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Original scientific paper

Diurnal Variation in Airborne Pollen Concentrations of the Selected Taxa in Zagreb, Croatia

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A B S T R A C T

The number of individuals allergic to plant pollen has recently been on a constant increase. The knowledge of diurnal distribution and abundance of allergenic pollen types, their patterns and response to source position and weather is useful to correlate hay fever symptoms with the presence of allergenic pollen in the atmosphere. The aim of this study was to determine diurnal distribution of total airborne pollen, pollen of particular allergenic taxa, possible variation in diurnal pollen distribution at measuring sites placed at different heights, and effect of some meteorological parameters on airborne pollen concentrations. A 7-day Hirst-type volumetric pollen trap was used for pollen sampling. Qualitative and quantitative pollen analysis was performed under a light microscope (magnification x400). Total pollen of all plant taxa (Ambrosia sp., Betula sp., Cupressaceae, Urticaceae, Poaceae, Quercus sp., Fraxinus sp., Alnus sp., Corylus sp., Populus sp., Pinus sp., Picea sp.) observed showed a regular diurnal distribution at both sampling sites in both study years, with a rise in the pollen concentration recorded after 4.00 a.m. and 6.00 a.m., respectively. The peak pollen concentration occurred between 12.00 a.m. and 4.00 p.m., and the lowest diurnal pollen concentrations were recorded overnight. About 50% of the 24-h pollen concentration were released to the atmosphere between 10.00 a.m. and 4.00 p.m. The timing and size of diurnal peaks were closely related to high temperature, low humidity and south-west maximum wind direction.

***Key words**: pollen monitoring, volumetric method, allergenic pollen, diurnal pollen distribution, weather conditions*

Introduction

Pollen grains are one of the most important groups of atmospheric biological particles that originate allergenic processes. Pollinosis increased in developed countries in the last decades, both in the number of affected patients and in the severity of allergic reactions[1,2]. Rhinitis affects up to 25% of the world population and asthma up to 18%, with a clear tendency to increase their prevalence[3]. Airborne pollen concentrations greatly differ spatially and temporally depending on the source location, the factors that govern the release to the airflow, and the factors of dispersal. Although pollen grains can travel several hundred miles, the concentrations of windborne pollen generally decrease sharply within a few hundred meters of the source. Pollen levels are strongly influenced by the depth of the air volume in which free mixing can occur, and this in turn can reflect the prevailing profile of the lower atmosphere. Overall, the levels of airborne pollen are increased in warm, dry, clear conditions and fall during cold and wet periods. However, finding regularities in the diurnal course of pollen concentrations is a difficult task due to different pollen release rhythms for individual species and modifications caused by changes in weather conditions[4]. Meteorological factors such as temperature, rainfall, relative and humidity control the broad patterns of particle dispersal and therefore they have an important influence on their concentrations in the air[5]. Atmospheric stability affects the intradiurnal pollen concentrations because it restricts the vertical movements of the air[6]. The direction and the speed of the wind influence on the horizontal dispersion of the particles and affect hourly distribution of pollen concentration. In calm conditions, the diurnal curve responds to a given pattern

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due to the registered pollen mostly originating from the nearest areas. Moreover, wind is a long-distance transporter that contributes to the detection of non-native pollen, influencing the diurnal distribution model of a particular type of pollen[7]. A typical diurnal pattern of airborne pollen (maximum values between 12.00 a.m. and 2.00 p.m.; minimum values between 4.00 a.m. and 6.00 a.m.) has been described by many authors[8–10]. For practical reasons of providing appropriate information to patients suffering from pollinosis, the knowledge of diurnal distribution and abundance of allergenic pollen types, their patterns and response to source position and weather is useful to allergologists allowing them to correlate hay fever symptoms with the presence of allergenic pollen in the atmosphere[11].

The aim of the present study was to determine diurnal (bi-hourly) distribution of total airborne pollen, pollen of particular allergenic taxa, possible variation in diurnal pollen distribution at measuring sites placed at different heights, and effect of some meteorological parameters on airborne pollen concentrations. This work will help to improve the quality of life of Zagreb citizens and visitors who suffer from allergy.

Material and Methods

Measuring sites and pollen sampling

Analysis of the pollen count distribution was performed on the basis of data collected in Zagreb from February to October in the years 2003 and 2005. Zagreb is situated in the central part of Croatia with continental climate[12]. The mean annual temperature is 11.2 °C and the mean annual precipitation is 883 mm (based on longterm average from the reference period 1961–1990). A 7-day Hirst-type volumetric pollen trap (VPPS 2000; Lanzoni, Bologna, Italy) was used for pollen sampling[13,14]. In 2003, the sampler was placed at 19.7 m on the roof of the Grič Observatory in the center of the City of Zagreb (Gauss-Krüger coordinates: 050-74-960 N, 055-75-940 E, 157 m above the sea level). In 2005, pollen trap was moved to the height of 2.5 m, on top of the air quality measuring unit container in Mirogojska (Gauss-Krüger coordinates: 050-76-794 N; 055-76-542 E; 175 m above the sea level). The sampler absorbs 10 L air *per* minute. It is supplied with a timer to move the adhesive tape (2 mm/h) to which pollen grains adhere.

Pollen counts

The tape was removed twice weekly, cut to a length corresponding to 24-h pollen sampling, applied onto a glass slide and embeded[15]. Samples were examined under a light microscope, magnification x400, to determine pollen type and count *per* 1 m^3 air. Five horizontal sweeps were analyzed on each slide. We decided to use horizontal sweeps because the variation in the concentration during the day can be observed along this axis (direction of the tape shift in the sampler). The minimal number of horizontal sweeps is the one that ensures total observation area, which is at least 20% of the sampled area. The accuracy of the measurement is proportional to the number of sweeps and concentration of particles[16]. Pollen concentration was expressed as pollen grain count/m^3 air. Twelve pollen types were selected for further analysis on the basis on their abundance, allergenic potential and source area. *Ambrosia*, *Betula*, Poaceae, *Alnus, Corylus,* Urticacea and Cupressaceae were selected as they are the main allergenic pollen types in Europe and very abundant in Zagreb. They originate from both inside and outside of the Zagreb urban area. *Quercus*, *Fraxinus*, *Populus*, *Pinus* and *Picea* originate almost completely within the Zagreb area, where they have been planted as street, garden and park trees[17].

Diurnal variation in each pollen type was analyzed during a closely defined pollen season following the methodology of Fernandez-Gonzalez et al. including 95% of total yearly pollen count[18].

Meteorological parameters

Meteorological data used in the analysis included hourly measurements of temperature, relative humidity, wind speed and wind direction. Data were obtained from the Croatian Meteorological and Hydrological Service at the sampling site Zagreb-Grič in 2003, whereas data on the Zagreb-Mirogojska sampling site in 2005 were collected by our own measurements (at the sampling site).

Results

Pollen types and abundance

At Grič sampling site 2003, pollen of the selected plant taxa (*Ambrosia* sp., *Betula* sp., Cupressaceae, Urticaceae, Poaceae, *Quercus* sp., *Fraxinus* sp., *Alnus* sp., *Corylus* sp., *Populus* sp., *Pinus* sp., *Picea* sp.) accounted for 60.7–68.8% of total pollen in all seasons of the year relative to annual total. At Mirogojska sampling site 2005, this range of percentual proportion was greater, 49.5–84.1%. At both sampling sites, the pollen of *Ambrosia* sp. accounted for the highest percentage ($n_{Grič}$=59.2%; $n_{Mirogojska}$=46.6%) in the autumn (September–November), followed by the pollen of plants belonging to the families Urticaceae ($n_{Grič}$=35.8%; $n_{Mirogojska}$=37.1%) (June–August) and Cupressaceae ($n_{Grič}$=15.7%; $n_{Mirogojska}$=24.0%), and *Betula* sp. ($n_{Grič}$=12.4%; $n_{Mirogojska}$=14.7%) (March–May). The prevalence of the pollen of other taxa did not exceed 10%, with the exception of Poaceae (n=10.8%), *Quercus* sp. (n=11.9%) and *Populus* sp. (n=13.8%) at Mirogojska sampling site. However, the proportion of particular pollen types in yearly total differed according to sampling sites, with the pollen of *Ambrosia* sp. predominating at Grič sampling site (n=18.3%), and that of *Betula* sp. at Mirogojska sampling site (22.3%) (Table 1).

Diurnal distribution of pollen types

Total pollen of all plant taxa observed showed a regular diurnal distribution at both sampling sites in both

TABLE 1
SEASONAL AND ANNUAL PATTERN OF TWELVE AIRBORNE POLLEN TYPES (%) IN ZAGREB

Taxon	Measuring site/year Zagreb-Grič-2003/Zagreb-Mirogojska-2005			
	Spring Mar – May (%)	Summer Jun – Aug (%)	Autumn Sep – Nov (%)	Annual total (%)
Ambrosia sp.	0.0/0.0	24.5/10.8	59.2/46.6	18.3/4.9
Betula sp.	12.4/14.7	0.0/0.0	0.0/0.0	11.8/22.3
Cupressaceae	15.7/24.0	0.6/0.2	0.0/0.0	8.6/18.1
Urticaceae	3.1/1.4	35.8/37.1	1.0/2.4	7.8/5.6
Poaceae	7.8/8.4	7.4/10.8	0.5/0.5	5.2/4.6
Quercus sp.	5.7/11.9	0.0/0.1	0.0/0.0	4.9/13.3
Fraxinus sp.	5.3/1.8	0.0/0.0	0.0/0.0	3.6/0.8
Alnus sp.	6.5/0.7	0.0/0.0	0.0/0.0	3.3/0.5
Corylus sp.	4.1/0.8	0.0/0.0	0.0/0.0	2.1/0.5
Populus sp.	3.2/13.8	0.0/0.0	0.0/0.0	1.8/8.8
Pinus sp.	1.5/1.6	0.1/0.5	0.0/0.0	0.7/0.6
Picea sp.	1.4/5.0	0.4/1.0	0.0/0.0	0.4/1.7

study years (2003 and 2005), with a rise in the pollen concentration recorded after 4.00 a.m. and 6.00 a.m., respectively. The peak pollen concentration occurred between 12.00 a.m. and 2.00 p.m. at Mirogojska sampling site (13.5% of average total annual 24-h concentration), and between 2.00 p.m. and 4.00 p.m. at Grič sampling site (11.6% of average total annual 24-h concentration). At both sites, the lowest diurnal pollen concentrations were recorded overnight (from 10.00 p.m. to 2.00 a.m.) (Fig. 1).

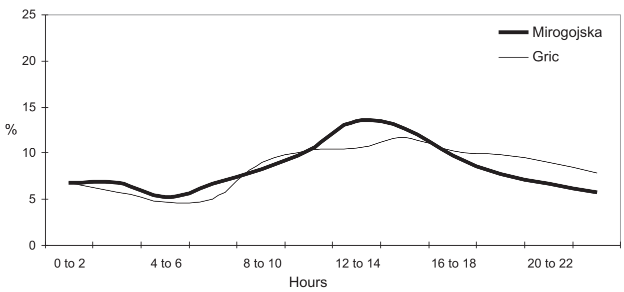

Fig. 1. Diurnal distribution of total pollen recorded in Zagreb (measuring sites Grič and Mirogojska during 2003 and 2005) expressed as percentage.

Analysis of diurnal pollen distribution of particular taxa showed regular distribution of all taxa at both sampling sites. At Grič measuring site, pollen concentration of most taxa (*Alnus* sp., *Corylus* sp. *Betula* sp., Cupressaceae, *Quercus* sp. *Picea* sp., Poaceae, *Ambrosia* sp. and Urticaceae) increased between 6.00 a.m. and 8.00 a.m., with the exception of *Populus* sp., *Pinus* sp. and *Fraxinus* sp. pollen, which showed an increase between 4.00 a.m. and 6.00 a.m. At Mirogojska measuring site, pollen concentration of most taxa (*Betula* sp., Cupressaceae, *Picea* sp., *Fraxinus* sp., Poaceae, *Ambrosia* sp. and Urticaceae) started rising between 4.00 a.m. and 6.00 a.m., with the exception of *Corylus* sp., *Quercus* sp., *Populus* sp. and *Pinus* sp., where it occurred at 6.00 a.m. and 8.00 a.m., and *Alnus* sp. between 8.00 and 10.00 a.m. In these intervals, the percentage of individual taxon pollen did not exceed 5% of total 24-h concentration of the respective taxon. At Grič sampling site, the highest diurnal pollen concentrations of four taxa (*Corylus* sp., Cupressaceae, *Quercus* sp. and *Ambrosia* sp.) occurred between 12.00 a.m. and 2.00 p.m., and of another three taxa (*Picea* sp., *Fraxinus* sp. and Urticaceae) between 2.00 p.m. and 4.00 p.m. Pollen concentrations of two taxa (*Alnus* sp. and *Betula* sp.) showed peak concentrations in the evening, between 8.00 p.m. and 12.00 p.m., and that of Poaceae between 10.00 a.m. and 12.00 a.m. A similar pattern was observed at Mirogojska measuring site, where the percentage of individual taxon pollen peaks ranged from 10% to 20%. The majority of taxa showed lowest pollen concentrations during the night (Fig. 2).

Diurnal distribution of meteorological parameters

We monitored monthly patterns of diurnal distribution of four meteorological parameters (temperature, relative humidity, wind speed and wind direction), and their effect on diurnal distribution of airborne pollen. Diurnal distribution of relative humidity, temperature and maximum wind speed were almost identical at the two sampling sites throughout the months of observation in both study years. At Grič sampling site, the highest relative air humidity in all study months (March–September) was recorded at 7.00 a.m. (64–80%), and lowest between 12.00 a.m. and 5.00 p.m. (40–53%). At Mirogojska sampling site, the highest relative humidity was recorded at 8.00 a.m. (70–90%), and lowest between 12.00 a.m. and 5.00 p.m. (42–69%). Due to its variation with the season of the year, air temperature showed a greater range of values, however, its diurnal distribution being highly regular and inversely proportional to the values of relative humidity. The lowest values (March–September) were

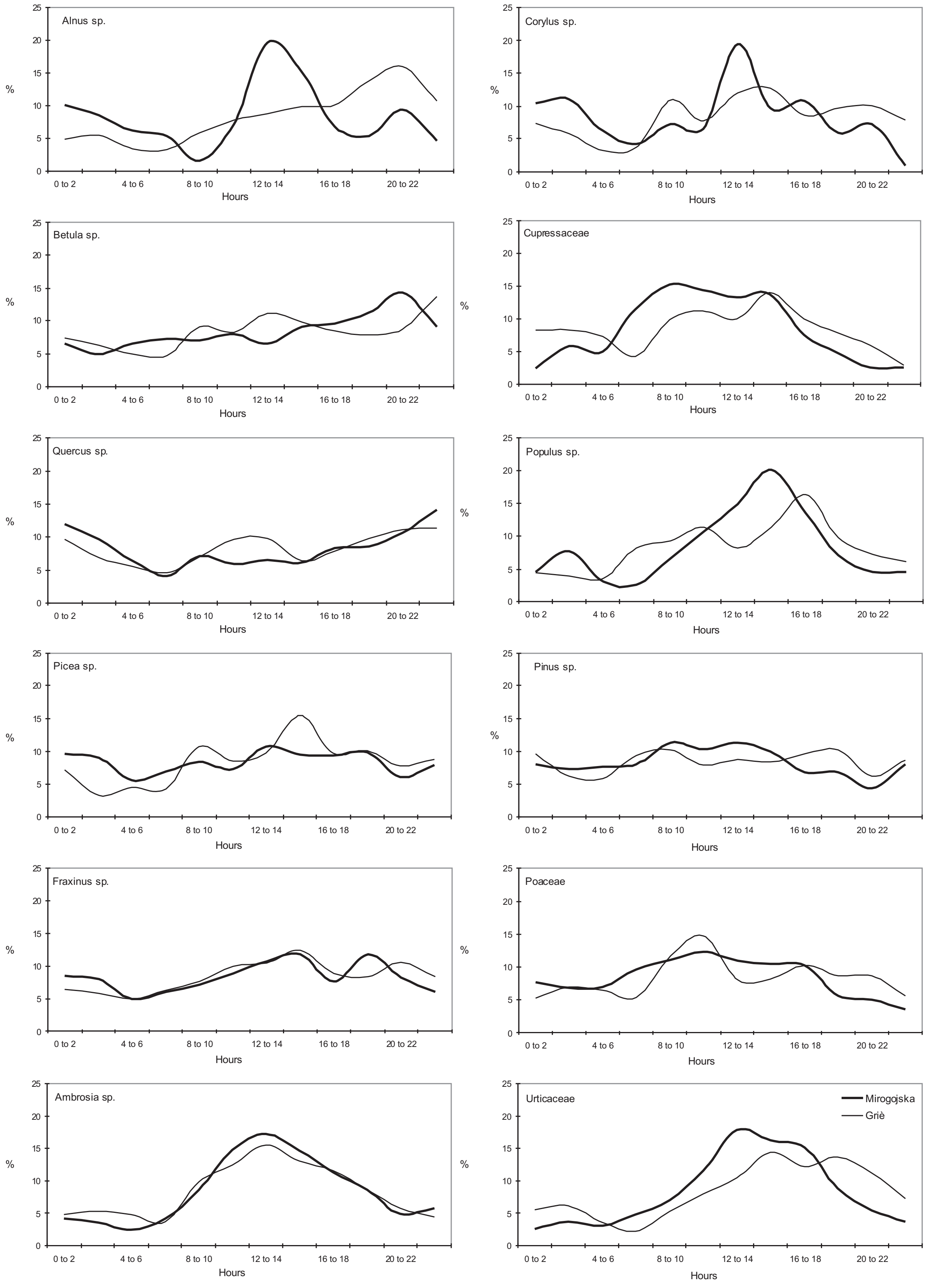

Fig. 2. Diurnal distribution of individual taxa pollen in Zagreb (measuring sites Grič and Mirogojska during 2003 and 2005) expressed as percentage.

TABLE 2
DIURNAL DISTRIBUTION OF MAXIMUM WIND SPEED AND ITS DIRECTION (MEASURING SITE ZAGREB-GRIČ, 2003)

Measuring site: Zagreb-Grič Wind direction/Max. speed (m/s)												
Hour	Apr		May		Jun		Jul		Aug		Sep	
0–1	NE	6.5	NE	3.3	N	2.9	NNW	2.6	NNW	3.3	NNE	4.3
1–2	NE	5.8	NE	3.2	NE	2.7	NE	5.0	SW	2.3	NE	4.1
2–3	NW	4.3	W	3.6	SE	2.4	NE	3.1	NNE	3.3	NNE	3.7
3–4	WSW	3.7	NE	3.5	NE	2.4	NNE	2.9	NE	3.0	NE	4.0
4–5	W	4.2	NE	2.7	NE	2.7	N	2.3	NE	3.3	NNE	4.0
5–6	NE	4.0	ENE	3.0	W	2.0	W	2.6	NE	3.8	NNE	4.8
6–7	NE	3.3	NNE	2.3	NE	2.6	WSW	2.9	NE	3.8	NNE	4.8
7–8	WSW	4.1	ENE	2.9	NE	2.6	WSW	3.7	NNE	2.9	NE	4.0
8–9	N	5.7	NE	4.1	SW	2.7	WSW	5.4	NNE	3.0	NE	5.2
9–10	WSW	5.4	SW	3.3	SSW	3.5	SW	6.2	NNE	2.9	NE	4.6
10–11	WSW	6.3	N	4.8	SW	3.5	WSW	7.1	NE	3.4	SW	4.3
11–12	WSW	6.0	N	4.4	SW	3.7	WSW	7.5	NNE	3.2	SSW	4.7
12–13	WSW	6.3	N	4.9	SW	4.1	SW	7.8	NE	4.1	SW	4.4
13–14	WSW	6.7	N	4.5	N	4.9	WSW	7.7	SW	4.1	SW	4.9
14–15	WSW	6.8	SW	4.8	SW	4.5	SW	7.5	SW	4.6	SW	5.2
15–16	SW	7.6	NE	5.5	SW	5.1	SW	8.0	WSW	5.8	N	4.3
16–17	SW	7.9	W	3.7	SW	5.3	SW	7.7	SW	6.8	N	7.7
17–18	WSW	6.6	W	3.7	WSW	4.9	SW	7.2	SW	6.2	NNW	5.1
18–19	WSW	6.3	S	3.1	SW	4.1	SW	4.2	SSW	6.5	W	2.9
19–20	SW	4.4	NE	2.8	WNW	5.3	W	6.9	SSW	5.3	WSW	3.5
20–21	W	4.6	ESE	4.3	NNE	4.8	NNE	4.3	NNE	2.6	NNE	3.5
21–22	W	4.3	NNE	3.3	NNE	4.5	NNW	4.9	NE	2.5	NNE	4.4
22–23	NE	4.5	NNE	3.5	NE	3.0	NNW	3.1	NW	4.1	NNE	4.7
23–24	N	3.7	NNE	3.1	NE	2.1	NNE	4.1	WNW	2.6	NNE	4.6

TABLE 3
DIURNAL DISTRIBUTION OF MAXIMUM WIND SPEED AND ITS DIRECTION (MEASURING SITE ZAGREB-MIROGOJSKA, 2005)

Measuring site: Zagreb-Mirogojska Wind direction/Max. speed (m/s)												
Hour	Apr		May		Jun		Jul		Aug		Sep	
0–1	WSW	1.9	WNW	1.7	NE	1.7	NNE	1.6	S	1.8	NE	1.6
1–2	WNW	2.3	NW	2.2	NE	1.5	NNE	1.3	W	2.2	NE	1.5
2–3	W	2.0	WNW	1.5	NW	1.6	N	1.3	ENE	2.0	NW	1.7
3–4	NW	2.1	NE	1.3	W	1.4	N	1.5	WSW	1.7	NE	1.1
4–5	WNW	2.2	NE	1.5	W	1.5	NNE	1.2	NW	1.3	NE	1.5
5–6	WNW	2.3	W	1.6	W	1.3	NW	1.5	E	1.0	NE	2.1
6–7	NE	2.5	WNW	1.9	W	1.5	W	1.6	S	0.8	NE	2.3
7–8	NE	2.8	W	1.9	W	1.3	ENE	1.5	WSW	0.9	NE	1.4
8–9	NE	2.6	ENE	1.7	WSW	1.5	SW	1.3	S	0.9	NE	2.1
9–10	WNW	2.4	NW	2.6	WSW	1.7	ENE	1.6	WSW	1.4	NE	1.7
10–11	WSW	3.1	SW	1.9	SW	1.8	E	1.6	SW	1.4	NE	2.1
11–12	WSW	3.8	NE	2.1	NE	2.1	NE	1.7	WNW	1.9	NE	2.5
12–13	WSW	3.7	WSW	1.9	SW	2.0	NE	1.8	SW	1.7	NE	2.9
13–14	SW	3.4	ENE	2.1	SW	2.2	ENE	1.9	SW	2.0	NE	2.3
14–15	WSW	3.1	NE	1.8	NE	3.1	NE	1.9	SW	2.1	SW	2.2
15–16	WSW	3.3	WSW	2.1	WSW	2.5	SW	2.3	SW	2.3	SW	1.8
16–17	WSW	3.0	NW	2.0	WSW	2.6	SW	2.2	SW	2.0	NE	1.7
17–18	NW	2.9	W	1.9	W	2.3	NE	1.7	SW	2.0	NE	1.9
18–19	NNW	3.0	WSW	1.8	W	2.4	NE	1.5	WSW	2.0	SW	1.6
19–20	NNW	2.8	W	1.4	W	1.9	NE	2.1	WSW	1.7	NE	1.3
20–21	W	2.1	W	1.8	NW	2.9	N	1.4	SW	1.1	NE	1.5
21–22	NW	2.9	WSW	1.6	NW	2.0	N	1.3	NE	1.5	NE	1.5
22–23	NW	2.5	NNW	1.9	WNW	1.1	SSE	1.6	NE	1.8	NE	1.9
23–24	NW	2.1	WSW	1.6	NE	1.4	NE	1.7	NE	2.3	NE	1.7

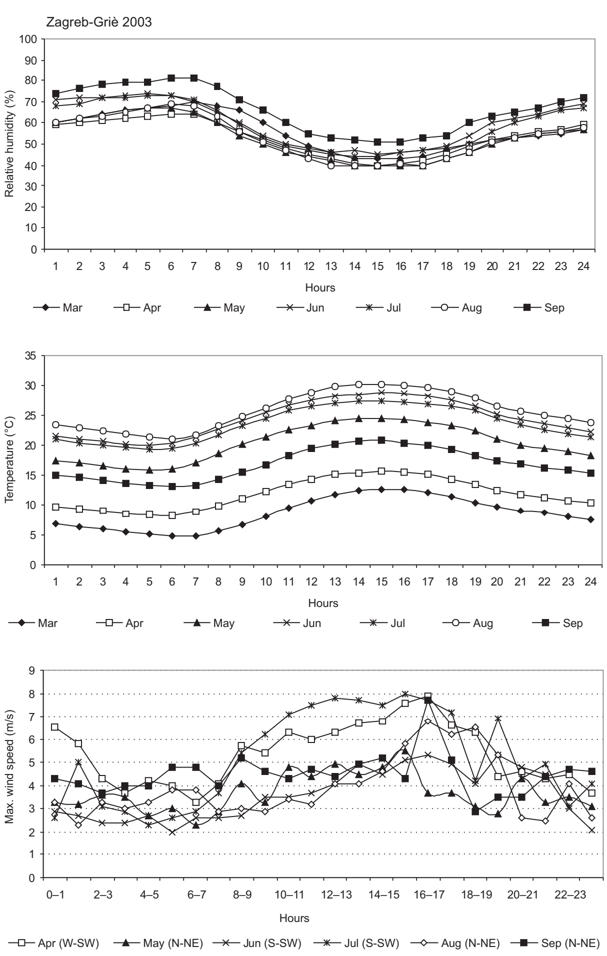

Fig. 3. Diurnal distribution of relative humidity, temperature and maximum wind speed (measuring site Zagreb-Grič, 2003).

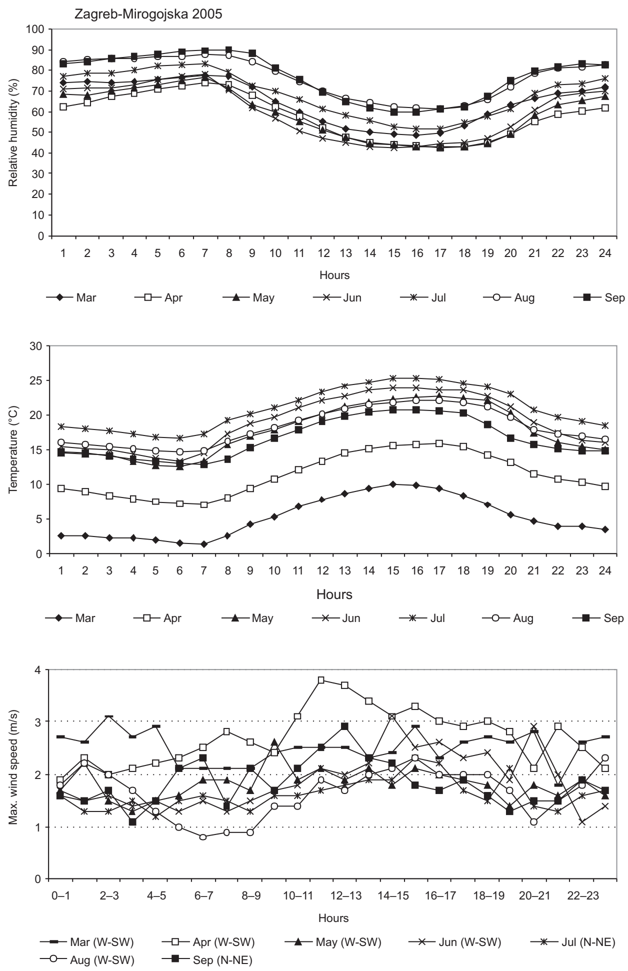

Fig. 4. Diurnal distribution of relative humidity, temperature and maximum wind speed (measuring site Zagreb-Mirogojska, 2005).

recorded at 6.00 a.m. and 7.00 a.m. ($t\ min_{Grič}$=4.7–21.7 °C and $t\ min_{Mirogojska}$=1.4–17.3 °C), and highest values between 2.00 p.m. and 4.00 p.m. ($t\ max_{Grič}$=12.4–30.3 °C and $t\ max_{Mirogojska}$=9.9–25.4 °C). Maximum wind speed as the most variable parameter started rising between 7.00 a.m. and 8.00 a.m., to reach maximum between 12.00 a.m. and 5.00 p.m. This parameter showed a nearly identical distribution at the two measuring sites, however, the values of maximum wind speed at Mirogojska sampling site were half those recorded at Grič sampling site and did not exceed 4 m/s (Figs. 3 and 4). At both sampling sites, the predominant maximum wind speed directions were south-west and north-east, with the former prevailing from 12.00 a.m. till 4.00 p.m. The only exceptions were recorded in May at Grič and in July at Mirogojska, when the north-east wind direction prevailed during the respective period of measurement (Tables 2 and 3).

Discussion and Conclusions

Diurnal distribution of total pollen of the study taxa showed a typical curve characteristic of the majority of European countries, with peak concentrations in the middle of the day, and constant between the sites and years[19,9,10]. In both study years, as much as 50% of the 24-h pollen concentration were released to the atmosphere between 10.00 a.m. and 4.00 p.m. at both sampling sites. Identical values were recorded in Malaga (Spain) during the 1992–1997 period[8]. Our analysis of individual taxa indicated the pollen of most taxa to follow the diurnal distribution of total pollen. At both sampling sites, the pollen of Urticaceae showed a characteristic peak concentration between 12.00 a.m. and 4.00 p.m. The timing and size of diurnal peaks were closely related to high temperature, low humidity and south-west maximum wind direction. A similar finding has been reported by Emberlin and Norris-Hill[20], who analyzed Urticaeae pollen in the center of London, where peak concentration occurred at 6.00 p.m., at the time of west winds and high temperature. Examination of diurnal variation in Poaceae pollen revealed the average pollen concentrations (regardless of differences in temperature and humidity) to achieve maximum between 10.00 a.m. and 12.00 a.m. The highest pollen concentrations were recorded at daily temparatures above 20 °C. In our study, grass pollen concentration was minimal between 6.00 a.m. and 8.00 a.m., to rise gradually during the day, a pattern also recorded in London[21]. However, there was variation in the size of peak concentrations and a slight difference in timing with temperature. The difference is only obvious in the maximal airborne pollen concentration, which in London occurred at 8.00 p.m. This difference in timing between our study and London report results from the fact that the grass pollen measured at our monitoring sites originated from the immediate sampling site surrounding, whereas the majority of grass pollen measured in London originated from the city outskirts. The delay observed in London was related to wind speed, wind direction, and pollen source location[22]. Diurnal periodicity of ragweed pollen showed a peak from 12.00 a.m. to 2.00 p.m., whereas in France the peak occurred earlier during the day, between 9.00 a.m. and 11.00 a.m.[23]. Birch pollen showed no striking peak during the day but there was a slight rise towards the night, thus its distribution could be compared with the distribution in Danzig (north Poland)[24]. Käpylä found this situation to be related to strong thermal and mechanical turbulence favoring suspension during daylight hours[25]. This could be considered a plausible explanation for the slight increase in the pollen curves around 12.00 p.m. when weakest winds allow the settling of pollen previously carried up by mid-afternoon upward flows, especially for local sources such as *Betula* sp. At Mirogojska sampling site, the pollen of oak also followed the distribution described for birch pollen, with a more significant concentration increase at 3.00 p.m., a tendency of further rise, and maximum reached during the night. Here, our results differ from those on Derby (UK), where maximal concentrations occurred at 3.00 p.m.[26]. Considering diurnal pollen distribution of most taxa, it obviously followed the daily course of air temperature, relative humidity, maximum wind speed and its direction. Air temperature rose first, between 6.00 a.m. and 7.00 a.m., followed by the wind speed increase and relative humidity decrease between 7.00 a.m. and 8.00 a.m., with concurrent increase in pollen concentration. This could be explained by the fact that during daytime, solar radiation supplies energy to warm the soil and develop convective turbulent movements that promote vertical mixing of the air. At night, the loss of heat has important effects on dynamic processes, leading to a decrease of turbulence and temperature. These processes promote changes in the transport of suspended particles. Airborne pollen concentrations follow this variation in response to the dynamic conditions of the medium in which the pollen is dispersed. During highest pollen concentrations the winds were mostly south-western, and northern during lowest pollen concentrations, suggesting the diurnal pollen distribution of most taxa to depend on meteorological parameters and to be most closely related to air temperature, relative humidity, maximum wind speed and its direction. The inert release of material from the surface will depend on the balance of two groups of forces. Bonding forces such as electrostatic force if the particle and surface are differently charged, or surface tension if the surface is wet, will tend to retain the particle on the surface, as will any physical attachment. Forces that might remove the particle from the surface include aerodynamic drag if the air adjacent to the particle is moving around it, similar electric charge, the impact of other particles knocking the particle from the surface, or the inertia of the particle when the movement of the surface is varying and the surface accelerates away from the particle. Such movement may occur as a result of wind, impact of raindrops or other physical disturbance. Particular taxa show a shift from the usual pattern, which may be due to the natural dynamics of pollen release or distant locations from which the pollen is transported to the atmosphere. The hourly concentrations of various tree pollen at distance from the source, on days when pollen concentration was high, were analyzed by Käpylä (1984)[4]. Pollen concentrations generally increased with lower relative humidity and higher temperature, although at highest temperatures pollen concentrations were reduced in case of *Quercus* sp, *Salix* sp. and *Ulmus* sp. Käpylä suggests that the diurnal concentration patterns of tree pollen are much more irregular than those of grasses, and that in trees once anthesis has started, it is relatively independent of weather variables. Opening of the anthers is probably caused by drying, hence the reduced pollen concentrations were observed when relative humidity was high. Rupture of the anthers may be temperature dependent. Comparison of the pollen concentration dependence of wind speed according to typical size of pollen grains produced three pollen groups: pollen tending to clump together, such as *Quercus* sp.; large pollen with air sacs with consequential low density, such as *Pinus* sp. and *Picea* sp.; and pollen from the remainder of wind pollinated trees. Plotting the variance ratio against the typical aerodynamic diameters of pollen grains, or clump of grains, would tend to bring all three groups towards a single linear relationship. The knowledge of these patterns and their response to source position and weather has proved to be of great value for exposure reduction to allergenic pollen in public health programs. Longterm investigations supplemented with floristic studies are needed to more precisely define the impact of meteorological parameters on variation in the diurnal airborne pollen concentrations and to identify the areas characterized by the presence of particular plant taxa, thus to determine the source of pollen.

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DIURNALNE VARIJACIJE KONCENTRACIJA NEKIH VRSTA PELUDA U ZRAKU GRADA ZAGREBA, HRVATSKA

S A Ž E T A K

Broj osoba alergičnih na pelud u stalnom je porastu. Diurnalna raspodjela, količina i vrste alergogenog peluda, te meteorološki parametri koji utječu na raspodjelu peluda u zraku u korelaciji su s pogoršanjem simptoma kod osoba preosjetljivih na pelud. Svrha ovog rada je odrediti diurnalnu raspodjelu ukupnog spektra peluda u zraku, peluda određenih taksona, varijacije diurnalnih raspodjela peluda na mjernim mjestima različitih visina te utjecaj nekih meteoroloških parametara na koncentracije peluda u zraku. Za uzorkovanje peluda korišten je sedmodnevni volumetrijski uzorkivač Hirstovog tipa, a za kvalitativnu i kvantitativnu analizu peluda svjetlosni mikroskop (povećanje 400x). Ukupna pelud svih biljnih taksona (*Ambrosia* sp., *Betula* sp., Cupressaceae, Urticaceae, Poaceae, *Quercus* sp., *Fraxinus* sp., *Alnus* sp., *Corylus* sp., *Populus* sp., *Pinus* sp., *Picea* sp.) pokazuje uobičajenu diurnalnu raspodjelu na oba mjerna mjesta u obje godine. Porast koncentracije peluda u zraku zabilježen je nakon 4:00, odnosno 6:00 sati, vršna koncentracija se pojavljuje između 12:00 i 16:00 sati, a najniža koncentracija tijekom noći. Približno 50% 24 satne koncentracije peluda otpušta se u zrak između 10:00 i 16:00 sati što je usko povezano sa porastom temperature zraka, smanjenjem vlažnosti zraka te jugozapadnim smjerom vjetra.