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The history and impacts of airborne *Ambrosia* (Asteraceae) pollen in Hungary

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Ambrosia arrived in Hungary from northern Mediterranean in the 1920s, and by the end of the 20th century it has become widely distributed. In Southern Hungary (northern part of Serbia-Montenegro included), *Ambrosia* pollen concentrations during the peak season are about one order of magnitude higher than the counts in the rest of Europe. The aim of the study is to survey the history of *Ambrosia* in the Carpathian Basin and analyse some *Ambrosia* pollen characteristics (season start, duration, average diurnal count and total count) focusing on a medium-sized city, Szeged, Southern Hungary. The data consists of daily *Ambrosia* pollen counts for the 15-year period between 1989 and 2003. Although *Ambrosia* pollen counts fluctuate considerably, no significant trends can be detected in their temporal course. According to the Makra-test, the highest pollen counts in Szeged are detected between 20 August and 11 September. This period is in good correspondence with both days comprising over 50 pollen grains per m^3, and the main pollination period (MPP).

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About one-third of Hungarian inhabitants have some type of allergy, two-thirds of them have pollen sensitivity and at least 60% of this pollen-sensitivity is caused by *Ambrosia* (Járai-Komlódi 1998) with 50 – 70% of allergic patients being sensitive to ragweed pollen (Mezei et al. 1992). The number of patients with registered allergic illnesses has doubled, and by the late 1990s the number of cases of allergic asthma has over the last 40 years become four times higher in Southern Hungary. In annual totals of pollen counts of various plants measured between 1990 and 1996 in Southern Hungary, *Ambrosia* produces about half of the total pollen production (47.3%). Although this ratio highly depends on meteorological factors year by year (in 1990 this ratio was 35.9%, while in 1991 it was 66.9%), it can be considered the main aeroallergenic plant in Hungary (Juhász 1995, Makra et al. 2004).

The aim of the study is to briefly survey the origin and distribution of *Ambrosia* from America to Europe, with special focus on the Carpathian Basin. Environmental and social conditions of its distribution are also shown. *Ambrosia* pollen characteristics, together with their time series analysis especially for a medium-sized city (Szeged, Southern Hungary), are presented.

AMBROSIA

The genus *Ambrosia* has 42 species, and belongs to the Asteraceae family. *Ambrosia* species which are distributed in Western Europe and in Hungary are annuals characterized by their rough, hairy stems and mostly lobed or divided leaves. *Ambrosia* flowers are greenish and inconspicuously concealed in small heads on the leaves. Male and female flowers are in separate heads on the same plant, the male flowers, usually drooping, are at the top of the plant, while the female flowers are in the upper leaves and bases of leaves. As annuals they can be eradicated by mowing just before the pollen-releasing period.

Origin and distribution of *Ambrosia*

Ambrosia originates in North America and has evolved to suit a dry climate and open environment. Among *Ambrosia* species only seaside *Ambrosia* (*Ambrosia maritima* L.) is native in Europe. Its earliest described colonization occurred in Dalmatia (Croatia), (Visiani 1842), where it was an endemic plant on the sandy seashores of the Ragusa (at the present time Dubrovnik, Croatia), Budva (Montenegro) area, and on the islands. In Western Europe, the first temporary colonization of *Ambrosia* was reported from Brandenburg (Germany) in 1863 (Priszter 1960). At that time, four American species became established: *Ambrosia artemisiifolia* = *Ambrosia elatior* (ragweed with mugwort leaves = short ragweed), *Ambrosia trifida* (great or giant ragweed), *Ambrosia psilostachya* (perennial ragweed) and *Ambrosia tenuifolia* (silver ragweed). Short ragweed is the most widely distributed in Western Europe and in Hungary (Járai-Komlódi & Juhász 1993).

The distribution of *Ambrosia* in Europe started after the First World War (Comtois 1998). Seeds of different *Ambrosia* species were transferred to Europe from America by purple clover seed shipments, and grain imports. Its distribution started probably

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from the European ports: e.g. from Rijeka towards Croatia and Transdanubia (the latter region is the western part of Hungary), from Trieste and Genoa towards Northern Italy, and from Marseille towards the Rhône valley.

There are three main regions invaded by *Ambrosia* in Europe: the valley of the Rhône (France), Northern Italy and the Carpathian Basin (Juhász 1998, Rybnícek & Jäger 2001).

Data on ragweed pollen have carefully been documented in France (Thibaudon 1992, Comtois & Sherknies 1992, Dechamp C. & Dechamp J. 1992). An epidemiological study for ragweed allergy was conducted on 646 employees from six factories located in the Rhône valley south of Lyon. In this study, 5.4% of subjects were symptomatic to ragweed pollen, whereas 5.9% were sensitized to this pollen (Harf et al. 1992). The spread of ragweed in the middle Rhône area over the 1980s has been considerable; this is especially true of the Drome, along the River Rhône. Although ragweed grows mainly in the plains, in this area it appears to be extending into the mountains (Couturier 1992).

Spread of ragweed and ragweed pollinosis has become a rapidly emerging problem in Italy (Politi et al. 1992). In 21 cities across Italy, among 2,934 patients with respiratory diseases of suspected allergic origin, ragweed pollen was shown to provoke asthma much more frequently than any other pollen grain (Corsico et al. 2000). Children appear to be less sensitised to ragweed pollen than adults are; only 5.9% of 507 asthmatic children aged between 1 and 17 years from a central Italian area had been sensitized to ragweed species (Verini et al. 2001).

Ambrosia pollen came to Switzerland by the southerly winds from Northern Italy and the Rhône valley (Peeters 1998). However, it was recently shown that there is native *Ambrosia* in Geneva, Switzerland (Clot 2002). *Ambrosia* pollen is assumed to be transported from Hungary to Burgenland and Vienna during August and September, when southeasterly winds are predominant in the region. Jäger & Litschauer (1998) detected pollen of *Ambrosia* originating from Transdanubia in the air of Vienna. Native *Ambrosia* is also found in Austrian countryside (Jäger & Berger 2000). The source region of *Ambrosia* in Slovakia is the Csallóköz (i.e. the plain of Danube) and Eastern Slovakia. The first description of its presence (Komárno, Southwest Slovakia) dated back to 1949. Seeds are partly native, partly transported by the southerly winds from Hungary (Makovcová et al. 1998). They might have been also introduced with cereals from the former Soviet Union (Makovcová et al. 1998). *Ambrosia artemisiifolia* arrived at Slovenia at the end of the Second World War. The map of its distribution was first published in 1978 and its appearance was considered to be temporary. However, *Ambrosia* managed to spread widely and fast in the lowlands of the country (Seliger 1998). In Russia, the most contaminated areas are Krasnodar, Stavropol and Sochi in the southern European part of the country (Juhász 1998, Rybnícek & Jäger 2001).

Ambrosia in Hungary

In Hungary, *Ambrosia* was noticed at the beginning of the 20th century at Orsova (Jávorka 1910), near the southern border of the country, along the banks of the river Danube. One of the popular names of *Ambrosia* in Hungary is "Serbian grass", which also refers to its place of origin. *Ambrosia artemisiifolia* were found in the southern part of Transdanubia in the 1920's, and in 30 years it occupied the whole region. Today it is the most common weed in Hungary.

Climatological, ecological, agricultural and social background

Climatological background

Hungary belongs to Köppen's *Cf* climate region (warm-temperate climate with uniform annual distribution of precipitation; Köppen 1931) or Trewartha's *D1* (continental climate with longer warm period in the summer, which provides optimal growing conditions for *Ambrosia*; Trewartha 1943). Short ragweed, as the most widely spread species in Hungary, is annual and can produce up to 60,000 seeds/plant.

Ecological background

In Hungary, the flowering of *Ambrosia* starts in the second half of July and ends in October. The peak season occurs in August. The timing and manner of pollination depend greatly on meteorological factors: temperature, humidity and light. Increasing temperature and decreasing humidity enhance pollination. The daily pollen production of *Ambrosia* is unimodal starting around 8 a.m. and with a maximum around noon.

Agricultural background

Ambrosia is a noxious agricultural weed. *Ambrosia* grows frequently on roadsides, railway embankments, waste places and in cultivated lands. It can overgrow alfalfa and purple clover entirely; cause severe damage in potato fields and occurs often in sunflower and cornfields, as well. It appears in large quantities among stubbles in the Great Hungarian Plain. Since *Ambrosia* is not an old adventive species of the Hungarian flora, it does not have any natural competitors. *Ambrosia* has less sensitivity to herbicides than other weeds (Voevodin 1982, Ballard et al. 1995, Patzoldt et al. 2001).

Social background

Human activities play an important role in the spread of *Ambrosia* (Comtois 1998). In Hungary, recent social changes have supported the rapid distribution of *Ambrosia*. After the collapse of communism in 1989, agricultural fields, which had belonged to co-operatives, were cut into smaller parcels due to privatization. The basic requirement remained to cultivate the land and keep it free from weeds, but once within the property, the new owners did not follow regulations. Realizing the danger, a countrywide anti-*Ambrosia* campaign was launched within the framework of the National Environmental Health Action Program. Hundreds of the 3,600 Hungarian settlements introduced special regulations against *Ambrosia* invasion. The campaign was supported by the Ministry of Welfare (Farkas et al. 1998).

MATERIAL AND METHODS

Topography and climatology of Szeged

Szeged (φ = 20°06′E; λ = 46°15′N; h = 79 m a.s.l.) lies near the confluence of the Tisza and Maros Rivers. It is one of the largest cities in Hungary with 155,000 inhabitants and the surface is about 46 km^2 (Fig. 1). Szeged and its surroundings occupy a flat and open region and the city has the lowest elevation in Hungary. Since Hungary lies in the Carpathian Basin, Szeged is a so-called double-basin situated city, which strengthens the effects of anticyclonic circulation patterns in accumulating pollutants together with pollen concentrations. The mean annual temperature is 11.2°C and the mean annual precipitation is 570 mm.

Data

In Szeged, the pollen content of the air has been examined with the help of a "Hirst-type" pollen trap (Lanzoni VPPS 2000) since 1989. The air sampler is located on top of the building of the Faculty of Arts, University of Szeged (20 m above the city surface). Daily pollen data were obtained by counting all pollen grains on four longitudinal transects (Käpylä & Penttinen 1981).

Linear trend analysis

The investigated data consists of daily counts for the years 1989 – 2003. The criterion of Main Pollination Period (MPP) follows Nilsson & Persson (1981), and is based on the period when 90% of the annual total pollen concentration is recorded, eliminating the initial 5% and the final 5%.

During further study, linear trends and their significance tests for the annual data sets of some *Ambrosia* pollen characteristics were determined. The theoretical basis of the analysis is following:

$$t = (b - \beta)/s_b$$

where

β is real (unknown) regression coefficient of the data set,
b is empirical regression coefficient, estimated from the data set,
s_b is standard deviation of the b regression coefficient of the data set.

According to the 0-hypothesis $b = \beta = 0$. The statistical decision for hypothesis is performed on the basis of the t-distribution (included

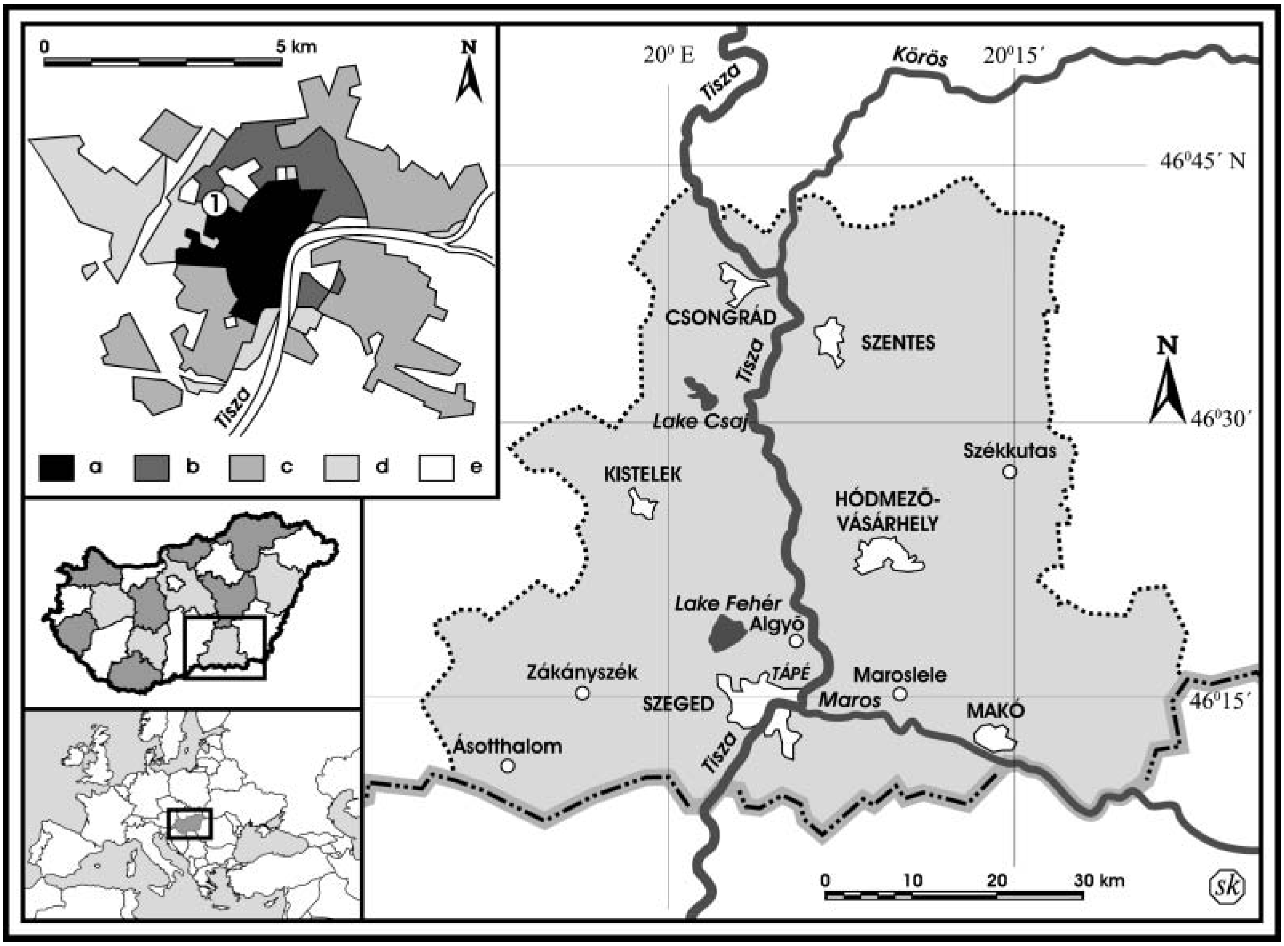

Fig. 1. Geographical position of Szeged (Hungary) (φ = 20°06′E; λ = 46°15′N; h = 79 m a.s.l.) and built-up types of the city [**a** – city centre (2 – 4-storey buildings); **b** – housing estates with prefabricated concrete slabs (5 – 10-storey buildings); **c** – detached houses (1 – 2-storey buildings); **d** – industrial areas; **e** – green areas; **1** – monitoring station].

in table, in practice). The significance analysis is made at the 5% (1%) significance level (the degree of freedom is $n-2$ and n is the number of elements in the data set). If the t-value computed by Eq. (1) is higher than the given threshold of the t-distribution, we consider b to be significantly different from 0; otherwise, it is not significant. Hence, in the first case the linear trend of the data set is significant and in the second case it is not.

A new interpretation of the two-sample test

The applied statistical test, developed by Makra, is a new interpretation of the two-sample test.

The basic question of this test is whether or not a significant difference can be found between the averages of an arbitrary sub-sample of a given time series, and the whole sample (Makra & Horváth 2000, Makra et al. 2002, 2004; Tar et al. 2001).

Let $\xi_1, \xi_2, \ldots, \xi_n, \ldots, \xi_N$ represent independent random variables of normal distribution, with mean m. Let $E(\xi)$ be the expected value of ξ, while $D(\xi)$ the standard deviation of it.

Suppose that the standard deviations of ξ_i-s are identical and equal to σ. Now, choose an optional sub-sample of n elements from the given whole time series of N elements ($n<N$). Let

$$\bar{\mathrm{m}}=\frac{\xi_1+\ldots+\xi_\mathrm{n}}{\mathrm{n}} \text{ and } \bar{\mathrm{M}}=\frac{\xi_1+\ldots+\xi_\mathrm{N}}{\mathrm{N}},$$

where $n<N$.

Then, after elementary steps, the hereby introduced random variable, the PS probe statistics

$$\mathrm{PS}=\frac{\bar{\mathrm{M}}-\bar{\mathrm{m}}}{\sqrt{\frac{\mathrm{N-n}}{\mathrm{N\cdot n}}}\cdot\sigma}$$

can be characterized by standard normal distribution, $N(0;1)$.

This implies that having fixed the sample mean $\bar{M}$, and the standard deviation σ, the test of the above 0-hypothesis, concerning a given sub-sample mean $\bar{m}$, leads to the following comparison of PS and x_p,

$$\mathrm{P}\left(\left|\frac{\bar{\mathrm{M}}-\bar{\mathrm{m}}}{\sqrt{\frac{\mathrm{N-n}}{\mathrm{N\cdot n}}}\cdot\sigma}\right|>\mathrm{x_p}\right)=\mathrm{p}$$

In Eq. (4), x_p is taken with p probability from the distribution function of the standard normal distribution, corresponding to a selected $0<p<1$ probability threshold.

If the absolute value of PS (Eq. 3) is higher than x_p then $\bar{M}$ and $\bar{m}$ differ significantly. The 0-hypothesis, according to which there is no significant difference between $\bar{M}$ and $\bar{m}$, can be rejected with the significance level p. (The significance-tests are carried out at $p=0.01$ significance level.)

This is a sufficient condition, ensuring normal distribution of PS in Eq. (3), but it can be relaxed in case of a very large N and n, following the Central Limit Theorem. Stationarity and independence of the original distribution, however, are unavoidably necessary conditions of the Makra-test.

The Makra-test performs Eq. (4) for all possible sub-samples with $n=3, 4, \ldots, N-1$ elements of duration, starting from the $1^{st}, 2^{nd}, \ldots, (N-n)^{th}$ element of the time series. For example, in case of 99 data (years), this means 4752-repeated comparison of the sub-sample average, and the overall mean. Comparison of averages of all possible sub-samples with that of the entire data set respectively is the most detailed calculation and hence gives greatest accuracy. Detection of significant deviations also includes information on their duration, onset and end (Makra & Horvath 2000, Makra et al. 2002, 2004; Tar et al. 2001).

When performing the Makra-test, the received significant breaks can be distinct or not. If they are not distinct, only one break is considered to be significant; namely, for which the value of the test statistics is the maximum (The "*break*" relates to the difference between the average of a sub-sample and that of the whole data set).

RESULTS AND DISCUSSION

All the highest counts on peak days are reported from the Carpathian Basin, Serbia and Hungary. Novi Sad (Vajdaság region of Serbia-Montenegro), the southern part of the Great Hungarian Plains, (Szeged) and Southwest Hungary (Pécs) have the highest concentrations of *Ambrosia* pollen, not only in the Carpathian Basin itself but in the whole European continent. Values recorded in Europe on peak days have never exceeded that of the 3,247 pollen grains per m^3 of air recorded in Novi Sad. Furthermore, the highest values observed in Novi Sad and Szeged on peak days are about one order of magnitude higher than those in other cities of Europe, considered to be highly polluted. On the reported peak days, there is more *Ambrosia* pollen even in the air of Budapest, having the lowest value among the listed Hungarian cities, than the total amount of pollen in the cities with highest rates listed from Europe (Table I). When considering annual totals, the highest *Ambrosia* pollen counts in Novi Sad and Szeged are several times higher than the total amount of pollen in the most intensely polluted cities listed from Austria, the Czech Republic, Slovakia, Switzerland and Bulgaria (Table II).

The starting date of the pollination period, between 15 June and 1 August, tends to vary much more widely than the closing date, between 11 and 29 October (i.e. the total pollination period, including MPP). The duration, average daily counts and total counts display definite fluctuations (Table III).

The annual sums of daily *Ambrosia* pollen grains undergo clear fluctuations as well. In certain years the total pollen counts are six or seven times higher or lower than the preceding years values (Fig. 2). The cumulative totals of the 15-year daily averages of *Ambrosia* pollen counts represent the Main Pollination Period (vertical lines; Fig. 3).

It is noted that the threshold value for clinical symptoms

Table I. *Ragweed pollen counts on peak days (list of some highest reported counts), pollen grains per m^3 air (Hungary and neighbouring countries).*

[1] – P. Radisic, Novi Sad University (Pers. Comm.); [2] – Juhász 1998; [3] – Járai-Komlódi 1998; [4] – Makovcová et al. 1998; [5] – Seliger 1998.

City	Country	Year	Counts on peak days
Novi Sad[1]	Serbia-Montenegro	2001	3,247
Szeged[2]	Hungary	1991	2,003
Szeged[2]	Hungary	1994	1,899
Szeged[2]	Hungary	1992	1,658
Pécs[2]	Hungary	1994	1,394
Budapest[3]	Hungary	1996	1,254
Novi Sad[1]	Serbia-Montenegro	1999	723
Bratislava[4]	Slovakia	1995	391
Bratislava[4]	Slovakia	1997	267
Ljubljana[5]	Slovenia	1997	118

Table II. *Annual total counts of ragweed pollen (list of some highest reported counts), pollen grains per m^3 of air (Hungary and neighbouring countries).*

^{1} – P. Radisic, Novi Sad University (Pers. Comm.); ^{2} – Juhász & Gallowich 1995; ^{3} – Juhász 1995; ^{4} – Jäger & Litschauer 1998; ^{5} – Peeters 1998; ^{6} – Rybnícek 1998

City	Country	Year	Annual total count
Novi Sad[1]	Serbia-Montenegro	2001	20,559
Szeged[2]	Hungary	1994	17,242
Szeged[3]	Hungary	1991	16,781
Szeged[3]	Hungary	1992	16,111
Pécs[2]	Hungary	1994	15,092
Pécs[2]	Hungary	1993	13,625
Novi Sad[1]	Serbia-Montenegro	1999	11,246
Szekszárd[2]	Hungary	1994	9,938
Zalaegerszeg[2]	Hungary	1994	8,478
Budapest[2]	Hungary	1993	6,753
Debrecen[2]	Hungary	1993	3,202
Vienna[4]	Austria	1992	1,869
Brno[6]	Czech Republic	1995	1,685
Bratislava[2]	Slovakia	1994	1,569
Lugano[5]	Switzerland	1994	932
Sofia[2]	Bulgaria	1993	179

for the majority of the sensitive patients is considered to be 20 pollen grains per m^3 of air (Jäger 1998). On the other hand, at the Hungarian National Health Centre this value is 30 pollen grains per m^3 of air. According to some authors, 50 pollen grains per m^3 of air is the threshold at which 60–80% of the patients suffering from pollinosis react sensitively to *Ambrosia* pollen (Juhász 1995). At the same time, the lowest threshold value is 10 pollen grains per m^3 of air. However, according to others, there is a threshold of as little as 5 or 6 pollen grains per m^3 (Thibaudon 2002). Most likely a higher pollen load acts like a specific immunotherapy, so that higher pollen loads result also in higher threshold levels in different areas. Environmental pollution may also affect pollen allergenicity through a direct effect on the pollen grain itself. It has been shown that the prevalence of hay fever in the urban environment is twice of that in the rural one, even though the pollen concentrations are higher in the latter (D'Amato 2000). Furthermore, certain matter from Diesel exhausts has been shown to be able to absorb airborne allergens, to act as atmospheric carriers for those and to prolong allergen retention (Subiza 2001). Therefore, the determination of pollen threshold levels that elicit allergy response is a complex task, since allergy depends on the combined effects of several factors: the patient, the allergens, the timing, and the duration of exposure and on the air quality of the environment (Geller-Bernstein et al. 1996, 2002).

The daily *Ambrosia* pollen counts are over 20–30–50 pollen grains per m^3 of air for 33–61, 27–57 and 16–50 days respectively of its 3-month long season, indicating severe pollen load in the air. The air is most polluted with *Ambrosia* pollen grains in August and September. The period of pollen load with pollen counts over 50 pollen grains per m^3 per day is between 12 August and 18 September (Table IV, Fig. 4).

Table III. *Selected indicators characterising the ragweed pollen season in Szeged, 1989–2003.*

Characteristics	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Average
Starting date	20 Jul	23 Jul	1 Aug	08 Jul	15 Jun	11 Jul	27 Jun	10 Jul	09 Jul	13 Jul	06 Jul	20 Jun	07 Jul	04 Jul	01 Jul	08 Jul
Finishing date	20 Oct	18 Oct	20 Oct	20 Oct	19 Oct	20 Oct	16 Oct	27 Oct	29 Oct	14 Oct	23 Oct	22 Oct	11 Oct	19 Oct	19 Oct	20 Oct
Duration (days)	93	88	81	105	127	102	82	110	113	94	110	95	97	108	111	101
Average diurnal count (pollen grains per m^3 per day)	37	37	207	153	75	169	31	68	61	29	67	88	93	40	43	80
Total count (pollen grains per m^3 per year)	3,407	3,256	16,781	16,111	9,539	17,242	3,525	7,509	7,994	3,859	8,847	11,592	12,277	4,288	4,760	8,732

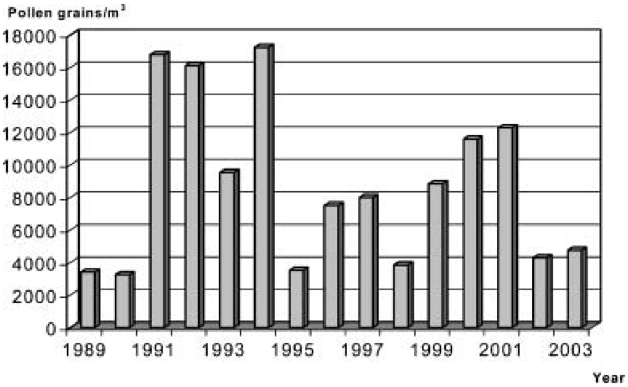

Fig. 2. Annual totals of ragweed pollen grains in Szeged, 1989–2003.

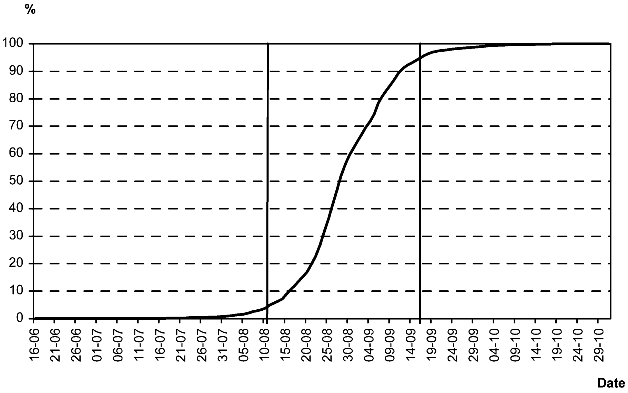

Fig. 3. Cumulative totals (%) of the 15-year daily averages of ragweed pollen counts in Szeged, 1989–2003. Main Pollination Period (Nilsson & Persson 1981) delimited by vertical lines.

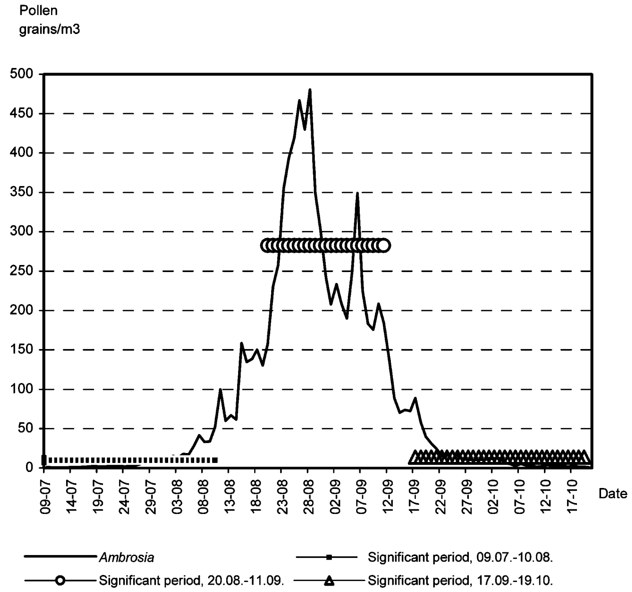

Fig. 4. Sub-periods with significantly different averages of ragweed pollen counts from the mean of the entire data set, i.e. the "*breaks*", diurnal average pollen counts (Szeged 1989–2003).

In order to establish whether or not clear trends can be observed, linear trends and their significance tests for the 15-year annual data sets (1989–2003) of the following *Ambrosia* pollen characteristics were calculated: the number of days with *Ambrosia* pollen (duration, days per year); the average diurnal count (pollen grains per m^3 per year); the total count (pollen grains per m^3 per year) and the number of days with higher than 20, 30 and 50 pollen grains per m^3 per year, respectively. Calculations resulted in no significant trends in any of the examined data sets, either at the 5% or even at the 10% significance levels, respectively.

On the basis of the Makra-test, we determined if significant differences could be found between the average of an arbitrary sub-sample of the 15-year mean daily *Ambrosia* pollen time series and that of the whole sample. It was found that averages of the sub-samples with periods: between 9th July and 10th August and 17th September and 19th October are significantly lower than that of the whole sample. On the other hand, the average value of the period between 20th August and 11th September is significantly higher than that of the whole sample. This means that, according to the examined data set, the period between 20th August and 11th September can be considered as the most polluted by *Ambrosia* pollen in the air; hence, the most dangerous one for pollinosis (Fig. 4).

The main step of the Makra-test, namely, the comparison of the average of a selected sub-period and the mean of the entire time series, is equivalent to the two-sample test applied to the given sub-period and the rest of the whole sample. In other words, application of Eq. (4) is possible to non-independent samples, i.e., the given data set and its fixed sub-sample. The reasoning of such use is the transformation into two non-overlapping sub-samples. The practical advantage of *PS* probe statistics (Eq. 3), used by the Makra-test, is that the procedure changes only three numbers ($\bar{m}$ and n – twice) in each step of the repeated applications, while in case of the two-sample test, six numbers have to be modified (Makra & Horváth 2000, Makra et al. 2002, 2004; Tar et al. 2001).

Ambrosia arrived in the Carpathian Basin from the region of the Mediterranean and was first described in the 1920s. While its pollen has not been detected in the air of Szeged until the late 1960s, recently (after 3.5 decades) Szeged has become the most polluted city with *Ambrosia* pollen in Hungary (Jäger 1998). Today the highest *Ambrosia* pollen concentrations can be found in the air of Hungary and the Vajdaság region of Serbia-Montenegro in Europe. *Ambrosia* pollen is the most aggressive of all pollens of plants in Hungary. This has resulted in many people suffering from *Ambrosia* pollinosis in Hungary (Járai-Komlódi 1998).

The examined parameters of *Ambrosia* pollen fluctuate considerably; however, the trend analysis did not indicate any significant trends in their temporal course.

The cumulative sums of *Ambrosia* pollen numbers display the Main Pollination Period (vertical lines; 11th August – 16th September) clearly, which is the steepest part of the curve (Fig. 3). The steeper the curve, the shorter and more intensive the pollination period is. The period of pollen load with pollen counts over 50 pollen grains per m^3 per day,

Table IV. *Counts on peak days and threshold values for clinical symptoms, ragweed pollen (Szeged, 1989–2003).*

*Threshold value for clinical symptoms after Jäger (1998)
**Threshold value for clinical symptoms after the Hungarian National Health Centre
***Threshold value for clinical symptoms after Juhász & Gallowich (1995).

Year	Counts on peak days (pollen grains per m^3)	Number of days with higher than 20 pollen grains per m^3 (*)	Number of days with higher than 30 pollen grains per m^3 (**)	Number of days with higher than 50 pollen grains per m^3 (***)
1989	318	36	29	18
1990	554	39	30	16
1991	2,003	49	47	38
1992	1,658	54	47	43
1993	1,229	47	41	31
1994	1,899	42	37	34
1995	301	33	27	25
1996	422	53	40	36
1997	848	47	37	34
1998	332	37	31	24
1999	571	41	37	32
2000	608	61	57	50
2001	1,125	56	50	43
2002	246	45	39	32
2003	404	44	37	29
Average	835	48	45	40

which is the highest considered threshold value, is between 12th August and 18th September. MPP and the calculated threshold coincide with the period of the most serious *Ambrosia* pollen load for Szeged (20th August – 11th September) as determined by the Makra-test. Thus this period is considered to be the most dangerous for pollinosis (Makra et al. 2004).

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