ORIGINAL ARTICLES AAEM

Ann Agric Environ Med 2005, 12, 75–79

AIRBORNE RAGWEED POLLEN CONCENTRATION IN NORTH-EASTERN CROATIA AND ITS RELATIONSHIP WITH METEOROLOGICAL PARAMETERS

Edita Stefanic, Vesna Kovacevic, Zeljko Lazanin

Faculty of Agriculture, J. J. Strossmayer University, Osijek, Croatia

Stefanic E, Kovacevic V, Lazanin Z: Airborne ragweed pollen concentration in north-eastern Croatia and its relationship with meteorological parameters. *Ann Agric Environ Med* 2005, **12**, 75–79.

Abstract: Airborne ragweed pollen concentration in the north-eastern part of Croatia was investigated in relation to some meteorological factors. Data was obtained for three consecutive years (2001, 2002 and 2003) using volumetric method (Burkard trap). The correlation between the concentration of pollen grains in the atmosphere and maximum, minimum and mean daily temperature, daily temperature range, sunshine hours, relative humidity and precipitation from daily monitoring was studied. The critical ragweed pollen season appears from 33rd to 38th week, with its peak at the beginning of September each year. Statistically significant correlation between the ragweed pollen count and selected meteorological variables were found in some study years, but only a correlation with the mean air temperature and ragweed pollen presence in the air was significant over time.

Address for correspondence: Dr. Edita Stefanic, Faculty of Agriculture, Trg Svetog Trojstva 3, J.J. Strossmayer University, 31000 Osijek, Croatia. E-mail: sedita@pfos.hr

Key words: ragweed (*Ambrosia artemisiifolia* L.), pollen count, meteorological conditions, Spearman's correlation coefficient, Croatia 2001-2003.

INTRODUCTION

Ragweed is an important genus of the Asteraceae family which has its probable origin in Southern North America. This highly allergenic, anemophilous genus includes about 42 species [1]. Among them, five species are recorded in Europe: short ragweed *Ambrosia atremisiifolia* L., (=*A. elatior* L.) giant ragweed *Ambrosia trifida* L., perennial ragweed *Ambrosia psilostachya* DC, (=*A. coronopifolia* Torrey), silver ragweed *Ambrosia tenuifolia* Sprengel and sea ragweed *Ambrosia maritima* L. [32]. However, only short ragweed represents a serious problem for the allergenic population in many areas of the world.

During recent decades, short ragweed has spread rapidly in Europe establishing itself as an important aeroallergen in some countries of South-Eastern, Central and Eastern Europe [13, 34, 35]. It has become a great problem in France, North Italy and in Hungary where clinical investigations prove that pollen of ragweed represents the major cause of the most serious and most lasting pollinosis [12, 16, 20].

In the Republic of Croatia short ragweed is recognized both as a principle source of pollen for autumn allergies and as a common agricultural weed causing an enormous economic problem for farmers [30]. Based on an investigation in 1977 [31], ragweed was recorded as the 19th most troublesome weed in row crops of the continental part of the Croatia. However, today it has became a dominant weed in row crops, wheat stubble-fields, along roadsides and railways lines, and ruderal areas of the same region.

Compared with other European countries, there were few aerobiological studies in the Republic of Croatia [17, 18] and all of them used the gravimetric method providing only qualitative pollen content results, but not

Received: 31 January 2005
Accepted: 20 April 2005

volumetric pollen concentration. The first volumetric study started in Osijek (north-eastern part of the Republic of Croatia) during the spring of 2001.

Ragweed pollen in the air represents the major cause of pollynosis in the investigated region. It is speculated that more than 10% of the population suffer from different kinds of unpleasant symptoms during the ragweed flowering period. These symptoms are manifesting as sneezing, itching, running nose and eyes, and can develop into asthma [27].

Since the meteorological factor has an important influence on airborne pollen concentration, the aim of this study tends to determine the seasonal behavior of ragweed pollen grains and its relationship to meteorological parameters for the conditions of north-eastern Croatia.

MATERIAL AND METHODS

The study area corresponds to north-eastern Croatia, a province situated at the northeast corner of the Republic of Croatia and represents a flat and open region. This district with an area of 2166 km² consisting of Baranja region in the north, is situated between the rivers Drava and Danube and the Hungarian state border, and the Drava valley in the south.

Investigated area represents the main agricultural part of the country, with Osijek as the administrative centre of the whole region (located at 18º68' N 45º55' E). From the climatic point of view this region experiences a warm and moderate dry lowland climate with an average yearly temperature of 11.4ºC and ranging from July as the warmest month (21.4ºC on average) to January (0.2ºC on average) as the coldest month. An average yearly rainfall is 699 mm with the highest spring rainfall regime in June. Mean precipitation and mean air temperature during the study period (2001-2003) is shown on Figure 1.

The representative samples of the atmospheric pollen content were taken using a Hirst-type volumetric sampler (Burkard Scientific, Uxbridge, Middlesex, UK) located at about 15 m above ground level [7]. The trap was calibrated weekly to maintain a flow rate of 10 l/min. The standardized methods according to the British Aerobiology Federation [4] were used for sampling, slide preparation and pollen counting. The samples were determined under a light microscope. All concentrations used in this study are average daily pollen concentrations per m^3 of air.

The local meteorological station at Osijek airport (part of the State Hydro Meteorological Institute) provided daily data for mean (T_{mean} ºC), minimum (T_{min} ºC) and maximum (T_{max} ºC) air temperature, daily temperature range (Δ T= T_{max} – T_{min}, ºC) rainfall (R) and relative humidity (RH %), and sunshine (hours/day). The concentration of ragweed pollen in the air was evaluated for each sampling year (August–October) over a three year period (2001–2003). The criterion for main pollination period was used according to Nilsson and Persson [23], taking into account 90% of annual total pollen concentration, eliminating the initial and final 5%. The characteristics of each pollen season were documented graphically and evaluated statistically.

The relationship between the selected meteorological parameters and daily ragweed pollen concentration was calculated by Spearman's (rs) (non-parametric) correlation analysis since the frequency distribution of all pollen counts is not normally distributed. The SPSS® version 9.0 for Windows was used for statistical analysis.

RESULTS

Ragweed pollen is present in the atmosphere of the north-eastern part of Croatia between beginning of August to the end of September, with the maximum pollination between mid-August and mid-September. In the remaining months only single pollen grains could be detected in the air.

In 2001, when the first volumetric measurement in the Republic of Croatia was performed, annual ragweed pollen level was 6,159, whereas in 2002 and 2003 the levels were significantly lower - 4,558 and 2,172 respectively.

Peak count date in each year occurred between the end of August or beginning of September with highest pollen count of 528 grains m^{-3} on 1 September in 2001. The other two investigated years had about 30% lower peak count compared to 2001. End dates of ragweed season were most variable, ranging from 28 September in 2002 to 11 October in 2003. Daily counts with more than 100

Table 1. Seasonal distribution of ragweed pollen in north-eastern Croatia (2001-2003).

Ragweed pollen	2001	2002	2003
Peak day	1 September	31 August	29 August
Peak count	528	365	370
Season duration	63	59	72
Total pollen count (pollen grains $m^{-3}year^{-1}$)	6159	4558	2173
Days count > 100	22	16	5
Days count 11- 100	29	28	30
Days count 1- 10	12	15	37

Table 2. Spearman's correlation between meteorological variables and ragweed total pollen count.

Variables/ Ragweed pollen	2001	2002	2003	2001-2003
Mean air temperature	0.022	0.354**	0.235**	0.238**
Maximum air temperature	0.014	0.365**	0.115	0.117
Minimum air temperature	-0.017	0.093	0.173*	0.167*
Daily temperature range	0.048	0.361**	-0.023	-0.025
Relative humidity (%)	-0.107	-0.433**	0.003	0.027
Precipitation (mm)	0.165	-0.260*	-0.013	-0.036
Sunshine (hours/day)	0.015	0.371**	0.086	0.068

* $p < 0.05$; ** $p < 0.01$

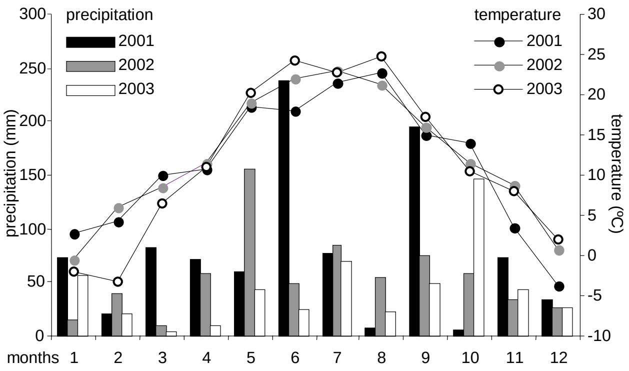

Figure 1. Mean precipitation and mean temperature during the study period.

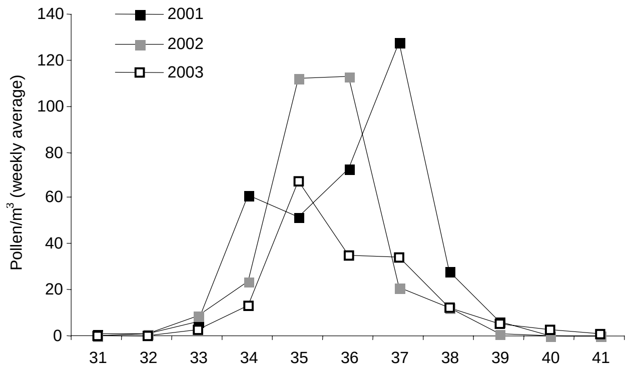

Figure 2. Average weekly concentration of ragweed pollen in three sampling years (2002-2003).

grains m^{-3} were recorded on 22 and 16 days during the sampling period in 2001 and 2002, respectively, and only on 5 days in 2003. Counts within the range of 11-100 grains m^{-3} were more uniformly distributed between investigated years and represent 29, 28 and 30 days (in 2001, 2002 and 2003, respectively). Low ragweed pollen concentration in the air were similar for 2001 and 2002, having 12 and 15 days with pollen counts 1-10 grains per m^3 of air, while in 2003 low pollen counts were recorded on 37 days throughout the season (Tab. 1).

The number of days with significant ragweed pollen concentration in our investigated area (meaning that the number of days which exceeded the threshold value, i.e. 10 grains per m^3 of air) was 51, 44 and 35 in 2001, 2002 and 2003, respectively. Moreover, the critical season appears each year almost at the same time: from 33rd to 38th week (Fig. 2).

The results of a Spearmann correlation analysis between the meteorological parameters, on the one hand, and the daily pollen concentrations on the other, for the whole period studied (2001-2003), reveal significant correlation, but not in all years (Tab. 2). When all investigated years are considered separately, only 2001 remains not significant, although the highest pollen count in the air was recorded during this pollination season (Tab. 2). In the remaining seasons, statistical analysis has shown significant correlation between the pollen count and the selected meteorological variables. In 2002, a positive statistically significant correlation was noted between ragweed pollen count and mean and maximum air temperature, daily temperature range and sunshine hours per day, but a significantly negative correlation between pollen count and relative humidity of air and precipitation. In 2003, only mean and minimum air temperature expressed a statistically significant correlation with the amount of ragweed pollen in the air.

The results of correlation analysis for the whole period studied (2001–2003), between the meteorological parameters on the one hand, and the daily pollen concentrations on the other, reveal a positive and significant correlation only with mean and minimum air temperature.

DISCUSSION

The ragweed population is very well established in the investigated region and covers the bare soils of wastelands or building sites, roadsides and more frequently crops in surrounding fields, such as maize, sunflower, soybean, or even wheat stubble. However, results of our investigation shows that the contribution of ragweed pollen in the air was quite distinct and changed from year to year. The duration, average daily count and total count have shown considerable fluctuations, having a similar pattern to observations in southern Hungary [19]. The high level of ragweed pollen exposure of inhabitants from our investigated area is during 5 weeks - between mid-August and mid-September. The ragweed pollen season presents similar behavior and duration in Hungary, which can be explained by the similar biogeographically and bioclimatic conditions [14, 22].

From the allergological point of view, there are several opinions about the number of ragweed pollen able to cause allergy. The symptomatological threshold value depends on individual symptoms and begins with an average daily concentration between 10-100 grains m^{-3} of air [22, 25] for the most of the sensitive people. Therefore, in our study we use these concentrations as a threshold value liable to provoke allergies among hypersensitive patients. Similarly, in some other regions, i.e. Austria, it seems to be a concentration of less than 20 pollen grains m^{-3} of outdoor air [9, 10]. Moreover, some results from France point out those even 3 pollen grains per m^3 are enough to cause allergenic symptoms [5].

Ragweed pollen counts collected during the investigated period (2001–2003) have shown a decreasing trend. Of course, a three year data set is not enough to detect a clear pattern. Even 5 years of investigation in southern Hungary showed definite fluctuations in total ragweed pollen count [19]. However, an opposite trend - constantly increasing ragweed pollen in the air - was reported in other European countries [11, 15, 24].

This noticeable decrease of pollen level in the investigated region could partly be the result of eradiction campaigns. Simultaneously with the establishing of the Aerobiology Laboratory at the Faculty of Agriculture in

Osijek and initiating the monitoring process, public authorities started to inform and educate the public about the prevention of ragweed allergy and, at the same time, encouraged the eradiction of this highly allergenic plant. Although the ragweed eradication campaigns in the region have been initiated since 2001, they still have limited effect and are restricted to a small area. Unfortunately, ragweed is still expanding and it is obvious that destroying this noxious weed is a long-lasting mission. Systematic cutting, continuous care-taking of the environment and nation-wide use of herbicides need to be repeated over a period of time. Therefore, decreasing the total ragweed pollen presence in the atmosphere of north-eastern Croatia could be partially addressed to the eradication campaign, but mostly due to the unfavorable meteorological conditions.

It is well documented that the occurrence of ragweed pollen grains in the atmosphere markedly relates to meteorological factors. The most important meteorological parameters determining the pollen count in the air include temperature, precipitation, relative air humidity, amount of total solar radiation, direction and speed of wind and pressure. Many authors have shown that warm and dry periods during the formation of anthers could notably increase pollen in the atmosphere [6, 26]. Most studies show that Spearman coefficients explain that temperature (weather minimum, maximum or mean values) and wind direction are the meteorological parameters that best explain atmospheric pollen concentration variations, showing their fundamental importance on the dispersion and transport of pollen grains [3, 24, 29].

Although the results of our investigations show that precipitation did not have statistical significance, in our pollen counts it was observed that during rainfall minimal amounts of daily pollen were trapped, indicating washing out of pollen from the atmosphere and supporting the reports of Hjelmroos [8], and McDonald [21]. It has been also reported that the increase of relative air humidity decreases the pollen count in the study of ragweed pollen determinants [5, 24, 28] and other pollen [3, 33].

Due to this fluctuating correlation analysis we are not able to draw conclusions about a clear tendency of the presence of ragweed pollen in the air and observed meteorological variables. Only the mean air temperature seems to have the best explanatory power with daily pollen counts. Further data and research are required for a better understanding of the relationship between the presence of ragweed pollen in the air and meteorological conditions in the north-eastern part of Croatia.

CONCLUSION

Ragweed pollen is the most abundant pollen type to occur in the atmosphere of north-eastern Croatia. Occurrence of ragweed pollen was observed in August and September with a peak at the end of August or beginning of September. The critical season appears each year almost at the same time: from 33 to 38 week; this is therefore the most dangerous period for pollynosis in the investigated region.

Ragweed pollen has a very high concentration in the air with 51, 44 and 35 days (in 2001, 2002 and 2003, respectively) when exceeding the threshold value.

Statistically significant correlation between the ragweed pollen count and selected meteorological variables were found in some study years, but only the correlation between mean air temperature and ragweed pollen presence in the air was significant over time.

REFERENCES

1. Allardd HA: The North American ragweeds and their occurence in the other part of the world. *Science* 1943, **98**, 292-294.
2. Barnes Ch, Pacheco F, Landuyt J, Hu F, Portnoy J: The effect of the temperature, relative humidity and rainfall on airborne ragweed pollen concentrations. *Aerobiologia* 2001, **17**, 61-68.
3. Bricchi E, Fornaciari M, Giannoni C, Greco F, Fascini D, Frenquelli G, Mincigrucci G: Fluctuations of grass pollen content in the atmosphere of East Perugia and meteorological correlations (year 1989). *Aerobiologia* 1992, **8**, 401-406.
4. British Aerobiology Federation: *Airborne Pollens and Spores. A Guide to Trapping and Counting*. BAF, Harpenden 1995.
5. Comtois P, Gagnon L: Concentration pollinique et fréquence des symptomes de pollinose. Une méthode pour détecter les seulis cliniques. *Rev Fr Allergol* 1988, **28**, 279-286.
6. Galán C, Emberlin J, Dominiquez E, Bryant RH, Villamandos F: A comparative analysis of daily variations in the Gramineae pollen counts in Cordoba, Spain and London, UK. *Grana* 1995, **34**, 189-198.
7. Hirst JM: An automatic volumetric spore-trap. *Ann Appl Biol* 1952, **36**, 257-265.
8. Hjelmroos M: Washout of long-distance transported pollen grains by snow and rain. **In:** Robertson AM, Hicks S, Risberg J, Akerlund A (Eds): *Landscapes and Life* 1997, **50**, 485-496.
9. Jäger, S: Global aspect of ragweed in Europe. *6th Int. Cong. on Aerobiology, Satelitte Symposium Proceedings: Ragweed in Europe. Perugia, 31 August-5 September 1998*, 6-11. Perugia 1998.
10. Jäger S: Allergenic significance of Ambrosia (Ragweed). **In:** D'Amato G, Spieksma FTM, Bonini S (Eds): *Allergenic Pollen and Pollinosis in Europe*. Blackwell Scientific Publications, London 1991, 125-127.
11. Jäger S, Litschauer R: Ragweed (Ambrosia) in Austria. **In:** *6th Int. Cong. On Aerobiology, Satelitte Symposium Proceedings: Ragweed in Europe. Perugia, 31 August-5 September 1998, 22-27.* Perugia 1998
12. Jarái-Komlódy M. Ragweed in Hungary. **In:** *6th Int. Cong. On Aerobiology, Satellite Symposium Proceedings: Ragweed in Europe, Perugia, 31 August-5 September 1998*, 33-39. Perugia 1998.
13. Jarái-Komlódy M, Juhász M: *Ambrosia elatior* (L.) in Hungary (1989-1990). *Aerobiologia* 1993, **9**, 75-78.
14. Juhasz M: History of ragweed in Europe. **In:** *6th Int. Cong. On Aerobiology, Satellite Symposium Proceedings: Ragweed in Europe,* Perugia, 31 August-5 September 1998, 11-15. Perugia 1998.
15. Laaidi K, Laaidi M: Airborne pollen of Ambrosia in Burgundy (France) 1996-1997. *Aerobiologia* 1999, **15**, 65-69.
16. Laaidi M, Laaidi K, Bescancenot JP, Thibaudon M: Ragweed in France: an invasive plant and its allergenic pollen. *Ann Allergy Asthma Immunol* 2003, **91(2)**, 195-201.
17. Lovašen-Eberhardt Ž: Godišnje kretanje i sastav polena na području Zagreba u vremenu od 1973. do 1978. g. **In:** *Drugi kongres ekologa Jugoslavije,* 229-240. Zagreb 1984.
18. Lovašen-Eberhardt Ž: The distribution of pallynoallergens in Croatia. *Rad HAZU* 1994, **466**, 75-79.
19. Makra L, Juhasz M, Borsos E, Beczi R: Meteorological variables connected with airborne ragweed pollen in Southern Hungary. *Int J Biometeorol* 2004, **49**, 37-47.
20. Mandrioli P, Di Cecco M, Andina G: Ragweed pollen: The aeroallergen is spreading in Italy. *Aerobiologia* 1998, **14**, 13-20.
21. McDonald ME: Collection and washout of airborne pollens by raindrops. *Science* 1962, **135**, 435-437.

22. Medzihradszky Z, Járai-Komlódi M: I came from America – my name i Ambrosia - some feature of the ragweed. *9th EWRS Symp. Budapest 1995*, 57-63. Budapest 1995

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

24. Puc M: Ragweeed pollen in the air of Szczecin. *Ann Agric Environ Med* 2004, **11**, 53-57.

25. Solomon WR: Aerobiology of pollinosis. *J Allergy Clin Immunol* 1984, **74**, 449-461.

26. Spieksma FThM, Frenguelli G, Nikkels AH, Mincigrucci G, Smithuis LOKJ, Bricchi E, Dankaart W, Romano B: Comparative study of airborne pollen concentrations in central Italy and the Netherlands (1982-1985). Emphasis on *Alnus*, Poaceae and *Artemisia*. *Grana* **28**, 25-36.

27. Spieksma, FThM: Allergy, pollinosis. **In:** *Syllabus of the First European Course: Assessment of Airborne Pollen Concentrations*. Kerms, Austria 1993.

28. Stark PC, Ryan LM, McDonald JL, Burge HA: Using meteorological data to predict daily ragweed pollen levels. *Aerobiologia* 1997, **13**, 177-184.

29. Stepalska D, Szczepanek K, Myszkowska D: Variation in *Ambrosia* pollen concentration in Southern and Central Poland in 1982-1999. *Aerobiologia* 2002, **18**, 13-22.

30. Stefanic E, Kresic K, Sokol K: Aerobiološki i alergološki značaj korovne vrste *Ambrosia artemisiifolia* L. u sjeveroistočnoj Hrvatskoj. **In:** *Prvi hrvatski kongres preventivne medicine*, Zagreb 2003.

31. Topić J: Fitocenološka istraživanja korovne vegetacije okopavina istočne Podravine. *Acta Bot Croat* 1978, **37**, 149-157.

32. Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA (Ed). *Flora europaea*. Cambridge University Press, 1976, 142-143.

33. Valencia-Barrera RM, Comtois P, Fernandez-Gonzales D: Biogeography and bioclimatology in pollen forecasting. An example of grass in León (Spain) and Montréal (Canada). *Grana* 2001, **40(4-5)**, 223-229.

34. Zanon P, Berra D, Alesina R, Cirla A, Corsico R, Guidoboni A: Spread of ragweed allergy in Lombardy (North Italy). *6th Int. Cong. On Aerobiology, Satellite Symposium Proceedings: Ragweed in Europe, Perugia, 31 August-5 September 1998,* 20-21. Perugia 1998.

35. Yankowa R, Baltadijeva D, Peneva R, Zlatev V: Pollen grains of *Ambrosia* in the air of Sofia, Bulgaria. *Aerobiologia* 1996, **12**, 273-227.