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RAGWEED POLLEN CONCENTRATION IN THE FUNCTION OF METEOROLOGICAL ELEMENTS IN THE SOUTH-EASTERN PART OF HUNGARY

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Összefoglalás – Magyarország lakosságának kb. 30 %-a valamilyen allergiás betegségben szenved, ezek 65 %-a pollen-érzékeny, s e pollen-érzékenységnek legalább 60 %-a a parlagfű pollenjétől ered. Dél-Magyarországon az allergiás betegek, valamint az allergén eredetű asztmás betegségben szenvedők száma az 1960-as évek adataihoz képest 1990-re megnégyszereződött. A magyar Nagyalföld déli része (Szeged) a parlagfű pollenjével a leginkább veszélyeztetett terület nemcsak a Kárpát-medencében, hanem egész Európát tekintve, sőt világméretekben is. A parlagfű (Ambrosia artemisiifolia = Ambrosia elatior) pollenje az összes növényi pollen közül a legagresszívabb. Klinikai vizsgálatok bebizonyították, hogy ez az allergén pollen a legkiterjedtebb, a legkomolyabb egészségügyi következményekkel járó és a legtartósabb pollinózis fő okozója. A tanulmány célja annak vizsgálata, hogy a meteorológiai elemek hogyan befolyásolják a parlagfű pollen koncentrációját egy közepes méretű dél-alföldi városban - Szegeden. A vizsgálat adatbázisát az 1997-2001 közötti ötéves időszak napi parlagfű pollenszámai, valamint 11 meteorológiai elem napi átlagértékei képezik. Mind a pollinációs időszak kezdetének (június 20. – július 13.), mind befejeződésének (október 11-29.) nagy az évi változékonysága. Évente a pollinációs időszak tartama, a parlagfű pollenek átlagos napi száma, illetve összes mennyisége a pollinációs időszakban, valamint a leginkább terhelt nap pollenszáma szignifikáns emelkedő trendet mutatnak.

Summary – About 30 % of the Hungarian population has some type of allergy, 65 % of them have pollen-sensitivity, and at least 60 % of this pollen-sensitivity is caused by ragweed. Number of patients with registered allergic illnesses doubled and number of cases of allergic asthma became four times higher by the late 1990s in Southern Hungary comparing to those in 1960s. The short (or common) ragweed (Ambrosia artemisiifolia = Ambrosia elatior) has the most aggressive pollen of all. Clinical investigations prove that its allergenic pollen is the main reason of the most massive, most serious and most long-lasting pollinosis. The aim of the study is to analyse how ragweed pollen concentration is influenced by meteorological elements in a medium-sized city, Szeged, Southern Hungary. The data basis consists of daily ragweed pollen counts and averages of 11 meteorological parameters for the five-year daily data set, 1997-2001. The southern part of the Great Hungarian Plain (Szeged) is the most polluted region with ragweed pollen, not only in the Carpathian basin itself but in Europe and even worldwide, too. Both starting date (between June 20 and July 13) and finishing date (between October 11-29) of the pollination period vary widely. Duration, average daily count, total count and counts on peak days show definite increasing trends, respectively.

Key words: pollen allergy, ragweed pollen concentration, Makra-test, factor analysis, regression analysis

POLLEN ALLERGY

Pollen allergy has become a widespread disease by the end of the 20th century. Nowadays, every 5th or 6th person, as an average, suffers from this immune system disease in Europe. Pollinosis involves unpleasant symptoms and can become asthma. It has been proved that persons fallen ill with pollen allergy can not concentrate on their work, feel unwell and can be on sick leave many times.

About 30 % of the Hungarian population has some type of allergy, 65 % of them have pollen-sensitivity, and at least 60 % of this pollen-sensitivity is caused by ragweed. It is a shocking fact that number of patients with registered allergic illnesses doubled and number of cases of allergic asthma became four times higher in Southern Hungary by the late 1990-ies comparing to those 40 years before.

Main plants having been caused pollen allergy in Europe are grasses (Poaceae), birch (Betula), mugwort (Artemisia) and, in Southern Europe, olive-tree (Oleaceae). From 1980-ies a new plant joined them, which spreads extremely aggressively. It appears in more and more countries, its blooming lasts for a long time (in some cases even for three months) and it produces much pollen. Breathing them, characteristic symptoms of pollinosis (coughing, sneeze, nasal discharge, inflammation of mucous membranes of eyes and nose) appear very fast. This is the short (or common) ragweed (Ambrosia artemisiifolia = Ambrosia elatior). [Ambrosia was once the delicious food eaten by the mythical Greek gods to make them live forever. Though the Latin name of ragweed and the Greek name of the mentioned delicious food are the same; however, they are completely different things. Ambrosia was the only food of newborns of gods. It is mentioned in the literature either as a food or as a drink. Ambrosia was imagined to have been made of some kind of honey. Wound curing effect was also attributed to it. Of course, the Greek gods didn't eat ragweed.] On the other hand, clinical investigations prove that the very allergenic pollen of ragweed is the main reason of most massive, most serious and most long-lasting pollinosis.

Considering annual totals of pollen counts of various plants measured between 1990 and 1996 in Southern Hungary, ragweed produces about half of the total pollen production (47.3 %). Though this ratio highly depends on meteorological factors year by year (in 1990 this ratio was 35.9 %, while in 1991: 66.9 %), it can be considered the main aero-allergen plant (*Juhász,* 1995).

The aim of our study is to give a short survey on history of ragweed and of its pollen's effect to humans, then to analyse connection of ragweed pollen counts with meteorological elements in Szeged city.

ORIGIN AND DISTRIBUTION OF RAGWEED

This unpleasant weed has its probable origin in Southern North America. This is a plant that has evolved in reaction to a dry climate and open environment. Among 42 species of the Ambrosia genus, only seaside ragweed (Ambrosia maritima) is native in Europe, namely in the Mediterraneum. Its earliest colonisation occurred in Dalmatia (Croatia), where it was an endemic plant on sandy seashores in the Ragusa (recent name: Dubrovnik, Croatia) and Budva (Montenegro) area and on the islands, firstly described in 1842. In Western Europe, first temporary colonisation of ragweed was reported to be in Brandenburg (Germany) in 1863. On the other hand, four American species have already become inhabited. These are as follows: ragweed with mugwort leaves (= short ragweed) (Ambrosia artemisiifolia = Ambrosia elatior), giant ragweed (Ambrosia trifida), perennial ragweed (Ambrosia psilostachya) and silver ragweed (Ambrosia tenuifolia). However, short ragweed is the most widely spread of all (*Járai-Komlódi and Juhász,* 1993).

Distribution of ragweed in Europe started after the First World War. Seeds of different ragweed species were transferred to Europe from America by purple clover seed shipments and grain imports. In this way, its distribution began probably from European ports: e.g. from Rijeka towards Croatia and Transdanubia (latter region is the western part of Hungary), from Trieste and Genoa towards Northern Italy and from Marseille towards the Rhône valley.

Recently, there are three main regions infected by ragweed in Europe: the valley of Rhône (France), Northern Italy and, the most infected region, the Carpathian Basin (*Juhász,* 1998). Ragweed pollen came to Switzerland by the southerly winds from Northern Italy and the Rhône valley. Atmosphere of the easternmost part of Austria is also sufficiently polluted. It is supposed that ragweed pollen is imported from Hungary to air of Burgenland and Vienna during August and September, when south-east winds are predominant in the region. *Jäger and Litschauer* (1998) detected pollen of ragweed originated from Transdanubia in the air of Vienna.

The source region of ragweed in Slovakia is 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 they come by the southerly winds from Hungary. Also, they were probably introduced with cereals from the former Soviet Union (*Makovcová et al.,* 1998).

Highest values of ragweed pollen concentrations in Czech Republic occur when south-east winds prevail. This suggests that pollen is not of local origin but come mainly from South-western Slovakia and even from Hungary (*Rybnícek,* 1998).

Short ragweed arrived at Slovenia at the end of the Second World War. The firstly published map of its distribution dates back to 1978. Its appearance was considered to be temporary. However, ragweed spread widely very fast. Its main regions are lowlands of the country, where ragweed grows as a weed on fields (*Seliger,* 1998).

In Russia, ragweed invasion is also a big problem. Most contaminated areas are Krasnodar, Stavropol and Sochi in the southern European part of the country (*Juhász,* 1998).

RAGWEED IN HUNGARY

In Hungary, its appearance was noticed at the beginning of the 20th century at Orsova, near the southern border of the country, along the bank of the Danube. One of the popular names of ragweed in Hungary is „Serbian grass", which also refers to its place of origin. Ragweed with mugwort leaves (short ragweed) got acclimatised most rapidly; only this species lives here widely. Samples of short ragweed were found in the southern part of Transdanubia in the 1920-ies, and gradually – within 30 years – they occupied the whole region. Since then, having been spread all over the country, it has become the most common weed in Hungary. However, when airborne pollen composition in Szeged (southern part of the Great Hungarian Plain) was analysed in 1968, no any ragweed pollen were found there (*Simoncsics et al.,* 1968). In the southern part of the Great Hungarian Plain there have been more favourable habitats, therefore all stages of the life-cycle (germination, growth, flowering, seed production) start earlier and last longer than those in other parts of the country.

CLIMATOLOGICAL BACKGROUND

There are many reasons of its rapid spread. Hungary belongs to the climate region of Köppen's Cf (warm-temperate climate with uniform annual distribution of precipitation) or Trewartha D1 (continental climate with longer warm period). Consequently, the climate here is favourable for growing, long-lasting blooming and reaching considerable seed production of ragweed. Its seeds are produced from a few thousands, up to 60,000 seeds by every plant and every year and have a long survival period in the ground (from 5 years up to more than 20 years).

ECOLOGICAL BACKGROUND

The flowering peak of ragweed in Hungary is in August but it may flower from the second half of July to the end of October. Flowers bloom only if the pollen has already ripened. Timing and manner of pollination depend greatly on meteorological factors, first of all on temperature, humidity and light. Increasing temperature and decreasing humidity enhance pollination. It has been observed that pollination starts around 8 a.m., when temperature is increasing and humidity is decreasing as a result of the sunlight and ends around noon. Daily pollen production of ragweed is unimodal with a maximum around noon.

AGRICULTURAL BACKGROUND

Ragweed is not only one of the most dangerous aero-allergen plants but is very noxious weed in agriculture, too. Being a ruderal plant, ragweed is as frequent on roadsides, railway embankments, waste places as in cultivated lands. It can overgrow alfalfa and purple clover entirely, causes severe damages in potato fields and occurs often in sunflower and corn fields, as well. It appears in large quantities among stubbles in the Great Hungarian Plain. Since ragweed is not an old adventive species of the Hungarian flora, it has not got any natural competitors. Light stimulates its germination; hence, waste lands and mixed soils are very soon infested by ragweed. Conditions of soils in Hungary are ideal for its colonisation and growing. Therefore, it has widespread and homogenous cultures all over Hungary. Owing to its special abilities, it can displace other plants, even perennials, and in the lack of competition it becomes dominant. Furthermore, ragweed has less sensitivity to herbicides than other weeds. Because of its here-mentioned characteristics and favourable conditions, ragweed is one of the most studied of non-economic plants.

SOCIAL BACKGROUND

Besides, recent social changes also supported rapid distribution of ragweed. After changing of the political system in 1989, agricultural fields, which had belonged to cooperatives, were cut into smaller parcels due to privatisation all over the country. The basic requirement remained to cultivate the land and keep it free from weeds but once being within the property, the new owners did not mind regulations. Realising the danger, a countrywide anti-ragweed campaign was launched in the frame of the National Environmental Health Action Programme. Hundreds of the 3,600 Hungarian settlements introduced special regulations against ragweed pollution. The campaign was supported by the Ministry of Welfare.

CLIMATIC CHARACTERISTICS OF SZEGED

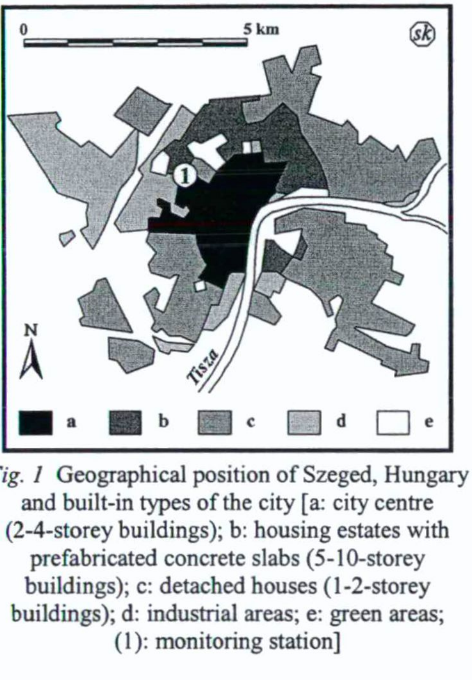

Fig. 1 Geographical position of Szeged, Hungary and built-in types of the city [a: city centre (2-4-storey buildings); b: housing estates with prefabricated concrete slabs (5-10-storey buildings); c: detached houses (1-2-storey buildings); d: industrial areas; e: green areas; (1): monitoring station]

Szeged (20°06'E; 46°15'N) lies near the confluence of the Tisza and Maros Rivers. It is the largest city in the south-eastern part of Hungary (*Fig. 1*). The number of inhabitants of the city is up to 160,000 and the surface of its built-up area is about 46 km^2. Though Szeged and its surroundings is flat and open region, the city has the lowest elevation in Hungary.

The basis of the city structure is a boulvard-avenue street system crossed by the River Tisza (*Fig. 1*). In this way the structure of the city is simple however, following to this system, motor vehicle traffic as well as air pollution are concentrated in the city. The industrial area is located mainly in the north-west part of the town. Thus the prevailing westerly and northerly winds transport the pollutants originating from this area towards the centre of the city.

DATA

In Szeged, pollen content of the air has been examined with the help of a high volume pollen trap (Lanzoni VPPS 2000) since 1989. The air sampler is found in the city, on the roof (20 m height from the city surface) of the building of Faculty of Arts, University of Szeged. Meteorological data were obtained from the monitoring station located 2 km from the sampling site in the downtown, which is operated by the ATIKÖFE (Environmental Protection Inspectorate of Lower-Tisza Region, Branch of the Ministry of Environment).

The data basis consists of diurnal ragweed pollen counts and averages of 13 meteorological parameters for not only the main pollination periods (MPP), but the whole data basis of the years 1997-2001, as well. The meteorological parameters are as follows: mean air temperature [T_{mean} (°C)], maximum air temperature [T_{max} (°C)], minimum air temperature [T_{min} (°C)], diurnal temperature range [ΔT (°C)], relative humidity [RH (%)], irradiance [I (Wm^{-2})], wind speed [WS (ms^{-1})], vapour pressure [VP (mb)], saturation vapour pressure [E (mb)], potential evaporation [PE (mm)] dew point temperature [T_d (°C)], diurnal sum of precipitation [P (mm)] and intensity of precipitation [PI (mm/min)]. The criterion of MPP was introduced by *Nilsson and Persson* (1981), which takes into account 90 % of the annual total pollen concentration, eliminating the initial 5 % and the final 5 %.

The ragweed pollen count and the mean air temperature of the previous day as well as those of the preceding 2nd and 3rd days are also taken into consideration. Furthermore, average diurnal pollen counts for the analysed period 1997-2001 are also used.

RAGWEED POLLEN COUNTS IN EUROPE, HUNGARY AND SZEGED

Table 1 Ragweed pollen count on peak days (list of some highest reported counts), pollen grains / m^3 air

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

Table 1 shows the list of some highest counts on peak days (as a comparison, data of some sites in Pennsylvania, USA are also presented), while *Table 2* displays annual totals of ragweed pollen grains.

All the highest counts are reported from the Carpathian Basin, Serbia and Hungary. Novi Sad (Serbia), the southern part of the Great Hungarian Plain (Szeged) and Southwest Hungary (Pécs) are the regions most polluted with ragweed pollen not only in the Carpathian Basin itself but in Europe, too. No higher count than 3247 pollen grains per m^3 of air (Novi Sad) has been measured in Europe. 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 and the United States, which are considered to be rather polluted. On the reported peak days, there is more ragweed pollen even in the air of Budapest, having the lowest value among the listed Hungarian cities, than the total amount for the cities listed from Europe and the United States having highest values (*Table 1*). When considering annual totals, the highest ragweed pollen counts in Novi Sad and Szeged are many times as much as the total amount for the most polluted cities listed from the rest of Europe (*Table 2*).

The starting date of the pollination period varies widely, between 20 June and 13 July, whereas the finishing date (between 11-29 October) show a much more limited range. The duration, average diurnal count and total count, except for 1998, show definite increasing trends.

Characteristics of the main pollination period of ragweed pollen for the examined five-year data set, as well as their averages are shown in *Table 3a*. These characteristics highly depend on the meteorological background (*Makra et al.*, 2002).

Table 2 Annual total count of ragweed pollen (list of some highest re-ported counts), pollen grains / m³ air

City	Country	Year	Annual total count
Novi Sad	Serbia-Montenegro	2001	20,559
Szeged	Hungary	1994	17,142
Szeged	Hungary	1991	16,781
Szeged	Hungary	1992	16,111
Pécs	Hungary	1994	15,092
Pécs	Hungary	1993	13,625
Novi Sad	Serbia-Montenegro	1999	11,246
Szekszárd	Hungary	1994	9,938
Zalaegerszeg	Hungary	1994	8,478
Budapest	Hungary	1993	6,753
Debrecen	Hungary	1993	3,202
Bécs	Austria	1992	1,869
Brno	Czeh Rep.	1995	1,685
Pozsony	Slovakia	1994	1,569
Lugano	Switzerland	1994	932
Szófia	Bulgaria	1993	179

It is noted that the threshold value for clinical symptoms for the majority of sensitised patients is considered to be 20 pollen grains per m³ of air (*Jäger,* 1998). According to some authors, 50 pollen grains per m³ of air is the threshold value at which 60-80 % of patients suffering from pollinosis are sensitive to ragweed pollen (*Juhász,* 1995). On the other hand, at the Hungarian National Health Centre this value is 30 pollen grains per m³ of air. At the same time, the lowest threshold value is 10 pollen grains per m³ of air. Ragweed pollen counts for the examined five-year period and the number of days with higher pollen grains than the threshold values, are found in *Table 3b*.

Table 3a Characteristics of ragweed pollen in Szeged for their main pollination period, according to *Nilsson and Persson* (1981)

Characteristics	1997	1998	1999	2000	2001	Average
Starting date	9 July	13 July	6 July	20 June	7 July	5 July
Finishing date	29 Oct.	14 Oct.	23 Oct.	22 Oct.	11 Oct.	20 Oct.
Duration (days)	113	94	110	95	97	102
Average diurnal count (pollen grains / m³)	61	29	67	88	93	68
Total count (pollen grains / m³)	7,994	3,859	8,847	11,592	12,277	8,914

Table 3b Characteristics of ragweed pollen in Szeged

Year	Counts on peak days, pollen grains / m³	[a]Number of days with higher than 20 pollen grains / m³	[b]Number of days with higher than 30 pollen grains / m³	[c]Number of days with higher than 50 pollen grains / m³
1997	848	41	37	34
1998	332	37	31	24
1999	571	41	37	32
2000	608	61	57	50
2001	1,125	56	50	43
[1]average	697	47	47	37
[2]values	301-2,003		16-43	

[a]Threshold value for clinical symptoms after *Jäger* (1998)
[b]Threshold value for clinical symptoms after the Hungarian National Health Centre
[c]Threshold value for clinical symptoms after *Juhász and Gallowich* (1995)
[1]main pollination period, 1997–2001
[2]1990–1996, annual data

During the examined period, both the total counts and counts on peak days increase with fluctuations. Diurnal ragweed pollen counts are over 50 pollen grains per m^3 of air for 24-50 days of its 3-months long season, which means severe pollen load of the air. According to the data, the number of days with higher than the threshold values increase, as well.

Comparing results of the two periods (1990–1996, annual data; 15 July – 15 October, 1997–2001), latest values seem to be less extreme. However, the number of days with higher than 30 pollen grains per m^3 of air increased definitely in the recent period.

OTHER CHARACTERISTICS OF RAGWEED POLLEN CONCENTRATION

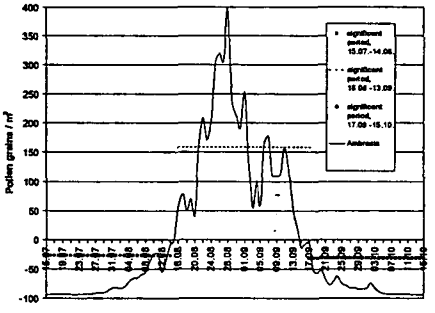

Fig. 2 Sub-periods with significantly different averages of ragweed pollen counts from the mean of the entire data series, i.e. the "breaks", diurnal average pollen counts, Szeged, 15 July – 15 October, 1997-2001

We determined whether or not significant differences can be found between the average of an arbitrary sub-sample of the mentioned time series and that of the whole sample. In our calculations five-year diurnal averages of the daily pollen counts were considered. It was found that averages of the sub-samples with periods between 15 July – 14 August and 17 September – 10 October are significantly lower than that of the whole sample, while the average of the period between 16 August – 13 September is significantly higher than that of the whole sample. This means that, according to the examined data set, the period between 16 August – 13 September can be considered to be the most polluted one by ragweed pollen in the air; hence, the most dangerous one for pollinosis (*Fig. 2*). The result received by this method confirms data of traditional pollen calculations.

CONNECTION OF RAGWEED POLLEN CONCENTRATION WITH METEOROLOGICAL ELEMENTS

In order to analyze the connection between ragweed pollen concentration and meteorological elements, multivariate statistical analysis was applied (SPSS 9.0 version).

Factor analysis makes it possible to represent connections among the original 12 variables by far less number of so called "theoretical variables" so that these factors together explain as much information of original variable, as possible. Using this procedure, connections among many variables can be interpreted and evaluated more easily. According to this method, information obtained on the original 12 variables was condensed into 4 theoretical variables; namely, into 4 factors, which together explain 90 % of information of the original variables. Connections among variables within each factor can be explained by the so called factor loadings belonging to the variables (*Table 4*). In order to rank effects of meteorological variables on ragweed pollen concentration (namely, to classify variables partly as essential and partly as unimportant ones), special transformation of Factors 1, 2, 3 and 4 to Factor 1 was required. Results are shown in *Table 5*.

Of all meteorological variables, only wind speed (WS) indicates significant (and positive) connection with ragweed pollen concentration. Though the other variables were also ranked, their effect – according to their factor loadings – cannot be measured. When wind is strengthening, a vast amount of ripe ragweed pollen come to the air and – according to our result – only this meteorological element modifies substantially the concentration of ragweed pollen.

CONCLUSION

Parameters of ragweed pollen [maximum daily concentration per year; total number per year; first observation day; last observation day; duration (day); average daily number; number of days exceeding threshold value of clinical symptoms (20-30-50 pollen grains per m^3 per day)], with slight fluctuations, show increasing trends.

Table 4 Factor loadings of the rotated component matrix.
Loadings higher than $|0.205|$ are written by bold

Parameters	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
pollen	**0.226**	-0.005	**0.232**	**0.740**
T_{mean}	**0.973**	0.184	0.012	0.108
E	**0.973**	0.183	0.001	0.095
T_d	**0.961**	**-0.209**	-0.044	0.116
VP	**0.960**	**-0.210**	-0.056	0.100
T_{max}	**0.929**	**0.222**	**0.216**	0.070
T_{min}	**0.830**	0.053	**-0.517**	0.090
PE	**0.738**	**0.626**	0.072	0.066
RH	0.014	**-0.954**	-0.140	0.029
I	0.054	**0.889**	0.058	-0.029
ΔT	0.006	0.193	**0.943**	-0.035
WS	0.018	-0.036	**-0.319**	**0.749**
Eigenvalue	6.145	2.470	1.163	1.018
Explained variance, %	51.209	20.580	9.690	8.486
Cumulative variance, %	51.209	71.789	81.479	89.965

Ragweed pollen load of Szeged is most serious between 16 August – 13 September. Hence, this is the most dangerous period for hay-fever. The above-mentioned period of highest pollen concentration, established by the Makra-test, confirms results of empirical pollen calculations. Application of factor analysis reduced dimension of the original data set (daily ragweed pollen concentration and the examined 11 meteorological variables) in order to detect connections among them more easily. After performing factor analysis, 4 factors were retained according to the Guttmann-criterion. These 4 factors explain 90 % of the total variance of the original 12 variables.

Table 5 Effect of variables on daily pollen concentration and rank of them on the basis of factor loadings specially transformed to Factor 1

Variables	Factor 1	Rank
pollen	0.740	–
T_{mean}	0.102	3
E	0.089	5
T_d	0.109	2
VP	0.093	4
T_{max}	0.065	7
T_{min}	0.081	6
PE	0.062	8
RH	0.028	11
I	-0.029	9-10
ΔT	-0.029	9-10
WS	**0.747**	1

Connections among variables, within each factor, can be well interpreted on the basis of their significant factor loadings. After performing special transformation, we concluded that among all the 11 meteorological variables only wind speed (WS) modifies substantially ragweed pollen concentration.

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