Bot. Bull. Acad. Sin. (2005) **46:** 53-59

Airborne pollen spectra at three sites in inland Croatia, 2003

Renata PETERNEL[1], Josip ČULIG[1], Božena MITIĆ[2], Ivana HRGA[1], and Ivan VUKUŠIĆ[1]

[1]*Research Department, Zagreb Institute of Public Health, Mirogojska 16, HR-1000 Zagreb, Croatia, Europe*

[2]*Department of Botany, School of Science, University of Zagreb, Zagreb, Croatia*

(Received January 5, 2004; Accepted August 13, 2004)

Abstract. The aim of this study was to determine whether there were major differences in the seasonal incidence and abundance of pollen grains and pollen types in pollen fall between sites of different land use. The material was collected from 5 January until 20 December 2003 at three sites in central Croatia. The sampling sites were located in an average urban setting (Zagreb), a rural setting (Ivanić Grad), and a small town surrounded by a large woodland with partially thermophilic vegetation (Samobor). Using the volumetric method of pollen collection, pollen grains of 35-37 taxa were identified, depending on the sampling site, eight of them producing the greatest amount of pollen (*Alnus* sp., *Ambrosia* sp., *Betula* sp., *Carpinus* sp., Poaceae, *Quercus* sp., *Taxus/Juniperus*, and Urticaceae). Differences among the sampling sites were recorded according to seasonal pollen concentration, total monthly pollen count, and total annual pollen count. The proportion of particular plant classes (tree, grass and weed) was quite comparable among the three sampling sites because of their relative geographic proximity (i.e. within the same climatic region). A difference was observed in the air pollen concentration. All three monitoring sites revealed the total annual airborne pollen concentration in inland Croatia to be dominated by highly allergenic pollen (Zagreb 54%, Samobor 58% and Ivanić Grad 82%) of the following taxa: *Alnus* sp., *Ambrosi*a sp., *Betula* sp., *Carpinus* sp., *Corylus* sp., Poaceae, Urticaceae and *Artemisia* sp. Accordingly, there were no distinct phenologically induced differences in pollen species recorded at the three monitoring sites. However, substantial differences were observed in seasonal pollen grain count and in the percentage proportion of some allergenic pollen grains (*Ambrosia* sp., *Betula* sp., *Carpinus* sp., Poaceae), providing valuable information to individuals suffering from pollen allergy.

Keywords: Aerobiology; Central Croatia; Pollen grain; Volumetric method.

Introduction

At present, pollen is definitely one of the most potent known allergens. The number of individuals allergic to plant pollen has been steadily increasing, especially in large cities and industrial areas (Hofman and Michalik, 1998; Nilson and Persson, 1981; Obtulowicz et al., 1996). Allergenic plants are characteristic of particular areas, depending on geographic and climatic region and vegetation. The occurrence of airborne pollen is temporally limited and specific for each plant species. The principal aim of aeropalinological studies is to assess the seasonal appearance of pollen grains in the air, and to make quantitative and qualitative analyses of pollen fall or aeroplankton. Atmospheric pollen has been measured for many years at various locations in Europe. Pollen calendars for particular countries have been published in a number of national or regional pollen atlases (Nilsson et al., 1977; Horak and Jäger, 1979; Stix, 1981; D'Amato, 1984; Driessen et al., 1988). Prediction of the initial occurrence of airborne pollen allows individuals allergic to a particular plant pollen to be informed and to adjust their daily activities so as to avoid contact with the allergens, the most efficient preventive measure.

*Corresponding author. Phone: ++385(0)1-4696-108; Fax: ++385(0)1-4678-002; E-mail: renata.peternel@publichealth-zagreb.hr

Papers published to date on spatial variation in the incidence of pollen refer to distant sites from different climatic regions (Hyde, 1959). Only rarely have aerobiological investigations been carried out at several sites within a small area of diverse land use (Emberlin and Norris-Hill, 1991).

The first research into allergenic pollen distribution in Croatia was launched in 1959 at four locations: Zagreb, Hvar, Crikvenica, and Dubrovnik (Volarić-Mršić, 1972). Using a gravimetric method, data were collected weeky throughout the year. Since 1973, allergenic pollen has been continuously studied in Zagreb (Lovašen-Eberhardt, 1979). Modern aeropalinological investigations using daily volumetric monitoring of atmospheric pollen began in Croatia in 2002 (Peternel et al., 2003).

The data presented here were obtained during a one-year study conducted at three sites in inland Croatia. Our aim was to determine whether there were any major differences in seasonal occurrence or in abundance of pollen grains and pollen types in pollen fall among the sites of different land use.

Materials and Methods

Material was collected at three sites in central Croatia from 5 January to 20 December 2003. Pollen sampling and floristic research were both conducted. Pollen sampling

was done by use of 7-day Hirst volumetric pollen and spore traps. The samplers were placed in Zagreb (45°49' N and 15°59' E, 157 m above sea level and 19.7 m above ground level), Ivanić Grad (45°43' N and 16°24' E, 101 m above sea level and 18.5 m above ground level), and Samobor (45° 48' N and 15°43' E, 168 m above sea level and 17.3 m above ground level). The distance between measuring sites was about 30 km (Figure 1). The sampler absorbs 10 L air *per* min, allowing for determination of pollen concentration at 2-h intervals. It is supplied with a timer which moves adhesive tape (2 mm/h) to which pollen grains adhere. The tape was removed twice weekly, cut to a length corresponding to 24-h pollen sampling, applied onto a glass slide, and embedded in the following medium: 70 g polyvinyl alcohol (Gelvatol) and 4 g phenol C_6H_6O, dissolved in 200 mL of distilled water. After resting overnight, 100 mL glycerol $C_3H_8O_3$ was added and warmed up in water bath until the solution turned liquid and clear. Then, 4 drops of alcohol solution of basic fuchsin $C_{20}H_{20}CIN_3$ *per* 100 mL were added. Samples were examined under a light microscope, magnification x400, to determine pollen type and count *per* 1 m^3 air *per* day. Pollen concentration was expressed as pollen grain count/m^3. Preliminary floristic research included plant collection at all three sites, in the surroundings of pollen samplers. This part of the investigation included standard field studies of autochthonous and cultivated plants (plant collection, botanizing, and data entry in floristic lists), and laboratory plant determination.

Criteria for definition of pollen allerginicity (HAP-highly allergenic pollen, AP-allergenic pollen) are based on results of skin-test positivity (percentage positive reaction in patients with pollinosis) in Europe (Bousquet et al., 1984; D'Amato and Lobefalo, 1989; Spieksma, 1986).

Results and Discussion

Zagreb is situated at the base of Medvednica Mountain, and the composition of airborne pollen there is strongly influenced by the forest vegetation to the north, which consists of the following species: *Acer* sp., *Ulmus glabra* Hudson, *Fraxinus excelsior* L., *Carpinus betulus* L., *Ostrya carpinifolia* L., *Corylus avellana* L., *Fagus silvatica, Quercus petraea* (Mattuschka) Liebl., *Taxus baccata* L., *Abies alba* L. (at higher altitudes), *Castanea sativa* L., various species of the genus Rubus, *Sambucus nigra* L., *Robinia pseudoaccacia* L., and others. Grassy and weedy grounds prevail in rural areas east and south of the city. In these areas, the vegetation consists of a number of ruderal and weedy, wild-growing and adventive plants, primarily from the families Poaceae, Chenopodiaceae, Compositae, Brassicaceae, Urticaceae, Lamiaceae, and Fabaceae. Among the adventive plants, the allergenic species *Ambrosia artemisiifolia* L. and *Artemisia vulgaris* L. are the most widespread. In the urban area along the Sava river, the species *Alnus glutinosa* (L.) Gaertn. and various species of the genera *Salix* and *Populus* prevail. In addition to this more or less natural vegetation, the city has numerous parks containing the following species: *Betula pendula* L., various species of the family Cupressaceae and of the genera *Pinus* and *Picea*, *Aesculus hippocastanum* L., *Platanus hybridus*, *Populus* sp., *Juglans regia* L., and *Tilia* sp.

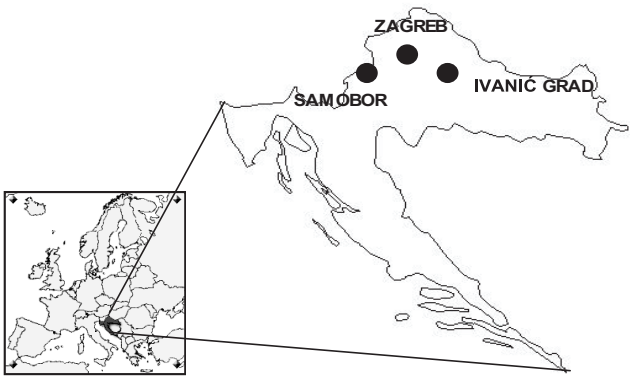

Figure 1. Measuring sites in inland Croatia.

Ivanić Grad is most rural of the three monitoring locations, with a lot of weedy areas. The respective airborne pollen also showed some elements of typical inland forest vegetation. A great impact of ruderal and weedy vegetation was recorded, with numerous species of the families Brassicaceae, Asteraceae, Amarantaceae, Apiaceae, Plantaginaceae, Poaceae, and others. The cultivation also contained some taxa from the family Cupressaceae, then *Betula pendula, Taxus baccata, Pinus, Picea* and *Abies* sp., and *Tilia* sp.

The region of Samobor is surrounded by the Žumberak-Samobor Mountains with large forests around the town and with numerous autochthonous and planted trees also found in it. Airborne pollen is influenced by this forest vegetation, which is dominated by many forest species such as *Acer campestre, A. pseudoplatanus, A. platanoides, Carpinus betulus, Corylus avellana, Fagus silvatica, Quercus petraea, Ulmus glabra, Castanea sativa, Taxus baccata*. In addition, this vegetation also includes a number of species characteristic of a sub-Mediterranean climate. Such a type of vegetation is mostly found on the south mountain slopes and includes woody plants such as *Quercus pubescens, Ostrya carpinifolia* (more common than *Carpinus betulus*), and *Fraxinus ornus*. A small river runs through the town, favoring the growth of woody plants characteristic of humid habitats, with a predominance of the species *Alnus glutinosa* and various species of the genera *Populus* (mostly *P. alba* in lower areas, and *P. tremula* in higher areas) and *Salix* (mostly *S. caprea*). Ruderal and weedy vegetation is less abundant than in the Zagreb area, and here adventive taxa of the families Asteraceae and Poaceae predominate. The city parks and gardens feature a great variety of different taxa (autochthonous and horticultural) of the genera *Pinus, Juniperus/Cupressus, Abies* and *Picea*, then widely planted *Betula pendula, Juglans regia*, and *Tilia* sp.

The highest amount of pollen grains in 2003 was counted in Ivanić Grad (n=53,710), in Zagreb (n=52,521) and lowest in Samobor (n=32,692). The number of identified

pollen taxa was 35 in Zagreb, 36 in Ivanić Grad, and 37 in Samobor. Eight of these taxa produced the greatest amount of pollen (*Alnus* sp., *Ambrosia* sp., *Betula* sp., *Carpinus* sp., Poaceae, *Quercus* sp., *Taxus/Juniperus*, Urticaceae), and nine occurred sporadically or in a small amount (*Aesculus* sp., Asteraceae, *Forsythia* sp., *Ligustrum* sp., *Morus* sp., *Robinia* sp., Rosaceae, *Rumex* sp., Umbelliferae) (Table 1). Monthly pollen concentrations measured at all three monitoring sites in 2003 showed two peaks (in April and August), with between-site differences. In April, pollen concentrations measured at monitoring sites in Zagreb and Samobor exceeded those recorded in Ivanić Grad (Zagreb n=17,846; Samobor n=14,697; and Ivanic Grad n= 9,238). In August, an inverse pattern was observed (Zagreb n=7,561; Samobor n=2,847; and Ivanic Grad n=19,781) (Figure 2). The earliest airborne pollen grains recorded in March originated from the following species: *Alnus* sp., *Corylus* sp., *Fraxinus* sp. and *Taxus/Juniperus*. In April, the number of species increased, with the pollen originating from *Betula* sp. as the most common, accounting for 30.8% in Samobor, 32.6% in Zagreb, and 37.4% in Ivanić

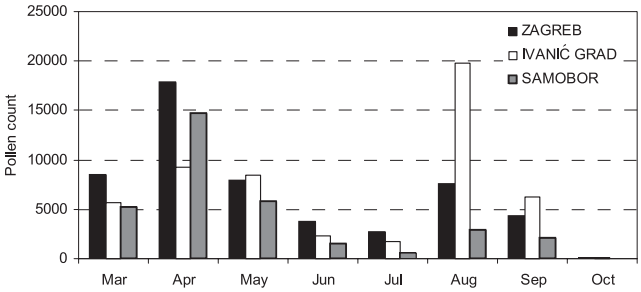

Figure 2. Monthly variation in airborne pollen total count according to measuring sites in inland Croatia, 2003.

Table 1. Total annual pollen counts at measuring sites in inland Croatia, 2003.

	ZAGREB		IVANIĆ GRAD		SAMOBOR	
	n	%	n	%	n	%
Abies sp.	106	0.2	70	0.1	126	0.4
Acer sp.	1,670	3.2	193	0.4	140	0.4
Aesculus sp.	1,733	3.3	6	Sporadically	62	0.2
***Alnus* sp.**	**1,728**	**3.3**	**3,185**	**5.9**	**2,062**	**6.3**
***Ambrosia* sp.**	**9,620**	**18.3**	**24,801**	**46.2**	**4,040**	**12.3**
Artemisia sp.	511	1.0	477	0.9	334	1.0
Asteraceae	56	0.2	95	0.2	8	Sporadically
***Betula* sp.**	**6,195**	**11.8**	**3,559**	**6.6**	**4,580**	**14.0**
Brassicaceae	395	0.8	291	0.5	191	0.6
***Carpinus* sp.**	**2,512**	**4.8**	**2,002**	**3.7**	**3,387**	**10.4**
Castanea sp.	2,198	4.2	526	1.0	924	2.8
Chenopodiaceae	329	0.6	270	0.5	190	0.6
Corylus sp.	1,110	2.1	1,467	2.7	1,184	3.6
Cyperaceae	65	0.2	92	0.2	89	0.3
Fagus sp.	673	1.3	582	1.2	510	1.6
Forsythia sp.	40	0.2	0	0	4	Sporadically
Fraxinus sp.	1,885	3.6	1,041	1.9	1,359	4.2
Juglans sp.	318	0.6	56	0.1	217	0.7
Ligustrum sp.	0	0	4	Sporadically	5	Sporadically
Morus sp.	1,384	2.6	44	0.1	4	Sporadically
Picea sp.	441	0.4	419	0.8	442	1.4
Pinus sp.	378	0.7	261	0.5	120	0.4
Platanus sp.	1,438	2.7	131	0.2	155	0.5
Plantago sp.	465	0.9	483	0.9	303	0.9
Poaceae	**2,711**	**5.2**	**5,732**	**10.7**	**2,918**	**8.9**
Populus sp.	889	1.8	346	0.6	662	2.0
***Quercus* sp.**	**2,576**	**4.9**	**2,546**	**4.7**	**2,335**	**7.1**
Robinia sp.	23	Sporadically	5	Sporadically	7	Sporadically
Rosaceae	344	0.7	39	0.1	9	Sporadically
Rumex sp.	0	0	7	Sporadically	8	Sporadically
Salix sp.	993	1.9	1,246	2.4	1,108	3.4
Sambucus sp.	441	0.8	170	0.3	125	0.4
Taxus/Juniperus	**4,501**	**8.6**	**984**	**1.8**	**4,035**	**12.4**
Tilia sp.	214	0.4	72	0.1	56	0.2
Umbelliferae	16	Sporadically	45	0.1	11	Sporadically
Ulmus sp.	449	0.9	149	0.3	206	0.6
Urticaceae	**4,114**	**7.8**	**2,314**	**4.3**	**776**	**2.4**
TOTAL	**52,521**	**100**	**53,710**	**100**	**32,692**	**100**

Grad. In this month, the pollen from *Quercus* sp. was also found in abundance. In May, plants of the family Poaceae clearly predominated, accounting for 22.9% to 50.3% of total monthly pollen count. In June, pollination of plants from the family Poaceae continued, but the pollen originating from *Castanea* sp. prevailed with 22.0% in Ivanić Grad, 57.9% in Zagreb, and 59.6% in Samobor. In July, the lowest monthly pollen count was recorded at all sampling sites, with a predominance of plants from the family Urticaceae. *Ambrosia* sp., the most allergenic plant of our climate, was in full bloom in August when it accounted for 70.1% to 91.8% of total monthly airborne pollen. This percentage rose further to 95.1%-99% in September. In 2003, the pollen season of the plants of the continental climate terminated in October (Table 2). Classification of plant species into the tree, grass and weed groups revealed exclusively tree airborne pollen to be found in March and April. Then in May and June the grass and weed pollen occurred while an absolute predomonance of weed pollen was recorded in July, August, September, and October. Differences were observed among the monitoring sites according to the tree to grass to weed ratio. In May, a higher proportion of grass pollen was measured at the monitoring sites in Ivanić Grad (50.4%) and Samobor (43.7%) than in Zagreb (23.5%) while in June the proportion of grass pollen was considerably higher in Ivanic Grad (52.8%) than at the other two sampling sites. In August, September, and October, weed pollen predominated at all sampling sites, ranging from 98.6% to 100% (Figure 3). Total annual pollen concentration in the air was strongly dominated by highly allergenic pollen grains at all three sampling sites located in inland Croatia, with a percentage proportion of 54% in Zagreb, 58% in Samobor, and 82% in Ivanic Grad, including pollen of the following taxa: *Alnus* sp., *Ambrosia* sp., *Betula* sp., *Carpinus* sp., *Corylus* sp., Poaceae, Urticaceae and *Artemisia* sp. The percentage proportion of ragweed and grass pollen was highest at the Ivanić Grad sampling site, and that of birch at the Samobor and Zagreb sampling sites (14% and 12%, respectively) (Figure 4).

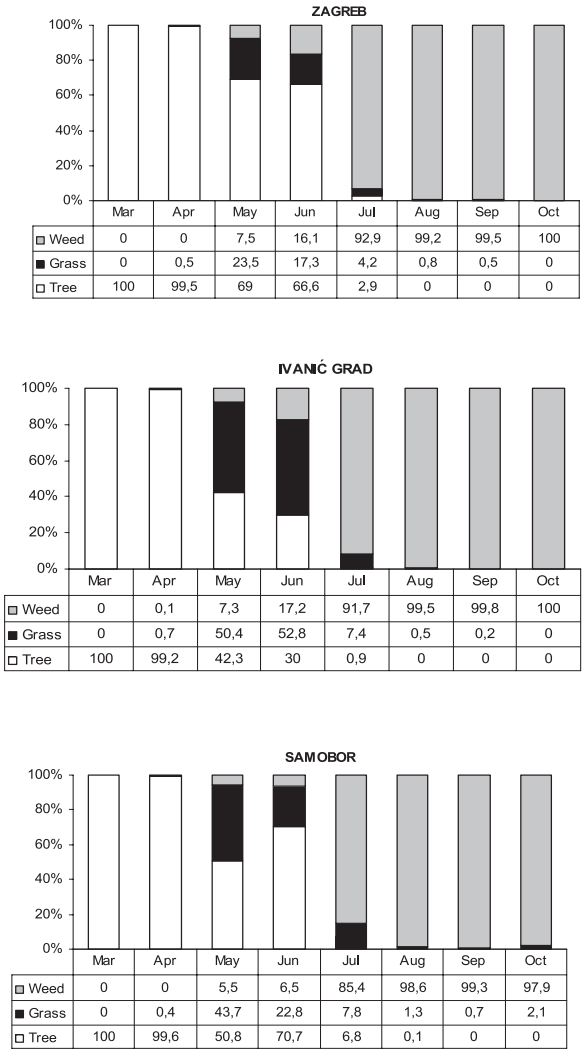

Figure 3. Monthly variation in percentage of tree, grass, and weed airborne pollen in inland Croatia, 2003. Legend: AP, allergenic pollen; HAP, highly allergenic pollen.

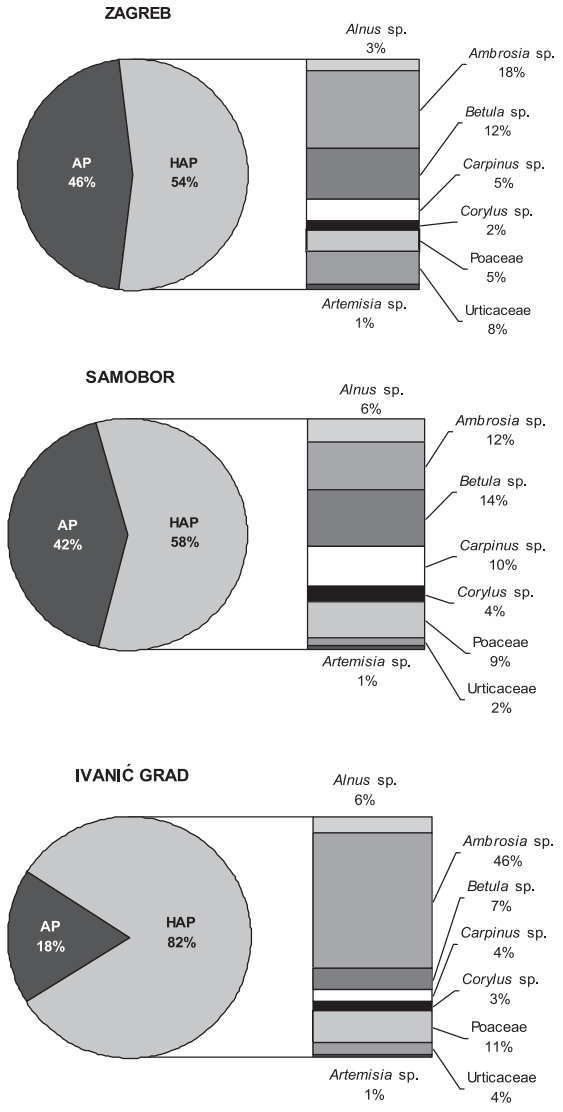

Figure 4. Variation in airborne highly allergenic pollen according to measuring sites in inland Croatia, 2003.

Table 2. Monthly pattern of airborne pollen (%) in inland Croatia, 2003.

	Mar			Apr			May			Jun			Jul			Aug			Sep			Oct		
	Z	I.G.	S	Z	I.G.	S	Z	I.G.	S	Z	I.G.	S	Z	I.G.	S	Z	I.G.	S	Z	I.G.	S	Z	I.G.	S
Abies sp.	-	-	-	spo	spo	0.1	1.1	0.8	1.8	0.2	0.2	0.1	0.2	-	-	-	-	-	-	-	-	-	-	-
Acer sp.	2.7	0.7	0.8	7.1	1.3	0.6	2.3	0.4	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aesculus sp.	-	-	-	4.7	spo	spo	11.3	spo	1.0	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus sp.	18.8	52.9	37.9	0.7	1.8	0.7	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ambrosia sp.	-	-	-	-	-	-	-	-	-	0.1	0.8	0.1	2.9	13.1	3.7	70.7	91.8	70.1	95.5	99.0	95.1	82.1	94.8	87.3
Artemisia sp.	-	-	-	-	-	-	-	-	-	-	-	-	1.6	-	2.3	5.8	2.4	10.7	0.5	0.1	0.7	5.7	-	-
Asteraceae	-	-	-	-	-	-	spo	0.5	-	0.9	2.5	-	0.2	0.3	-	0.2	0.1	0.3	-	-	-	-	2.5	-
Betula sp.	2.9	1.0	0.7	32.6	37.4	30.8	1.8	-	0.3	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brassicaceae	-	-	-	-	spo	spo	3.8	3.0	3.0	2.5	1.0	1.3	-	-	-	-	-	-	-	-	-	-	-	-
Carpinus sp.	0.8	0.5	0.2	10.4	12.8	18.5	7.0	9.4	11.2	0.7	0.3	0.3	0.2	0.2	-	-	-	-	-	-	-	-	-	-
Castanea sp.	-	-	-	-	-	-	-	-	0.2	57.9	22.0	59.6	1.9	0.7	6.0	-	-	-	-	-	-	-	-	-
Chenopodiaceae	-	-	-	-	-	-	-	spo	-	0.4	0.3	-	1.7	3.2	2.1	2.3	0.9	5.3	2.2	0.3	1.1	2.2	1.6	8.5
Corylus sp.	11.4	24.2	21.7	0.8	0.9	0.4	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyperaceae	-	-	-	0.1	0.2	0.3	0.6	0.9	0.9	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fagus sp.	-	-	-	2.5	3.7	1.9	2.9	2.8	3.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Forsythia sp.	0.5	-	-	spo	-	spo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fraxinus sp.	9.6	6.7	3.6	5.8	6.8	7.9	0.5	0.3	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juglans sp.	-	-	-	0.9	spo	0.4	1.9	0.6	2.8	0.1	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Ligustrum sp.	-	-	-	-	-	-	-	-	-	-	0.2	0.3	-	-	-	-	-	-	-	-	-	-	-	-
Morus sp.	-	-	-	4.2	spo	spo	7.4	0.5	spo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Picea sp.	-	-	-	0.3	0.1	spo	4.3	4.6	7.1	1.1	1.5	1.9	0.2	-	-	-	-	0.1	-	-	-	-	-	-
Pinus sp.	-	-	-	0.1	spo	spo	4.6	3.0	0.9	0.1	0.1	4.6	-	-	-	-	-	-	-	-	-	-	-	-
Platanus sp.	-	-	-	5.9	0.4	0.6	4.8	1.1	1.4	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantago sp.	-	-	-	-	-	-	0.6	0.9	1.0	2.9	4.2	0.2	6.6	8.7	14.6	1.5	0.7	3.7	0.5	0.2	2.2	7.9	0.9	2.1
Poaceae	-	spo	-	0.4	0.5	0.1	22.9	50.3	42.8	17.2	52.8	22.8	4.2	7.4	7.8	0.8	0.5	1.3	0.5	0.2	0.7	-	-	2.1
Populus sp.	9.0	4.1	7.6	0.7	1.2	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp.	-	-	-	12.3	20.2	11.9	4.8	8.1	10.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Robinia sp.	-	-	-	-	-	-	0.3	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rosaceae	0.1	-	-	1.9	0.4	0.1	spo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rumex sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-
Salix sp.	3.7	3.5	2.9	2.3	8.7	4.6	3.2	3.0	4.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sambucus sp.	-	-	-	-	-	0.1	5.4	1.1	1.7	0.5	3.3	1.0	-	-	-	-	-	-	-	-	-	-	-	-
Taxus/Juniperus	36.6	4.8	21.6	5.6	2.9	18.8	4.9	5.2	2.6	0.6	0.6	0.5	-	-	-	-	-	-	-	-	-	-	-	-
Tilia sp.	-	-	-	-	-	-	0.3	0.4	0.3	4.8	1.8	2.3	0.4	-	0.8	-	-	-	-	-	-	-	-	-
Umbelliferae	-	-	-	-	-	-	spo	spo	spo	-	0.2	-	0.4	0.9	0.8	0.1	0.1	0.2	-	-	-	-	-	-
Ulmus sp.	3.9	1.6	3.0	0.7	0.6	0.4	spo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Urticaceae	-	-	-	-	0.1	spo	3.1	2.9	1.5	9.3	8.2	4.9	79.5	65.5	61.9	18.6	3.5	8.0	0.8	0.2	0.1	2.2	-	-

Z: Zagreb; I.G.: Ivanić Grad; S: Samobor; spo: Sporadically.

Pollen of anemophilous plants prevailed at all monitoring sites while pollen of entomophilous taxa occurred sporadically or in very low amounts. A similar pattern was reported in southeast Poland, however, with a different floral composition due to climatic differences. In Poland, pollen of the allergenic alder tree (*Alnus* sp.) accounts for most of the pollen count while in central Croatia the most allergenic weed, ragweed (*Ambrosia* sp.) does (Kasprzyk, 1999). Monthly pollen concentrations showed two peaks, in April and August, at all three sampling sites. These peaks coincided with the flowering of generally anemophilous tree and weed, especially ragweed. Similar results have also been reported from central Italy and south France (Clot, 2001; Emberlin et al., 1993; Spieksma and Frenguelli, 1991; Jäger et al., 1991). Between-site differences were observed: monthly pollen concentrations measured in April at the Zagreb and Samobor sampling sites exceeded those recorded at the Ivanić Grad sampling site, a fact ascribed to the variation in their respective flora compositions. Ivanic Grad is a typical rural, lowland region abundant in overgrown, weedy ground, with little forest vegetation. Thus only a minor amount of tree pollen is found in the total pollen count in spring. Zagreb, and Samobor in particular are closely surrounded by large forest areas, thus the amount of tree pollen is high in the spring. A reverse pattern was observed in August, when a huge amount of ragweed pollen in the air was recorded in Ivanić Grad, with the pollen grain count at this monitoring site approaching 20,000 or twofold that measured in Zagreb. Hyde (1959) observed the vegetation patterns to influence the pollen fall, and the highest pollen grain counts were found in samples taken at rural or suburban sites. The proportion of tree, grass and weed groups at the three sampling sites was quite comparable, with a variation recorded only in the amount of pollen in the air because the sampling sites were a relatively small distance apart, in the same climatic region, with a concurrent onset and termination of a particular plant group's pollination. This resulted in the seasonal concurrence of pollen in the entire area's atmosphere. The spectrum of highly allergenic pollen isolated from total pollen count was generally identical to that recorded in inland Europe (Lejoly-Gabriel and Leuschner, 1983; Dalen and Voorhorst, 1981; Eriksson, 1978; Spieksma et al., 1989; Horak et al., 1981; Kasprzyk, 1999), differences being only found in their percentage proportion. Ragweed pollen shows a specific pattern, as the plant has mostly spread over east and Central Europe. In our study, ragweed pollen accounted for a high proportion of total pollen in late summer and early autumn, which is not the case in northern and western European countries.

The phenology and type of pollen species showed no distinct variation among the three sampling sites. However, substantial differences were recorded in pollen grain count and percentage proportion of some highly allergenic plant pollen (*Ambrosia* sp., *Betula* sp., *Carpinus* sp. and Poaceae). The latter is of utmost importance for the individuals suffering from pollen allergy. This was a preliminary study, obviously calling for longterm research to be undertaken in the future.

Literature Cited

Clot, B. 2001. Airborne birch pollen on Neuchatel (Switzerland): onset, peak and daily patterns. Aerobiologia **17:** 25-29.

Bousquet, J., P. Cour, B. Guerin, and F.B. Michel. 1984. Pollen calendar and pollinosis of the Montpellier area. Clin. Allergy **14:** 249-258.

Dalen, G. and R. Voorhorst. 1981. Allergen community in pollen from certain tree species. Ann. Allergy **46:** 276-278.

D'Amato, G. 1984. La Pollinosi in Italia Rilievo Regionale Dei Principali Pollini Allergenici. Lepetit, Napoli.

D'Amato, G. and G. Lobefalo. 1989. Allergenic pollen in the Mediterranean area. J.Allergy Clin. Immunol. **83:** 116-122.

Driessen, M.N.B.M., J.W.M. Derksen, F.T.M. Spieksma, and E. Roetman. 1988. Pollenatlas Van De Nederlandse Atmosfeer. Fisons, Leusden.

Emberlin, J. and J. Norris-Hill. 1991. Spatial variation of pollen deposition in North London. Grana **30:** 190-195.

Emberlin, J., M. Savage, and R. Woodman. 1993. Annual variations in the concentrations of Betula pollen in the London area. Grana **32:** 359-363.

Eriksson, N.E. 1978. Allergy to pollen from different deciduous trees in Sweden. Allergy **33:** 299-309.

Hofman, T. and J. Michalik. 1998. Alergia Pylkowa. Wyd. TOM, Poznan.

Horak, F. and S. Jäger. 1979. Die Erreger des Heufiebers. Medizinisch-botanische Dokumentation der Pollenallergie in Mitteleuropa. Urban & Schwarzenberg, Wien.

Horak, F., S. Jäger, and R. Turk. 1981. Ragweed Pollen Allergy in Austria-New Trends in Allergy. Springer –Verlag, Berlin, pp. 175-177.

Hyde, H.A. 1959. Atmospheric pollen in relation to land use. Nature **183:** 1694-1695.

Jäger, S., F.T.M. Spieksma, and N. Nolard. 1991. Fluctuations and trends in airborne concentrations of some abundant pollen types, monitored at Vienna, Leiden and Brussels. Grana **30:** 309-312.

Kasprzyk, I. 1999. Comparative analysis of pollen fall at three sites in south-eastern Poland. Ann. Agric. Environ. Med. **6:** 73-79.

Lejoly-Gabriel, M. and R.M. Leuschner. 1983. Comparison of airborne pollen at Louvain-la-Neuve (Belgium) and Basel (Switzerland) during 1979 and 1980. Grana **22:** 59-64.

Lovašen-Eberhardt, Ž. 1979. Godišnje kretanje i sastav polena na području Zagreba u vremenu od 1973.-1978. Godine. Sec. Cong. Ecol. Yugosl., Zadar, pp. 229-234.

Nilsson, S. and S. Persson. 1981. Tree pollen spectra in the Stockholm region (Sweden), 1973-1980. Grana **20:** 179-182.

Nilsson, S., J. Proglowski, and I. Nilsson. 1977. Atlas of Airborne Pollen Grains and Spores in Northern Europe. Natur och Kultur, Stockholm.

Obtulowicz, K., T. Kotlinowska, M. Stobiecki, K. Dechnik, A. Obtulowicz, A. Manecki, M. Marszalek, and M. Schejbal-Chwastek. 1996. Environmental air pollution and pollen allergy. Ann. Agric. Environ. Med. **3:** 131-138.

Peternel, R., J. Čulig, B. Mitic, I. Vukušić, and Z. Šostar. 2003. Analysis of airborne pollen concentrations in Zagreb, Croatia 2002. Ann. Agric. Environ. Med. **10:** 1-6.

Spieksma, F.T.M. 1986. Airborne pollen concentrations in

Leiden, The Netherlands, 1977- 1981. III. Herbs and weeds flowering in the summer. Grana **25:** 47-54.

Spieksma, F.T.M., G. D'Amato, J. Mullins, N. Nolard, R. Wachter, and E.R. Weeke. 1989. City spore concentrations in the European Economic Community (EEC). VI. Poaceae (grasses), 1982-1986. Aerobiologia **5:** 38-43.

Spieksma, F.T.M. and G. Frenguelli. 1991. Allergenic significance of *Alnus* (Alder) pollen. *In* G. D'Amato, F.T.M. Spieksma, and S. Bonini (eds.), Allergenic Pollen and Pollinosis in Europe, Blackwell Scientific Publications, London, pp. 36-44.

Stix, E. 1981. Pollenkalender. Regionale and jahreszeitliche Verbreitung von Pollen. Wissenschaftliche Verlagsgesellschaft, Stuttgart.

Volarić-Mršić, I. 1972. Istraživanje polena u zraku u nekim krajevima Hrvatske. Acta. Bot. Croat. **29:** 83-94.

克羅地亞 2003 年內陸三個地點之空氣傳播的花粉圖譜

Renata PETERNEL[1], Josip ČULIG[1], Božena MITIĆ[2], Ivana HRGA[1], and Ivan VUKUŠIĆ[1]

[1]Research Department, Zagreb Institute of Public Health,

Mirogoiska 16, HR-1000, Zagreb, Croatia, Europe

[2]Department of Botany, School of Science, University of Zagreb, Zagreb, Croatia

本文之目的在檢測不同土地利用之地點在植物花粉散佈期間其季節性的花粉傳播頻率、花粉量、花粉型共三個參數是否存在重要差異。實驗材料自 2003 年 1 月 5 日至 12 月 20 日在克羅地亞中部三個地點分別收集。三個地點分別位於平均都市化區（Zagreb），農村區（Ivanić Grad），及小鎮旁近圍繞一大樹林及部份好熱之植被（Samobor）。使用花粉收集之體積法，35-37 類之花粉粒（依地點而略為不同）被收集到。其中 8 類為量最多（即：*Alnus* sp., *Ambrosia* sp., *Betula* sp., *Carpinus* sp., Poaceae, *Quercus* sp., *Taxus/Juniperus* 及 Urticaceae）。不同地點之差別項目被記錄的有季節性之花粉濃度，每月之花粉全量，及全年花粉量。特別植物類（樹木，草本，及野草）之比例在三個地點是十分相近，此乃因它們之相對地理鄰近性（屬於同一氣候區）。在空氣傳播之花粉濃度以高度過敏原花粉為主（Zagreb 54%, Samobor 58% and Ivanic Grad 82%）其花粉源如下：*Alnus* sp., *Ambrosi*a sp., *Betula* sp., *Carpinus* sp., *Corylus* sp., Poaceae, Urticaceae 及 *Artemisia* sp. 。因此，在此三地點測到之花粉源缺少明顯的氣象引起之差別。但是，在季節性的花粉量及某些過敏原花粉之比例（*Ambrosia* sp., *Betula* sp., *Carpinus* sp., Poaceae）這兩個項目上有相當之差異，因此對花粉過敏之個人提供有用之資訊。

關鍵詞：氣生生物學；中部克羅地亞；花粉粒；體積法。