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Variations in Mugwort (*Artemisia* Spp.) Airborne Pollen Concentrations at Three Sites in Central Croatia, in Period from 2002 to 2003

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A B S T R A C T

In spite of the low atmospheric pollen levels, Artemisia *sensitisation and allergy has been reported widely. The aim of the study was to determine the length of pollen season, intradiurnal, daily and monthly pollen variation, and the effect of some meteorological parameters on atmospheric pollen concentrations in Central Croatia. Seven-day Hirst volumetric pollen and spore traps were used for pollen sampling. The* Artemisia *pollen season lasted from the end of July until the end of September with the highest concentrations in August. The percentage of the total pollen count ranged from 0.52% to 0.92%. The intradiurnal peak occurred between 10 a.m. and 12 a.m. Statistical analysis showed a significant correlations between higher air temperature and high pollen concentration as well as high precipitation and low pollen concentration. Results of this study are expected to help in preventing the symptoms of allergic reaction in individuals with* Artemisia *pollen hypersensitivity.*

Key words*: aeropalynology, meteorological parameters,* Artemisia*, pollen season*

Introduction

The genus *Artemisia* belongs to a very extensive plant family *Asteraceae (Compositae)*, which includes a number of allergenic representatives[1]. *Artemisia* is a typical and widespread weed. The most common species in Europe are *Artemisia vulgaris* (mugwort), abundantly present all over the continent, and *A. verlotorum* and *A. annua,* predominantly in the southern half of Europe[2,3]. Many species of *Artemisia* preferably grow on ruderal and disturbed soils, in urban and suburban areas, at industrial and building sites, in rural areas and in the countryside along roads. Although this weed is widely spread, its highly allergenic pollen is rarely found at high concentrations in the air, accounting for only 0.5% to 5% of the total annual pollen concentration at particular monitoring sites in Europe[2,4,5]. In spite of the low atmospheric pollen count, the incidence of pollen allergies (asthma, allergic rhinitis and allergic conjunctivitis) caused by *Artemisia* pollen ranges between 3% and 10% of the overall prevalence of pollinosis in some European countries. *Artemisia* is an important cause of sensitisation and allergy in Germany[6], in Italy and France with sensitisation prevalence increasing[7–9], Poland[10,11], south Hungary[12] and in Switzerland[13,14]. *Artemisia* pollen sensitisation has also been reported from Sweden and Finland, but during 12-year period, showed a decrease, as compared to other pollen allergens[15].

The first research into allergenic pollen distribution in Croatia was launched in 1959 at four locations: Zagreb, Hvar, Crikvenica and Dubrovnik[16]. Using gravimetric method, data were collected weekly throught the year. Since 1973, allergenic pollen has been continuously studied in Zagreb[17]. Modern aerobiologic investigations using daily volumetric monitoring of atmospheric pollen began in Croatia in 2002[18].

The aim of the study was to determine the length of pollen season, intradiurnal, daily and monthly pollen variation, effect of some meteorological parameters on atmospheric pollen concentration, and possible variation in the occurrence and concentration of *Artemisia* pollen at three monitoring sites in Central Croatia over 2002–2003. Results of this aeropalynological study are expected to contribute to the prevention of allergic symptoms in individuals with *Artemisia* pollen hypersensitivity, thus improving their quality of life.

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Material and Methods

Monitoring sites

This study was conducted in 3 localities of Central Croatia from January 5, 2002 to December 20, 2003. The samplers were placed in Zagreb (45° 49' N and 15° 59' E, 157 m above the sea level and 19.7 m above the ground level), in Ivanić Grad (45° 43' N and 16° 24' E, 101 m above the sea level and 18.5 m above the ground level), and in Samobor (45° 48' N and 15° 43' E, 168 m above the sea level and 17.3 m above the ground level). The distance between recording sites is about 30 km (Figure 1). All monitoring sites have a contintntal climate (Table 1). The meteorological data for each location were provided by different stations of the Croatian Weather Bureau (Zagreb-Grič, Čazma and Samobor).

Fig. 1. Monitoring sites in central Croatia.

Pollen sampling and counts

A 7-day Hirst volumetric pollen and spore traps were used for pollen sampling[19]. The sampler absorbs 10 L air per minute, allowing determination of pollen concentration at 2-hour intervals (for practical sampling details see[20,21]). It is supplied with a clock-work driven drum which moves adhesive tape (2 mm/h) for pollen grains to stick to. The tape was 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 was clarified. Then, 4 drops of alcohol solution of basic fuchsin $C_{20}H_{20}CIN_3$ *per* 100 mL were added. Recognition and counting of pollen grains was performed under light microscope (400x). Pollen grain counts were expressed as pollen grains per cubic meter of air[22,23]. Pollen data set in relation to the meteorological parameters (mean air temperature and precipitations) was tested with Spearman's rank test.

Results

In 2002, *Artemisia* pollen grains initially occurred in the second half of July at all monitoring sites (Zagreb: July 20, Samobor: July 19, and Ivanić Grad: July 21). Peak daily pollen concentrations were recorded from August 9 to August 16 at different monitoring sites. A high concentration of *Artemisia* pollen (72 pollen grains/m^3 air *per* day) was only recorded on a single day at the Zagreb monitoring site (August 9), whereas low to moderate concentrations were measured on all other days of observation. At other monitoring sites, air concentration of *Artemisia* pollen grains did not exceed moderate levels during the 2002 pollen season. The percentage of *Artemisia* pollen in the total annual atmospheric pollen concentrations was low at all monitoring sites, ranging from 0.52% in Ivanić Grad to 0.92% in Zagreb. In 2003, the pollen season started earlier than the previous year in Zagreb, whereas at the other two sites it was delayed by ten days (Zagreb: July 14, Samobor: July 27, and Ivanić Grad: August 2). However, total *Artemisia* pollen count exceeded that of the previous year's, despite the shorter pollen season. This did not apply for the Zagreb, where an inverse pattern was observed. The peak daily concentration did not exceed moderate levels at any of the monitoring sites (Table 2).

At all monitoring sites, *Artemisia* pollen concentrations were significantly influenced by temperature and precipitation. Concerning weather conditions, the *Artemisia* pollination months in 2002 were warm and wet, with average temperature and total precipitation (July 21.7–23 °C, 60.9–148.2 mm; August 21–23 °C, 128.5–151.0 mm), whereas a temperature decline and increased precipitation were recorded in the last ten days of September (15.6–17 °C, 67.5–94.9 mm). The number of pre-

TABLE 1
MEAN YEARLY AIR TEMPERATURES AND PRECIPITATIONS COMPARED TO THE LONG-TERM MEANS

Meteorological station	Temperature (°C)			Precipitation (mm)		
	Long-term average (1961–1990)	2003	2004	Long-term average (1961–1990)	2003	2004
Zagreb	11.2	12.9	11.2	882.8	624.4	918.4
Samobor*	10.4	11.7	11.2	1181.9	728.4	1044.6
Čazma	10.5	11.4	10.9	880.3	692.0	972.0

* long-term average for Samobor (1972–1990)

TABLE 2
DATA CONCERNING THE PRESENCE OF *ARTEMISIA* POLLEN ON THREE MONITORING SITES IN CROATIA, 2002–2003.

Site	Year	Period of occurrence	Peak day	Peak day concentration	Total pollen	*Artemisia* pollen	% of *Artemisia* pollen in total pollen
Zagreb	2002	July 20th – September 28th	August 9th	72	71,286	667	0.92
	2003	July 14th – September 29th	August 10th	50	72,556	506	0.69
Samobor	2002	July 19th – September 30th	August 11th	28	50,112	294	0.58
	2003	July 27th – September 30th	August 10th	30	52,996	345	0.65
Ivanić Grad	2002	July 21th – September 28th	August 16th	39	70,698	374	0.52
	2003	August 2nd – September 28th	August 11th	48	76,254	474	0.62

cipitation days during these three months ranged from 33 to 45 at the three monitoring sites. Temperature decline was recorded on rainy days and was associated with a decrease in daily pollen concentration at all three monitoring sites (Figure 2). In 2003, the *Artemisia* pollination months were very warm and dry (July: 22.2–23.8 °C, 53.5–78.6 mm; August: 22.2–26.2 °C, 17.4–57.4 mm), followed by temperature decline and precipitation increase

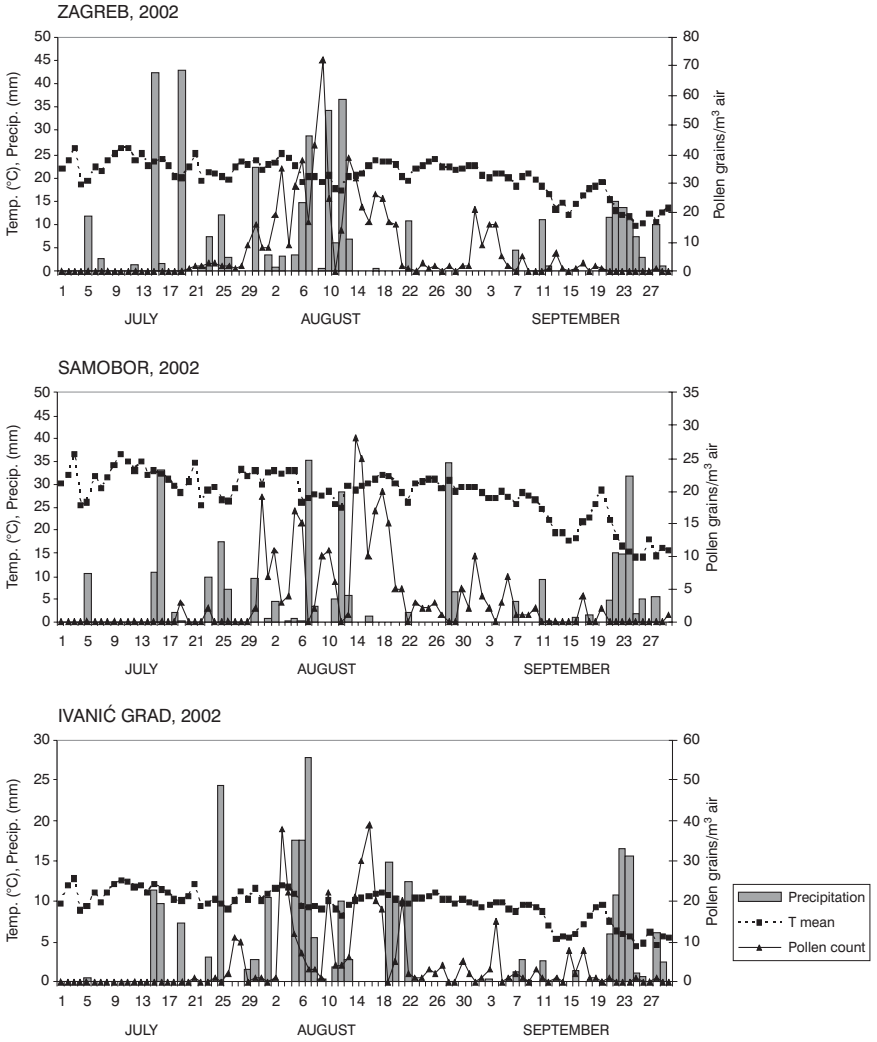

Fig. 2. Daily variations in Artemisia *pollen concentrations, temperature (Temp.) and precipitations (Precip.) in three different sites in Central Croatia over 2002.*

in September (16.1–17.2 °C, 60.7–106.6 mm). The number of rainy days was lower than the year before, ranging from 29 to 33 (Figure 3). Finally, the *Artemisia* pollen concentrations showed a statistically significant correla-

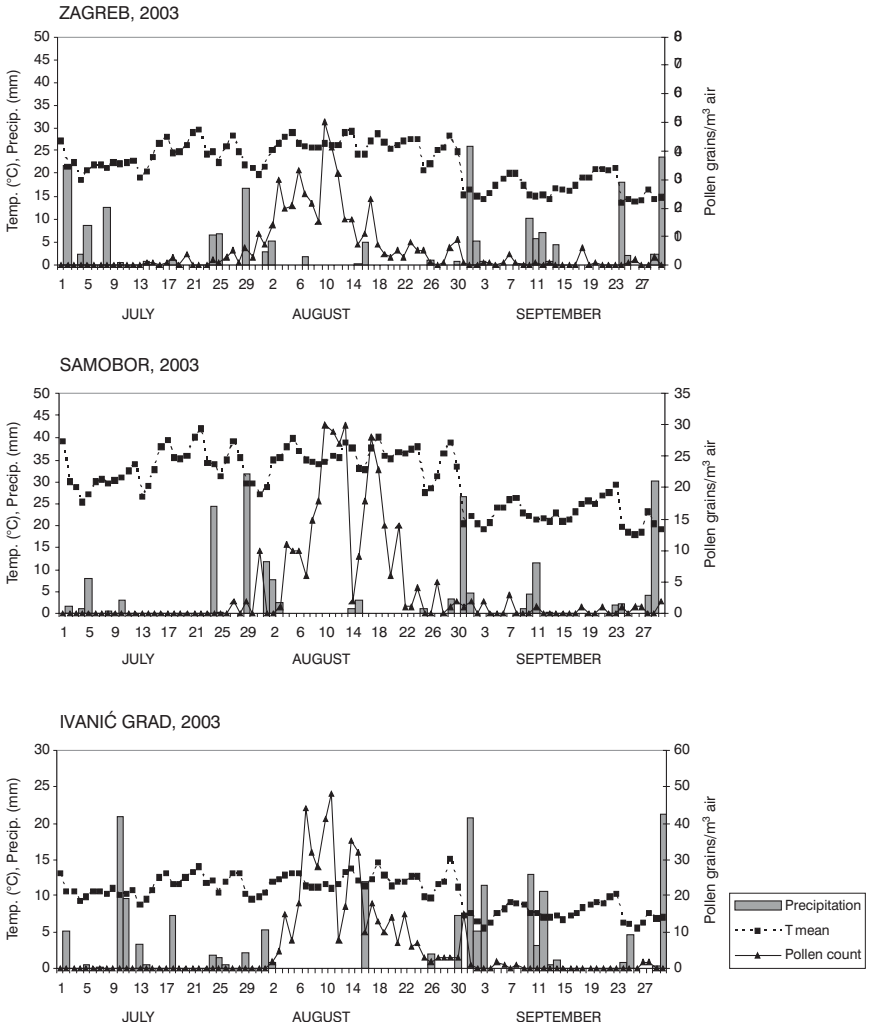

Fig. 3. Daily variations in Artemisia *pollen concentrations, temperature (Temp.) and precipitations (Precip.) in three different sites in Central Croatia over 2003.*

TABLE 3.
SUMMARIZED RESULTS OF THE STATISTICAL ANALYSIS POLLEN DATA IN RELATION TO THE METEOROLOGICAL PARAMETERS

Pair of variables	Spearman rank order correlations			
	Valid N	Spearman rank	t(N-2)	p-level
Temperature and pollen				
Zagreb	62	0.471838	4.11060	0.000124*
Samobor	62	0.099544	0.76843	0.445298
Ivanić Grad	62	0.414697	3.50054	0.000891*
Precipitation and pollen				
Zagreb	62	–0.429622	–3.65443	0.000550*
Samobor	62	–0.462305	–4.00468	0.000176*
Ivanić Grad	62	–0.282265	–2.26002	0.027526*

Marked values (*) are statistically significant ($p<0.05$), pair of variables – variables in correlation, Valid N – valid number of variables, t(N-2) – t distribution on N-2 degrees of freedom, p-level – probability level

tion with temperature, however, no such correlation was found in Samobor. In both seasons at all monitoring sites there was a statistically significant negative correlation with precipitation (Table 3.)

Intradiurnal pollen distribution was almost identical in 2002 and 2003 at all three monitoring sites. A slight decrease in pollen concentration was recorded between 2 and 4 a.m. relative to 0–2 a.m., and an abrupt increase after 8 a.m. Peak concentrations were recorded at 10–12 a.m., followed by a decline by the end of the day. A major difference in the peak pollen concentration was only recorded at the Zagreb monitoring site, where a total of 181 pollen grains were found between 10 and 12 a.m. throughout the 2002 pollen season (July, August and September), whereas a nearly half this concentration (95 pollen grains) was observed in 2003 (Figure 4).

Discussion

In spite of the widespread and common occurrence of *Artemisia* plants, their airborne pollen concentrations have hardly ever been reported to reach high levels. In Central Croatia, a high concentration of *Artemisia* pollen was recorded on a single day at one of the three sampling sites in 2002. At the other two sampling sites, the concentration did not exceed 50 pollen grains *per* m^3 in either 2002 or 2003. The percentage of *Artemisia* pollen in the total annual pollen count was low, ranging from 0.52% to 0.92%, which is consistent with the lower European sample limit of 0.5% to 5% [24–26]. In Central Croatia, the *Artemisia* pollen season starts in the end of July and terminates towards the end of September. Major concentrations of *Artemisia* pollen grains were recorded in August. A similar pattern has also been reported from other European countries[2,3,25–27]. In Croatia, the pollen season was somewhat prolonged in the two study years. Intradiurnal pollen distribution at the three monitoring sites showed peak concentrations between 10 and 12 a.m. in both 2002 and 2003. The timing of peak *Artemisia* pollen concentration depends on the sampling height, because of different wind speed[28]. Generally, *Artemisia* releases its pollen in the early morning hours, before the air turbulence convection preventing pollen grains from being lifted up to atmospheric layers higher than 3–10 m, which is why this production peak is not recorded by pollen traps located on the building roof tops, their usual positions. When later in the day insolation at the Earth surface causes air turbulence, the *Artemisia* pollen has already deposited on the available substrates, while hardly any further pollen release occurs. As pollen trap located close to the ground level will measure the early morning peak, leading to the observation of higher daily airborne concentrations and a distinct diurnal pattern[29]. However this phenomenon is sometimes much more complex: influence of topography and regional vegetation. The pollen released to the atmosphere is mostly influenced by temperature and precipitation[30–32]. Statistical analysis showed that mean temperature and preci-

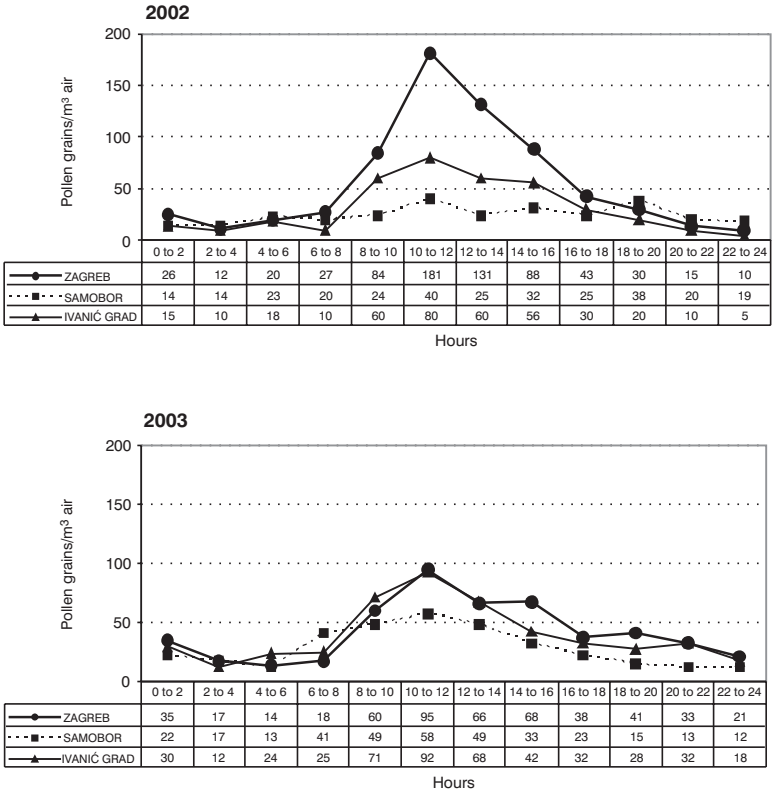

Fig. 4. Intradiurnal variations of Artemisia *pollen concentrations in Central Croatia, July-September 2002 and 2003.*

pitation are parameters that yealds highest correlation with *Artemisia* pollen in the atmosphere. On rainy days, the pollen concentration decreased to the minimum, as indicated by our results.

Daily concentration variation is usually useful for published pollen reports prophylaxis of allergenic individuals, because whenever possible they could plan their activities and by choosing the time and place of holidays they can avoid exposure to large doses of the allergen. Data of intradiurnal concentration variation are the most important for establishing relations between pollen counts and local meteorology. These conclusions have been made on the basis of two years investigation; future studies over a longer study period will be necessary to gain a clearer insight into the relationship between weather parameters and airborne pollen concentrations in the air.

REFERENCES

1. RAKOSKI, J., Alergologie, 12 (1989) 230. — 2. CARAMIELLO, R., C. SINISCALCO, V. POLLINI, Grana, 28 (1989) 105. — 3. ROMANO, B., G. MINCIGRUCCI, G. FRENGUELLI, E. BRICCHI, Experientia, 44 (1988) 625. — 4. GOLDBERG, C., H. BUCH, I. MOSEHOLM, E. R. WEEKS, Grana, 27 (1988) 209. — 5. SPIEKSMA, F. T. M., Grana, 25 (1986) 47. — 6. KRAMER, U., E. LI NK, H. BEHRENDT, Pneumologie, 55 (2001) 229. — 7. NARDI, G., O. DEMASI, A. MARCHEGIANI, R. PIERDOMENICO, G. MINCIGRUCCI., B. ROMANO, G. FRENGUELLI, E. BRICCHI, Ann. Allergy, 57 (1986) 193. — 8. CORSICO, R., P. FALAGIANI, R. ARIANO, D. BERRA, C. BIALE, F. BONIFAZI, P. CAMPI, J. Investig. Allergol. Clin. Immunol., 10 (2000) 155. — 9. DECHAMP, C., D. HOCH, M. CHOURAQUI, M. BENSOUSSAN, J. DECHAMP, Allerg. Immunol. (Paris), 19 (1987) 244. — 10. MAY, K., Pol. Tyg. Lek., 45 (1990) 861. — 11. SILNY, W., D. KUCHTA, D. SIATECKA, P. SILNY, Otolaryngol. Pol., 53 (1999) 55. — 12. KADOCSA, E., M. JUHASZ, Orv. Hetil., 138 (1997) 851. — 13. SCHMID-GRENDELMEIER, P., Schweiz Rundsch. Med. Prax., 87 (1998) 1300. — 14. SCHMID-GRENDELMEIER, P., Ther. Umsch., 58 (2001) 285. — 15. ERIKSSON, N. E., A. HOLMEN, J. Investig. Allergol. Clin. Immunol., 6 (1996) 36. — 16. VOLARIĆ-MRŠIĆ, I., Acta Bot. Croat., 29 (1972) 83. — 17. LOVAŠEN-EBERHARDT, Ž., Godišnje kretanje i sastav polena na području Zagreba u vremenu od 1973.–1978. godine. In: Proceedings. In Croat. (Second Congress of Ecologists Yugoslavia, Zadar, 1979). — 18. PETERNEL, R., J. ČULIG, B. MITIĆ, I. VUKUŠIĆ, Z. ŠOSTAR, Ann. Agric. Environ., 10 (2003) 1. — 19. HIRST, J. M., Ann. Appl. Biol., 39 (1952) 257. — 20. OGDEN, E. C., G. S. RAYNOR, J. V. HAYNES, D. M. LEWIS, J. H. HAINES: Manual for sampling airborne pollen. (Hafner, New York, 1974). — 21. GIOULEKAS, D., D. PAPAKOSTA, A. DAMIALIS, F. SPIEKSMA, P. GIOULEKA, D. PATAKAS, Allergy, 59 (2004) 174. — 22. BUSH, R., J. Allergy Clin. Immunol., 64 (1989) 1120. — 23. GALANT, S., W. BERGER, S. GILLMAN, A. GOLDSOBEL, G. INCAUDO, L. KANTER, Ann. Allergy Asthma. Immunol., 81 (1998) 203. — 24. LEJOLY-GABRIEL, M., R. M. LEUSCHNER, Grana, 22 (1983) 59. — 25. MEIFFREN, I., Grana, 27 (1988) 183. — 26. SPIEKSMA, F. T. M., G. FRENGUELLI, A. H. NIKKELS, G. MINCIGRUCCI, L. O. M. J. SMITHVIS, I. BRICCHI, W. DANKAART, B. ROMANO, Grana, 28 (1989) 25. — 27. D'AMATO, G., G. COCCO, G. LICCARDI, G. MELILLO, Clin. Allergy, 13 (1983) 537. — 28. WAHL, P. G., K. F. PULS, Aerobiologia, 5 (1989) 55. — 29. SPIEKSMA, F. T. M., P. G. VON WAHL, Allergenic significance of Artemisia (mugwort) pollen. In: D'AMATO. G, F. T. M. SPIEKSMA, S. BONINI (Eds): Allergenic Pollen and Pollinosis in Europe. (Blackwell Scientific Publications, London, 1991). — 30. CARAMIELLO, R., V. POLLINI, C. SINISCALCO, L. MERCALI, Grana, 29 (1990) 239. — 31. CARAMIELLO, R., C. SINISCALCO, L. MERCALLI, A. POTENZA, Grana, 33 (1994) 327. — 32. EMBERLIN, J. C., M. SAVAGE, R.WOODMAN, Grana, 32 (1993) 359.

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VARIJACIJE KONCENTRACIJA PELUDA PELINA (*ARTEMISIA* Spp.) U ZRAKU SREDIŠNJE HRVATSKE, 2002–2003

SAŽETAK

Usprkos niskim koncentracijama peluda *Artemisia* u zraku, alergije na tu vrstu peluda široko su rasprostranjene. Cilj rada bio je odrediti duljinu peludne sezone, intradiurnalne, dnevne i mjesečne varijacije koncentracije peluda *Artemisia* u zraku središnje Hrvatske. Za uzorkovanje se koristio sedmodnevni volumetrijski uzorkivač za pelud i spore, Hirst-ovog tipa. Sezona pojavljivanja peluda *Artemisia* u zraku traje od kraja srpnja, do kraja rujna, sa najvišim koncentracijama u mjesecu kolovozu. Postotni udio peluda *Artemisia* ima raspon od 0.52% do 0.92% od ukupnog godišnjeg broja peluda svih ostalih taksona. Najviše intradiurnalne koncentracije zabilježene su između 10:00 i 12:00 sati. Statističkom analizom dobivene su pozitivne signifikantne korelacije peluda s temperaturama zraka te negativne s količinama padalina.