

The contribution of long-distance transport to the presence of *Ambrosia* pollen in central northern Italy

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Abstract Ragweed is an allergenic weed of public health concern in several European countries. In Italy ragweed occurs prevalently in north-north-eastern regions, where sensitization is increasing. Because of the small diameter of pollen grains, ragweed pollen is often involved in episodes of long-range transport, as already shown in central Italy. The objective of this study was to evaluate the extent of such transport by

comparing pollen and meteorological data for two northern Italian cities (Parma and Mantova) with data from Pistoia and Florence in central Italy. In 2002 and 2004 peaks in ragweed pollen levels were detected in these four cities on the same day, and concentrations of the grains were above clinical thresholds. Weather-map analysis and computation of back-trajectories showed that air masses from eastern Europe might carry ragweed pollen to a wide area of central and northern Italy. These findings suggest that episodes of long-range transport of ragweed pollen could be clinically relevant, resulting in sensitization of a large number of people. The results might provide a basis for monitoring and forecasting periods of long-distance transport with the objective of reducing their effects on allergic patients.

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1 Introduction

The genus *Ambrosia* (A.) includes both *A. trifida* (giant ragweed) and *A. artemisiifolia* (short or common ragweed), annual, anemophilous, and extremely allergenic weeds producing enormous amounts of pollen which, because the pollen grains are small (18–22 µm), are often involved in episodes of long-distance transport (Mandrioli et al. 1998).

Distribution of the plant in Europe covers the area at medium latitude characterized by a continental climate. The plant started expanding in the last decades of the 19th century from Hungary, the country where ragweed is most abundant (Jarai-Komlodi and Juhasz 1993), Croatia (Peternel et al. 2005), some parts of France (Laaidi et al. 2003), and Italy (D'Amato et al. 1998). Since then ragweed has also been detected in Bulgaria (Yankova et al. 2000), Austria (Jäger 2000), Switzerland (Peeters 2000), the Czech Republic (Rybánek and Jäger 2001), the Slovak Republic (Bartková-Ščevková 2003), Sweden, (Dahl et al. 1999) Poland, (Stepalska et al. 2002), and Russia (Ostroumov 1971).

Ragweed was found in two Italian regions, Piemonte and Liguria, for the first time in 1902; nowadays the regions most affected are Lombardia and Friuli Venezia-Giulia, located in the north-north-east of the country (Mandrioli et al. 1998; Asero 2002). Common ragweed has also been sporadically detected in Lazio and Campania (central-southern Italy) and giant ragweed in Campania (Pignatti 1982).

In a study conducted within the framework of the third National Health and Nutrition Examination Survey in the US, 26.2% of the population had a skin prick test positive to short ragweed (Arbes et al. 2005). In Europe sensitization is strongly increasing, especially where *Ambrosia* is widespread, for example in France (Dessaint et al. 2005), Hungary, where the 80% of the allergic population is sensitized to ragweed (Mezei et al. 1995), Poland, and Croatia (Cvitanovic et al. 2004).

In Italy sensitization is high in the north and low in the rest of the country; the only study performed in central Italy showed prevalence of 5.9% among atopic children (Verini et al. 2001). Recent findings confirmed high co-sensitization to ragweed and mugwort, making it difficult to interpret results from epidemiological studies (Asero et al. 2006).

Many studies have discovered that ragweed pollen may be involved in episodes of long-distance transport, because of the small size of the pollen grains (18–22 μm); this may prolong the pollen season in regions where *Ambrosia* is already present and may induce new sensitization in regions where ragweed is not yet established. In Poland, long-distance transport of ragweed pollen has been hypothesized for the period 1995–2004 (Piotrowska and Weryszko-Chmielewska 2006) and for the period 2000–2003

(Puc 2006). Occurrences of long-distance transport of ragweed pollen from the south of France to Switzerland have also been reported (Clot et al. 2002; Defila and Clot 2001). Long-distance transport from France to Catalonia, northern Spain, has also been hypothesized as a possible cause of the presence of ragweed pollen detected in the atmosphere of several Catalan cities (Belmonte et al. 2000).

Long-distance transport of ragweed pollen has been demonstrated in a previous study in Florence and Pistoia, Central Italy, (Cecchi et al. 2006), in a region where ragweed plants have not become established. The presence of ragweed pollen in the atmosphere of the two cities in 2002 and 2004 was attributed to long-range transport; it was suggested the most probable source was south Hungary. The authors suggested that these events can prolong the allergy season until late summer even in the areas where the species is not yet established.

The objective of this study was to identify, by large-scale weather analysis and computation of back-trajectories, the source of ragweed pollen detected in two Italian cities. To evaluate the geographical extent of these episodes pollen count and back-trajectories from Mantova and Parma were also compared with those from Florence and Pistoia (central Italy).

2 Materials and methods

2.1 Study sites

Parma ($\lambda = 10^{\circ}20' \text{ E}$; $\Phi = 44^{\circ}48' \text{ N}$, 50 m asl) and Mantova ($\lambda = 10^{\circ}44' \text{ E}$; $\Phi = 45^{\circ}06' \text{ N}$, 30 m asl) are Italian cities located in the Padana plain. Both cities have a continental temperate climate, with cold winters and hot summers.

Florence ($\lambda = 11^{\circ}11' \text{ E}$; $\Phi = 43^{\circ}46' \text{ N}$, 50 m asl) and Pistoia ($\lambda = 10^{\circ}57' \text{ E}$; $\Phi = 43^{\circ}57' \text{ N}$, 70 m asl) are Italian cities located in the region of Tuscany, in a closed valley bottom at the foot of the Apennines. Both cities have a Mediterranean semi-continental climate, with cold winters and hot summers.

2.2 Pollen data

Ragweed pollen was monitored in Parma, Mantova, Florence, and Pistoia between 1st August and 30th September over a six-year period (1999–2004).

The air was sampled by use of Hirst-type instruments (Hirst 1952) which apply the principles recommended by the International Biological Program (Benninghoff and Edmonds 1972).

The instruments were located on the flat roofs of buildings situated in the cities under study, 18–20 m above ground level and far away from walls and protection.

The samplers were adjusted to handle air flows of 10 L min^{-1} and were at all times oriented into the wind by means of a wind vane. Pollen grains impacted on a cylindrical drum covered with a plastic strip coated with an uniform layer of adhesive solution (Mandrioli and Puppi 1978). Every week the strip was removed and cut into seven equal segments corresponding to the 7 days of the week. The samples were examined by optical microscopy. The pollen grains were not counted over the whole $14 \text{ mm} \times 48 \text{ mm}$ -sampled area; instead a fraction of the entire deposit of particles was counted (statistical count). For this purpose the slide was examined by means of parallel (longer side of the slide) horizontal sweeps using the continuous-sweep technique. The minimum number of horizontal sweeps is that which ensures a total observed area not less than a 16% of the sampled area. The results were expressed as the number of pollen grains per cubic meter of air. Aerobiological data were provided by the Department of Medical Clinic, Nephrology, and Health Sciences, University of Parma, Italy, for Parma, by the “Centro di monitoraggio aerobiologico dell’ASL di Mantova”, for Mantova, and by the Aerobiology Operative Branch of the Environmental Protection Agency of Tuscany (ARPAT), Pistoia, Italy, for Florence and Pistoia.

2.3 Meteorological data

To determine daily atmospheric circulation patterns with the objective of determining the origin of the air mass reaching the area of the study in the period under investigation, synoptic weather maps (isobaric levels 500 and 850 hPa) were analyzed. Maps generated by the Global Forecast System (GFS) operational at the US National Center for Environmental Prediction (NCEP) (<http://www.ncep.noaa.gov>) were used for the period studied.

Air-mass back-trajectories starting from Parma and Mantova were also computed to enable determination

of the real origin of air masses and the time taken to arrive at the area studied. Air-mass back-trajectories starting from Florence and Pistoia, already published elsewhere (Cecchi et al. 2006), were also used. Air-mass back-trajectories are a useful means of establishing source–receptor relationships for air particles (Stohl 1998; Beverland et al. 1998). The Hysplit version 4 transport and dispersion model (Draxler and Rolph 2003; Rolph 2003) provided by the NOAA Air Resources Laboratory (ARL) was used for this purpose (<http://www.arl.noaa.gov/ready/hysplit4.html>). The path followed by the air masses for the previous 48 h was determined, in time steps of 6 h.

3 Results and discussion

The total pollen count (sum of daily counts per cubic meter of air) in the periods studied, the dates of the peak amounts, and the maximum daily count reached in the year for each city are shown in Table 1. Pollen data for Parma are lacking for the last 10 days of September 2002, for which the total pollen count is not available.

Ragweed pollen was detected in Parma and Mantova during almost the whole period under study, suggesting the presence of a local or near-local source of *Ambrosia*. In this respect the pattern of seasonal pollen count is similar to that observed in other European areas where ragweed plants occur (Makra et al. 2004).

In contrast, in Florence and Pistoia (central Italy) (Fig. 1) pollen grains were found during or near the peak days only. This observation suggests that in the central cities the presence of ragweed pollen is exclusively because of long-distance transport.

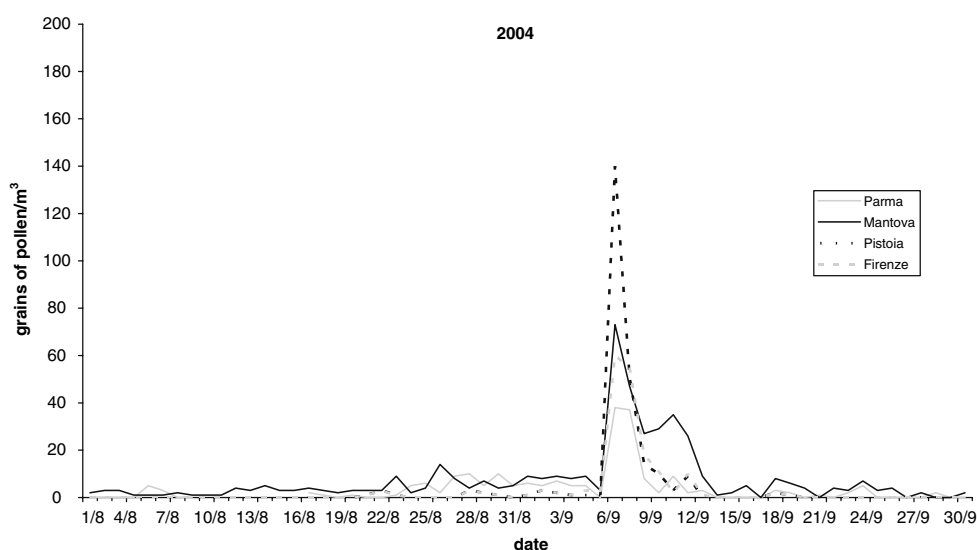
Table 1 and Fig. 1 show that in 2002 and 2004 peak amounts of pollen were recorded on the same days in all the cities under study and the peak values were higher than those observed in the other years. The pollen peaks of 2002 and 2004 are unlikely to be because of local dispersion, because of the numbers of grains and because they were detected in different geographical areas at the same time. The occurrence of long-range transport episodes during the local pollen season has previously been shown in France (Laaïdi and Laaïdi 1999) and Poland (Puc 2006).

Table 1 Characteristics of ragweed pollen count in Parma, Mantova, Florence, and Pistoia in the period 1999–2004

Characteristics	City	1999	2000	2001	2002	2003	2004
Total count ^a (pollen grains)	Florence	50	58	31	218	61	184
	Pistoia	46	59	33	235	93	250
	Parma	230	119	241	n.a.	379	207
	Mantova	170	422	459	882	351	452
Peak day	Florence	11th Sept	9th Sept	26th Aug	2nd Sept	14th Sept	6th Sept
	Pistoia	11th Sept	9th Sept	26th Aug	2nd Sept	15th Sept	6th Sept
	Parma	24th Aug	21st Aug	30th Aug	2nd Sept	26th Aug	6th Sept
	Mantova	5th Sept	24th Aug	27th Aug	2nd Sept	27th Aug	6th Sept
Daily maximum (pollen grains m ⁻³)	Florence	13	28	5	76	20	60
	Pistoia	8	31	5	83	30	140
	Parma	36	16	35	98	76	38
	Mantova	18	56	37	190	35	73

^a Total count = the sum of daily counts between 1st August and 30th September

n.a.: not available

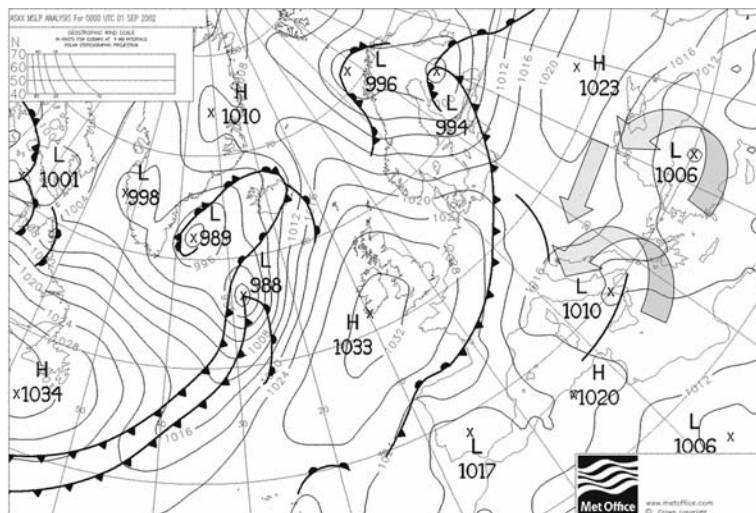
**Fig. 1** Ragweed pollen concentration in 2004 in the cities under study

Weather synoptic analysis shows that detection of *Ambrosia* pollen in the peak days (2002 and 2004) was always associated with days characterized by air masses coming from eastern or north-eastern Europe (Fig. 2). This situation occurred from one to five days before the pollen peak and was characterized by two anticyclonic systems centered over the Atlantic Ocean, close to Great Britain, and over Russia, and persistent cyclonic systems centered on the Southern Adriatic sea and over the Balkans. This situation

induces air flow over Italy from the eastern and north-eastern part of the European continent.

Computation of back-trajectories ending in Parma and Mantova in the peak days of *Ambrosia* pollen confirmed data obtained by analysis of weather-circulation patterns. Figures 3 and 4 show the back-trajectory of air masses ending at 23 UTC (coordinated universal time) on 2nd September, 2002, and at 23 UTC on 6th September, 2004, in Parma and Mantova, respectively. The path computed by the

Fig. 2 Weather map for 00 coordinated universal time (UTC) on 1st September 2002, the day before the peak of ragweed pollen



NOAA HYSPLIT MODEL
Backward trajectories ending at 23 UTC 02 Sep 02
CDC1 Meteorological Data

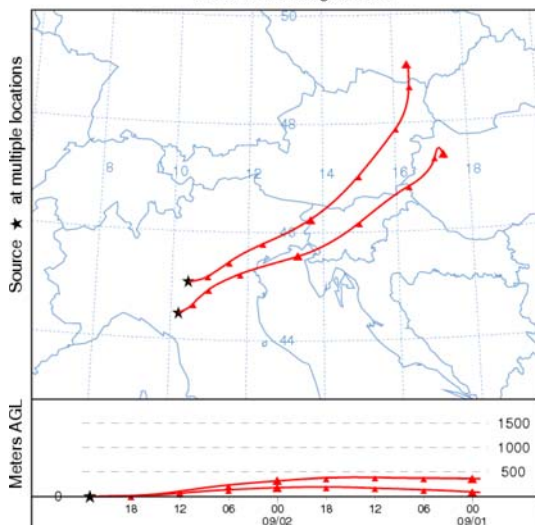


Fig. 3 Back-trajectories ending in Parma and Mantova at 23 UTC on 3rd September 2002

NOAA HYSPLIT MODEL
Backward trajectories ending at 23 UTC 06 Sep 04
CDC1 Meteorological Data

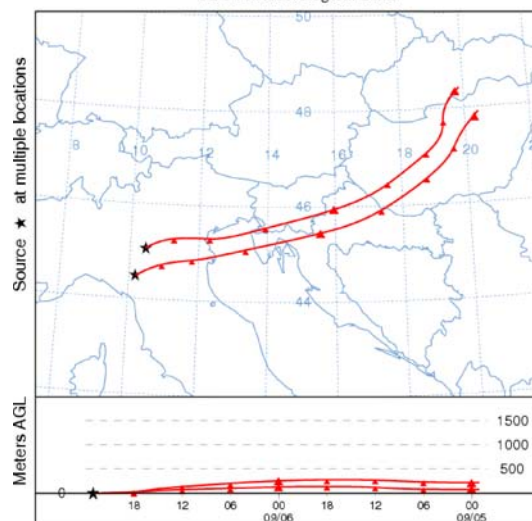


Fig. 4 Back-trajectories ending in Parma and Mantova at 23 UTC on 6th September 2004

Hysplit model suggests an area around the Balkans as a possible source of the ragweed pollen.

These findings confirmed the hypothesis that ragweed pollen reaches the Italian peninsula carried by air masses from the Balkans and/or central-eastern Europe, as recently proposed (Cecchi et al. 2006). The simultaneous occurrence of pollen peaks in cities hundreds of kilometers apart and separated by mountains which rise up to 2,000 m. asl (the Apennines) also shows that such episodes involve a large part of Italy.

The possible effect on the allergic population is speculative. This phenomenon may prolong the ragweed pollen season in areas where *Ambrosia* is already present (e.g. Mantova). In areas where the species is not yet established (e.g. Parma, Florence, and Pistoia) it might induce new sensitization, as recently reported in Bologna (central Italy) by Zauli et al. (2006).

Finally, it is important to note that pollen peaks during long-distance transport episodes are always

substantially above the clinical threshold (from 13 grains m^{-3} (Banken and Comtois 1990) to 20 grains m^{-3} (Jäger 1998)), which is the pollen concentration threshold at which allergy symptoms develop.

4 Conclusion

Further research is needed to assess whether ragweed pollen from eastern Europe reaches other parts of Italy, or other neighboring countries.

Taken together, these data suggest that transboundary transport of ragweed pollen to central-northern Italy could have a clinical effect on atopic patients in an area which is highly populated.

Given the increasing sensitization to ragweed in the allergic population, it would be of interest to develop a system to enable monitoring and forecasting of long-range transport episodes to provide information for reducing exposure during “at risk” days.

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