceae, *Justicia*, Solanaceae and Rutaceae, in order of incidence. Finally,

the remaining pollen types were found only sporadically in the atmosphere, and their concentration did not attain 20 pollen grains during the study period.

DISCUSSION

The pollen results provide a direct and synthetic view of the vegetation of the city of Caxias do Sul and its surroundings. In general, the image of the current vegetation obtained from the analysis of the pollen spectrum is that of a set where the communities of grasses and rudimental species, besides the forest areas and the ornamental flora, are plentiful.

In the results, 40 types of pollen grains were identified in the pollen spectrum of the atmosphere of Caxias do Sul, out of which 18 constitute the pollen Calendar due to their concentration level. Data registered by HILGERT (1998) report 12 pollen types during the sampling period (from May to November), 8 of them belong to the pollen types of tree and shrub taxa. In this study 29 pollen types have been registered in this group, corresponding on average to the triple of the pollen of the herbaceous taxa, 11 in the pollen calendar. However, the number is very different, possibly due to the methodology used and to the duration of the sampling period. It was the pollen of the tree-shrub category that predominated in both studies, highlighting the diversity of plants of the tree-shrub size in this region (VERGAMINI *et al.*, 2006). In other Brazilian cities such as Rio de Janeiro (OLIVEIRA LIMA & GRECO, 1942a), Belo Horizonte (OLIVEIRA LIMA

& GRECO, 1942b) and Curitiba (SEABRA *et al.*, 1961; ROSÁRIO FILHO, 1983) the diversity was lower, mainly due to the different bio-climatic differences of these cities, situated farther north in Brazil and where the annual humidity is very high and plants with entomophily pollination predominate.

In South America, according to the studies consulted, the city of Santiago, Chile, presented the greatest variety of pollen types, with 103 (ROJA VILLEGAS & ROURE NOLLA, 2001), maybe due to a greater variety of vegetation in that city.

On the other hand, in the cities of La Plata and Buenos Aires, only approximately half the number of distinct pollen types have been registered in each one of these groups (NOETINGER, 1993; NITIU & ROMERO, 2001). GATTUSO *et al.* (2003) found, in the city of Rosario, Argentina, 24 pollen types pertaining to cultivated plants of tree-shrub size. In our analyses of the 29 types, 10 were from plants that are found in the streets of that city.

The total annual pollen concentration of the city of Caxias do Sul did not present a great variation in the two study years (16,221 pollen grains in 2001 and 14,248 pollen grains in 2002). These values are higher than those registered in other aeropalynological studies focusing on other Brazilian cities: Porto Alegre, Rio de Janeiro, Belo Horizonte, and Curitiba (OLIVEIRA LIMA & GRECO, 1942a,b; BERND & OLIVEIRA LIMA, 1951; SEABRA *et al.*, 1961; ROSÁRIO FILHO, 1983), due to different aspects: on one hand, the different methodologies, especially because of the use of distinct collection methods and the duration of the collections, and on the other hand, it may also

be a consequence of the differences in climatic conditions.

When analyzing the dynamics of the pollen in the atmosphere of the city of Caxias do Sul, the existence of seasonal rhythms is clearly visible as the maximum pollen concentrations are registered in the winter (July and August). In winter the temperatures are low and there is occasional frost, and most of the vegetation is in a vegetative state, but there is a dominance of pollen grains of tree and shrub taxa, especially in the month of August when the *Mimosa scabrella*, *Cupressaceae* and *Pinaceae* predominate. The aeropalynological studies carried out in Buenos Aires (MAJAS & ROMERO, 1992; NOETINGER, 1993; NOETINGER & ROMERO, 1997) and in Santiago (ROJAS VILLEGAS & ROURE NOLLA, 2001) confirm the same winter period for their pollination. Undoubtedly, in these cities, the pollen type *Mimosa scabrella* appears in a very small concentration. This is not what happens in Caxias do Sul, where it ranks third in the pollen spectrum. This may be due to the fact that it is a plant that forms part of the open woods that surround the city and no specific edafic conditions are required.

In spring, in the month of November, the pollen concentration is very high because a large number of herbaceous plants bloom, such as: *Poaceae*, *Cyperaceae*, *Plantago*, *Amaranthus*, *Rumex*, and also tree and shrub taxa, such as *Urticaceae*, *Myrtaceae*, *Sorocea*, *Ricinus*, *Araucaria* and *Carya*. Out of all of these, the pollen concentration of the *Poaceae* family was one of the highest in the atmosphere of this city. The difference in the quantities registered in the

two years analyzed is a result of a higher precipitation in 2001. In other Brazilian cities such as Brasilia, São Paulo, Rio de Janeiro, Belo Horizonte, Florianópolis and Curitiba, the *Poaceae* pollen season was during the months of May, June, and October (OLIVEIRA LIMA & GRECO, 1942a,b; MENDES *et al.*, 1958; CARDOSO, 1975; MELHEM & MAKINO, 1978; ROSÁRIO FILHO, 1983; PAUL *et al.*, 2000), leading to the assumption that they are distinct species with a different blooming period and also because of the different climate of these cities. However, in other cities of South America such as Buenos Aires, Mar del Plata, Montevideo, and Santiago, the predominance of *Poaceae* pollen grains was during the same month as in Caxias do Sul. The high quantities of *Myrtaceae* pollen registered in this study are due to the great number of trees of this family that are found in the urban vegetation near the collector. *Araucaria angustifolia* is a tree typical of southern Brazil forming woods in the regions near the city, explaining its incidence in the pollen spectrum. The *Moraceae* family is mentioned in studies carried out in other cities in South America, but the pollen type *Sorocea* had not been mentioned in any previous studies. On the whole, similar results have been observed in Argentina, in the cities of Mar del Plata (LATORRE & PÉREZ, 1997), Posadas (PAUL *et al.*, 2000), La Plata (NITIU & ROMERO, 2001), Buenos Aires (NITIU *et al.*, 2003), Rosario (GATTUSO *et al.*, 2003), and in Chile, in the city of Santiago (ROJAS VILLEGAS & ROURE NOLLA, 2001). Another pollen type found in the atmosphere of Caxias do Sul during the collection years is the *Carya*, a taxon growing in

the surroundings of the collector. Its pollination period is short, in the spring months. No registers of studies citing this pollen type have been found in Brazil. Similar results with regard to incidence and monthly concentration were found in Argentina (MAJAS & ROMERO, 1992; NOETINGER, 1993; LATORRE & PÉREZ, 1997; PÉREZ & PÁEZ, 1998).

The minimum concentrations are registered in the periods of summer and fall. Among the 18 most important pollen types in the atmosphere of the city of Caxias do Sul, we point out the pollen type *Myrsine* with a blooming period that lasts almost the whole year round and which presents many oscillations in the collection period, registering higher concentrations in April. The species *Myrsine ferruginea* is one of the most important in the city and its blooming period is in the months of March and April. Therefore, the dominant presence of this pollen in the atmosphere in the fall is considered abnormal. No explanation for this fact has been found yet, so this behavior will have to be studied in further studies. In the bibliography concerning South America, we found registers of this pollen type in the study by TEJERA & BERI (2002), for one year, in Montevideo, Uruguay, using a Rotorod apparatus. The pollen types Asteraceae and Melastomataceae did not have a dominant pollen season.

These patterns of seasonal behavior comprising the pollen calendar of

Caxias do Sul are similar to the studies of pollen concentration in the months of May through November 1995 carried out in that city by HILGERT (1998). The results obtained also partly corroborate the study by VIEIRA & NEGREIROS (1989) mentioning the months of September through November as the period of allergic symptoms, evidencing a clearly defined pollen season during the year.

The data obtained in this study confirm, to a great extent, the studies carried out in Buenos Aires (NITIU *et al.*, 2003), Mar del Plata (LATORRE & PÉREZ, 1997), La Plata (NITIU & ROMERO, 2001), Rosario (GATTUSO *et al.*, 2003), and Posadas (PAUL *et al.*, 2000). The first four cities present a temperate oceanic climate granting them seasonality similar to that found in many temperate regions of the northern hemisphere. However, even though Caxias do Sul and Posadas are tropical cities, the seasonality reflected in the annual pollen concentration is due to the pluvial character of their bioclimate. These results do not coincide with BERND & OLIVEIRA LIMA's data (1951), especially those about the South of the country, which emphasize, in a uniform way, that there is not a defined pollen season in Brazil. This generic statement does not apply in the states of the extreme South, which have a severe winter followed by an exuberant spring, as in the case of Caxias do Sul.

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