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VARIATION IN RAGWEED (*AMBROSIA ARTEMISIIFOLIA* L.) POLLEN CONCENTRATION IN CENTRAL CROATIA, 2002-2003

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Abstract: The aim of the study was to determine the onset, duration and termination of the ragweed pollen season; intradiurnal, daily and monthly pollen variation, and possible differences in the occurrence and concentration of ragweed pollen according to sampling sites between 2002 and 2003. The study was conducted at three sampling sites in central Croatia over two pollen seasons (2002 and 2003) using the volumetric method of sampling (Hirst type sampler). In 2003, the ragweed pollen season was by 43% longer and the percentage proportion of ragweed pollen by 3.4% greater in comparison with 2002. The total ragweed pollen count and number of days with ragweed pollen concentration greater than 30 pollen grains per m^3 air showed a declining tendency from East to West in both seasons. The intradiurnal peak concentration occurred between 10.00–14.00. The air concentration of ragweed pollen decreased with temperature decline and precipitation. Results of the study provided useful information to individuals allergic to ragweed pollen thereby allowing them to adjust their outdoor activities to avoid contact with the allergen.

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INTRODUCTION

Ragweed (*Ambrosia artemisiifolia* L.) is an annual, anemophilous, extremely allergenic weed belonging to the family Asteraceae. The genus *Ambrosia* has some 40 species, of which only the following five have been found in Europe: *Ambrosia artemisiifolia* L., *A. trifida* L., *A. maritima* L., *A. tenuifolia* Spreng and *A. coronopifolia* Torr et Gray [28]. Ragweed was brought to Europe from America with corn transports. It is characterized by very fast spread due to the high production of dormant seed that can persist silently in the soil for up to 40 years with preserved sprouting ability [2]. In Europe, ragweed is found in Hungary, the Czech Republic, Slovakia, Poland, Austria, Switzerland, France, Italy (north-west regions of Piedmont and Lombardy, and north-east regions of Veneto and Friuli Venezia Giulia) [30], Bosnia [21], Croatia (Zagreb surroundings, Podravina, Posavina, Srijem) [10, 17], and Serbia (Vojvodina) [24]. In Central Europe, ragweed is not found at altitudes higher than 400 m above sea level, whereas in France it grows up to 1,000 m above sea level [3]. Ragweed grows on uncultivated ground, along roads, railways and watercourses, preferably in a warm climate and dry soil [5]. Being sensitive to competition with other plants, ragweed does not grow in forests or in areas with thick vegetation. Each

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Table 1. Pollen rating scale categories.

Pollen Rating Scale: (PRS)*	Pollen density (grains/m^3)			Allergy sufferers who are allergic to these pollens may experience symptoms of hay fever or asthma
	trees	grasses	weeds	
Absent	0	0	0	No symptoms
Low	1-15	1-5	1-10	Only individuals extremely sensitive to these pollens
Moderate	16-90	6-20	11-50	Many individuals sensitive to these pollens
High	91-1500	21-200	51-500	Most individuals with any sensitivity to these pollens
Very high	>1500	>200	>500	Almost all individuals with any sensitivity at all these pollens

*The following ranges are used to correlate the pollen density of different pollen types (trees, grasses & weeds) with the Forsyth County Environmental Affairs Department Pollen Rating Scale: (PRS)

individual plant produces huge amounts of highly allergenic pollen, which is then transported by air to great distances [2]. Because of its allergenic character, monitoring of ragweed pollen has been performed in Europe for years, e.g., since 1960 in the district of Lyon in France [6, 26, 27], soon thereafter in Burgundy [18], since 1989 in Italy and Hungary [11], in Slovenia [16], and since 2002 in Croatia [22].

The aim of the study was to determine the onset, length and termination of the ragweed pollen season; intradiurnal, daily and monthly pollen variation, and possible differences in the pollen occurrence and concentration according to sampling site between 2002–2003. The results of the study are expected to help prevent the symptoms of allergic reaction in individuals with ragweed pollen hypersensitivity, thus improving their quality of life.

MATERIAL AND METHODS

Pollen sampling. The material was collected at 3 sites in central Croatia in 2002 and 2003. Seven-day Hirst volumetric pollen and spore traps were used for pollen sampling [9, 23]. 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), in Ivanić Grad (45° 43' N and 16° 24' E, 101 m above sea level and 18.5 m above ground level), and in Samobor (45° 48' N and 15° 43' E, 168 m above sea level and 17.3 m above ground level). The distance between monitoring sites is about 30 km. The sampler absorbs 10 L of air per minute, allowing determination of pollen concentration at 2-hour intervals. It is supplied with a timer which moves adhesive tape (2 mm/h) for pollen grains to stick to.

Pollen counts. The tape was removed twice weekly, cut to a length corresponding to 24-hour 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, and dissolved in 200 mL of distilled water. After overnight rest, 100 mL glycerol $C_3H_8O_3$ were 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 ×400, to determine pollen type and count per 1 m^3 air per day. Pollen concentration was expressed as pollen grain count per m^3 and characterized as absent, low, moderate, high, or very high [29] (Tab. 1).

In order to define pollen season the study was limited by eliminating days with sporadic and accidental presence of pollen in the atmosphere at the start and end of the pollen season. The start of the pollen season was defined as the moment at which pollen appears in the air continuously.

RESULTS

The monitoring was performed at 3 sampling sites during the years 2002 and 2003. In 2002, the first pollen grains occurred at the beginning of August at all 3 sampling sites (August 2 in Ivanić Grad; and August 1 in Zagreb and Samobor). The peak pollination with highest daily pollen concentration was recorded in the first week of September, while the number of days with pollen concentration exceeding 30 pollen grains per m^3 air ranged from 19 (Samobor) through 34 (Zagreb) to 45 (Ivanić Grad). The percentage proportion of ragweed pollen in pooled annual pollen count ranged from 5.8–24.1% at different sampling sites.

Table 2. Data on the presence of ragweed pollen in 3 measuring sites in 2002-2003.

Sampling site	Year	Period of occurrence	Peak day	Concentration on peak day (p/m^3)	No. of days with > 30 p/m^3	Total pollen count	Ragweed pollen count	% of ragweed pollen in total pollen count
Zagreb	2002	1/8 – 5/10	3/9	652	34	71,286	9,243	12.9
	2003	28/6 – 29/10	6/9	883	46	72,556	9,601	13.2
Samobor	2002	1/8 – 11/10	1/9	367	19	50,112	2,946	5.8
	2003	27/6 – 30/10	26/8	447	30	52,996	4,034	7.6
Ivanić Grad	2002	2/8 – 17/10	4/9	1,239	45	70,698	17,057	24.1
	2003	25/6 – 31/10	19/8	2,819	54	76,254	24,801	32.5

In 2003, the first pollen grains were recorded at the end of June at all sampling sites (25 June in Ivanić Grad; 28 June in Zagreb; and 27 June in Samobor). The peak pollination was observed in the second half of August, except for the Zagreb sampling site where it occurred at the beginning of September. The number of days with pollen concentration greater than 30 pollen grains per m^3 air exceeded that recorded in 2002 by 17–37%, ranging from 30 (Samobor) through 46 (Zagreb) to 54 (Ivanić Grad). The percentage proportion of ragweed pollen in pooled annual pollen count was also greater than that recorded in 2002, and ranged from 7.6% in Samobor to as high as 32.5% in Ivanić Grad (Tab. 2, Fig. 1).

Total concentrations of ragweed pollen measured at all 3 sampling sites in 2002 (Ivanić Grad 17,057, Zagreb 9,243 and Samobor 2,946 pollen grains) were lower than those recorded in 2003 (Ivanić Grad 24,801, Zagreb 9,601 and Samobor 4,034 pollen grains) (Tab. 2, Fig. 2). The concentration of ragweed pollen during pollination was greatly influenced by temperature and precipitation. In 2003, the very early onset of the pollen season (end of June) was influenced by high temperature, which was 23.8°C and by 4.5°C higher on an average than in the same period of 2002. In August and September 2002, i.e. peak pollen season, there were 25 days with considerable precipitation, thus the concentrations of ragweed pollen were reduced to quite low and moderate levels. During the peak ragweed pollination (1-4 September) recorded at all monitoring sites, the temperature was between 20.8–22.4°C, without precipitation. During the same period of 2003, there were less days (n=18) with low precipitation,

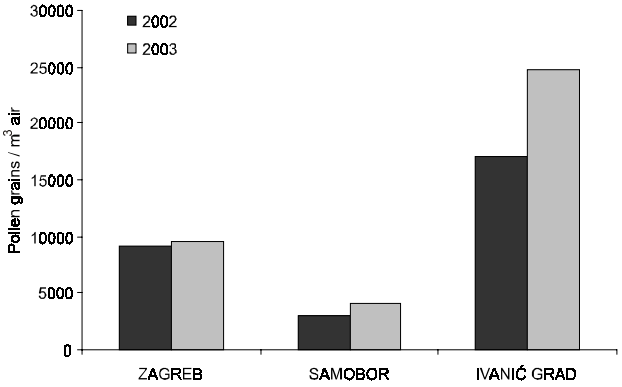

Figure 2. Total ragweed pollen count at sampling sites in Zagreb, Samobor and Ivanić Grad, 2002 and 2003.

thus pollen concentrations were considerably higher. On the days characterized by highest pollen concentrations at all sampling sites (6 September, 19 and 26 August), the temperature ranged from 19–26.9°C, also without precipitation (Fig. 1 and 3). The long dry period with a relatively high temperature for this time of the year prolonged the 2003 pollen season until the end of October.

There were no major differences in the intradiurnal pollen pattern at the 3 sampling sites between 2002–2003. In August and September 2002, pollen concentrations started rising between 06:00–08:00 at all sampling sites, to reach peak levels between 12:00–14:00 at the Ivanić Grad and Samobor sampling sites, and between 10:00–12:00 at the Zagreb sampling site. In September, the peak concentration was recorded between 10:00–12:00 at the

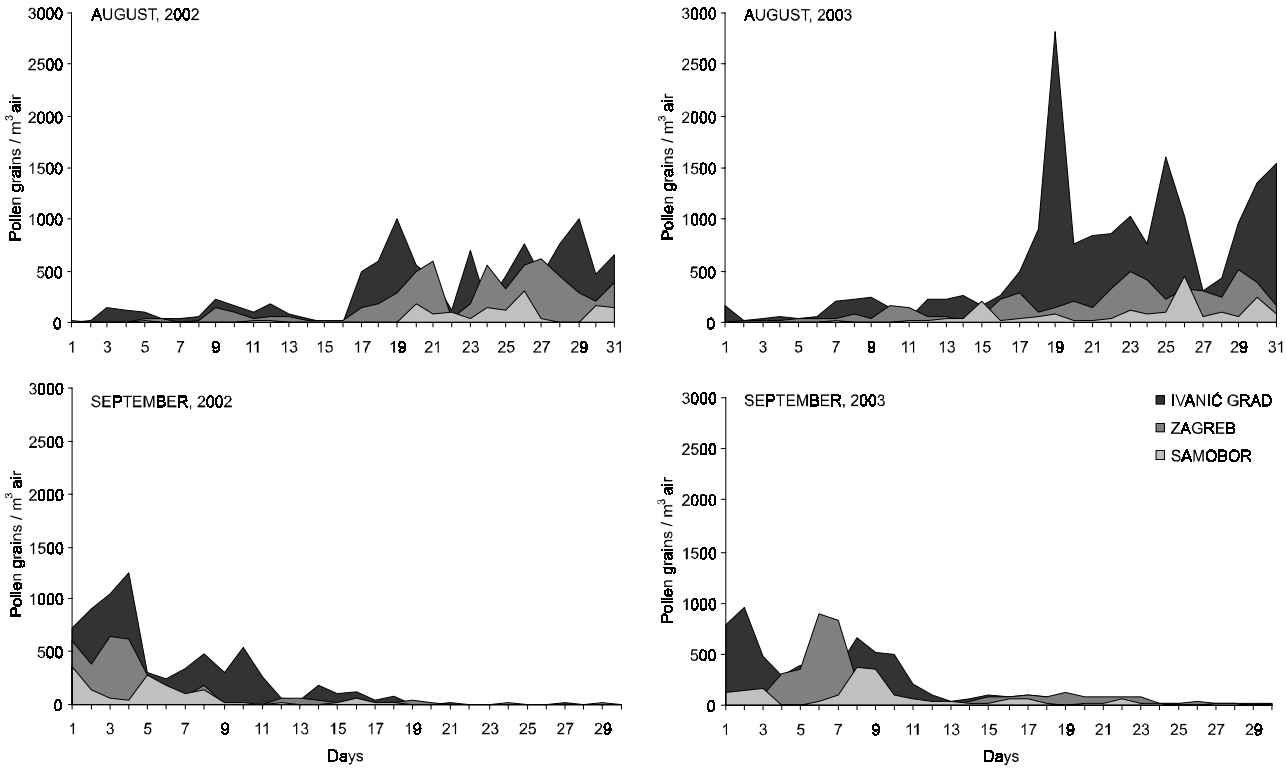

Figure 1. Daily variation in ragweed pollen concentration at monitoring sites in Ivanić Grad, Zagreb and Sambor in August/September 2002 and 2003.

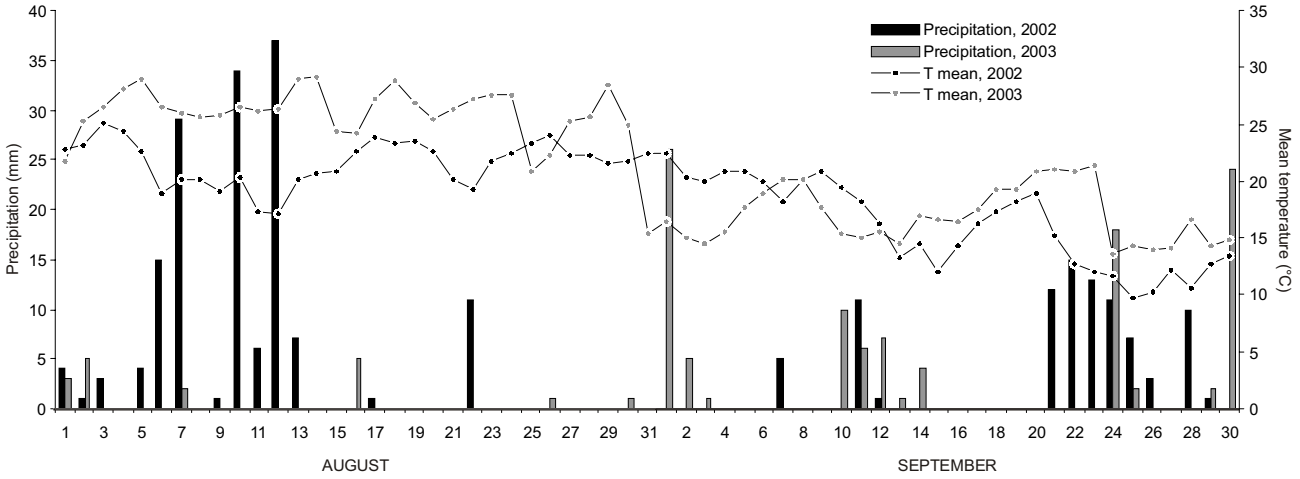

Figure 3. Daily temperature and precipitation variation in August/September 2002 and 2003.

Ivanić Grad and Samobor sampling sites, and between 12:00–14:00 at the Zagreb sampling site. In 2003, the peak concentration in August was recorded between 10:00–12:00 at all three sampling sites, and in September between 12:00–14:00 at the Zagreb and Ivanić Grad sampling sites, whereas 2 peaks were observed at the Samobor sampling site, i.e. between 08:00–10:00, and between 14:00–16:00 (Fig. 4).

DISCUSSION

Ragweed pollen is the third most abundant pollen type to occur in the atmosphere of central Croatia, accounting for 14.3% in 2002 and 17.7% in 2003 annual pollen spectrum, which was by 1.3% a greater percentage proportion in the city of Zagreb recorded in 2002 [22]. However, such a high proportion is still lower than the proportion of ragweed pollen in Montreal, Canada, where it accounts for one third of the total annual pollen count, causing 50–75% of seasonal rhinitis cases [2]. Results of the present study showed considerable variation in ragweed pollen concentration according to monitoring sites. Highest concentrations during both pollen seasons were measured at the sampling site in Ivanić Grad, which is a typical lowland rural area with much uncultivated and overgrown ground, whereas the land under cultivation is partly with corn and sunflower, the cultures most abundant in ragweed. Considerably lower pollen concentrations were

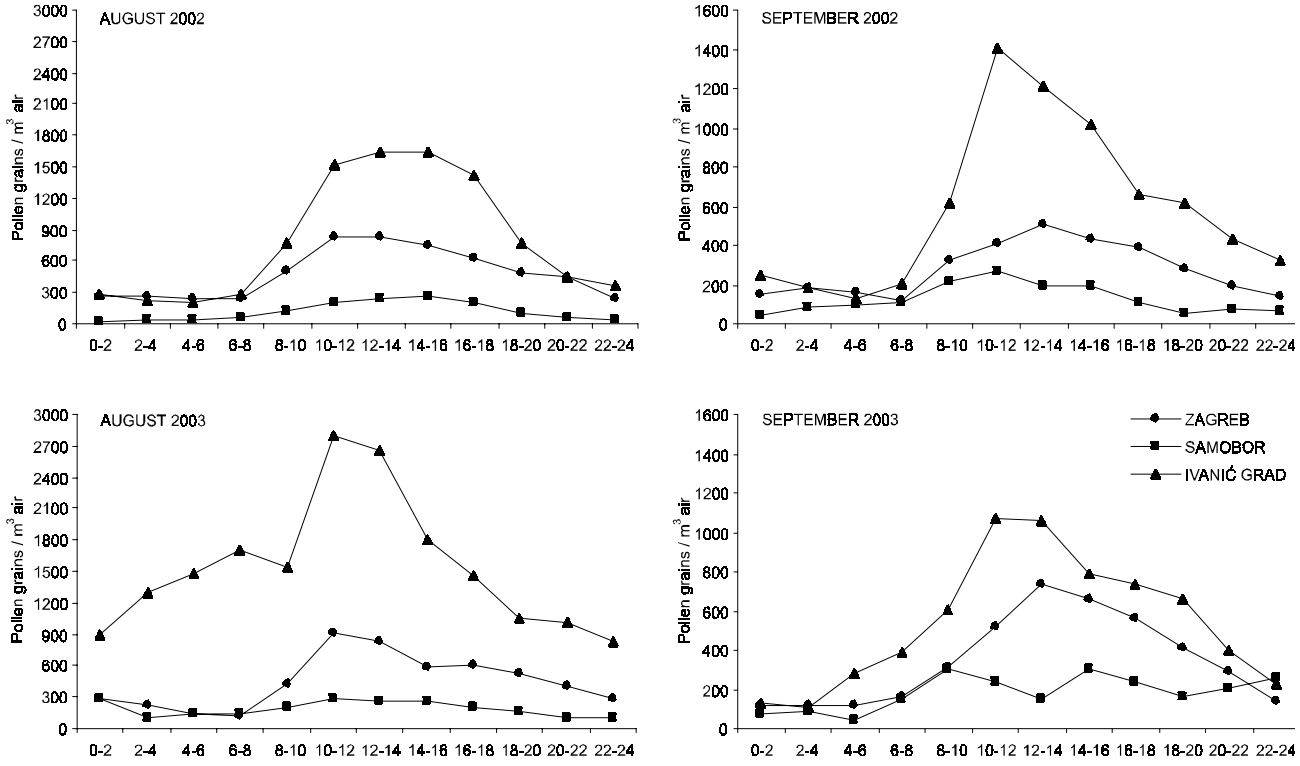

Figure 4. Intradiurnal ragweed pollen variation at monitoring sites in Zagreb, Samobor and Ivanić Grad in August/September 2002 and 2003.

recorded at the sampling site in Zagreb, which is quite conceivable knowing that Zagreb is closed by the Medvednica mountain (effect of forest vegetation) to the north and is open to the south crossing the Sava river (effect of ruderal, weedy and aqueous vegetation). The sampling site in Samobor is located in a valley surrounded by thermophilic forest vegetation, thus the concentrations of ragweed pollen are the lowest. The monitoring sites were placed in an E-to-W direction (Ivanić Grad, Zagreb and Samobor), the same direction of ragweed dissemination in Europe [13]. Maximum emissions were restricted to the summer months of August and September, the warmest and driest months of the year [15], which is consistent with the data reported for Austria and Switzerland, as well as for countries in the central part of eastern Europe [4, 14, 20]. Variations in ragweed airborne pollen concentrations greatly depend on weather conditions, i.e. on a number of meteorologic parameters. The individual rhythm of plant pollination and phenologic phenomena is modified by the effects of weather conditions [1, 7, 8]. Results of this study showed that the ragweed airborne pollen concentrations throughout the pollen season declined with temperature decrease. This is clearly demonstrated during the period of cold weather (and opposite). The ragweed airborne pollen concentration in the air decreases with precipitation, as indicated by lower pollen concentration on a rainy day or the day thereafter. Also, a rising tendency of the ragweed pollen concentration related to weather conditions was observed in 2003, as this was an extremely warm and dry year; thus the pollen season was considerably prolonged.

Accurate information on daily pollen concentrations exceeding 30 pollen grains per m^3 air is of great importance to persons with ambrosia pollen allergy, because the accumulation of high pollen amounts in the atmosphere produces the effects of pollinosis in the respiratory tract. Our results show that 19-45 days in 2002 and 30-54 days in 2003 were the critical periods with daily pollen counts over the allergologic threshold value, which considerably exceeded the periods reported for Hungary (25-30 days) [12] and Poland (1-5 days) [25]. In the present study, the pronounced intradiurnal periodicity showed a peak from 10:00–14:00, whereas in France the peak occurs earlier during the day, between 9:00–11:00 [19]. Intradiurnal variation in pollen concentration seems to be the most crucial part of public reports, allowing allergy patients to adjust their daily outdoor activities according to pollen peaks and off-peaks.

CONCLUSIONS

1. In 2003, the pollination of ragweed in central Croatia was by 54 days (or 43%) longer than that recorded in 2002.

2. In 2003, the percentage proportion of ragweed pollen in the overall annual pollen count was by 3.4% greater than that recorded in 2002.

3. Total ragweed pollen count measured at 3 sampling sites showed a decrease in the E-to-W pattern in both pollen seasons.

4. The number of days with pollen concentration in the atmosphere exceeding the threshold of 30 pollen grains per m^3 air differed among sampling sites, showing a decrease in the E-to-W pattern.

5. Air concentration of ragweed pollen decreased with temperature decline and precipitations, and vice versa (short-term effect).

6. Intradiurnal periodicity of ragweed pollen showed no major differences between the 2 seasons at any of the sampling sites. Peak concentrations were recorded between 10:00–14:00.

7. Results of this study provide useful information to individuals with ragweed pollen allergy, allowing them to adjust their outdoor activities to avoid contact with the allergen.

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