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ORIGINAL PAPER

Evolution of ragweed pollen concentrations, sensitization and related allergic clinical symptoms in Parma (northern Italy)

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Abstract The pollen released in the atmosphere by the ragweed represents a question of public health in several European countries. In Italy, the ragweed is mostly distributed in the North. In our region (Emilia Romagna), the presence of ragweed was not described yet if not occasionally, but this plant is thriving well in the North of the Po river. The aim of our study was to estimate the concentration trends of ragweed pollens in the air of Parma starting from 1992 until 2008 and to describe the clinical related situation. The aerobiological surveillance was made with the methods standardized by the Italian Association of Aerobiology. We analyzed 19,468 outpatients affected by respiratory disease. The patients studied address our clinical Center, mainly with pathologies respiratory, most of them with allergic origin. To detect the existence of significant trends and correlations since, we used the non-parametric tests with SPSS software. Our observations showed that since 1995, the year until when pollens of ragweed were only sporadically observed in the air of Parma, there has been a significant increase in ragweed pollens. Among the patients addressed at our clinical Center, 876 patients had positive SPT (skin prick test) for ragweed pollen with respiratory illnesses, all polysensitized. Besides, we found a significant increase in patients with positive SPT for the ragweed, and among these, the increase in the asthma has been significant. On the basis of our results, we expect, in the absence of intervention from public authorities, a more significant increase in the positive subjects and an aggravation of the symptoms related to the presence of ragweed pollen in the air of Parma.

Keywords Aerobiology · Allergy · Asthma · Monitoring · Pollen · Ragweed

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1 Introduction

The short/common ragweed (*A. artemisiifolia)* is a wild annual herbaceous plant pollinated by the wind that belongs to the *Compositae* family and has late summer–early fall pollination. Its pollen is a well-recognized

source of hay fever during the months of August and September. Aerobiological and clinical studies from various countries have documented the importance of ragweed pollen as an aeroallergen (Asero 2002, 2004; Gergen et al. 1987; D'Amato et al. 2007; Waisel et al. 2008). This genus of plants evolved in North America but later spread into Europe and Asia. In Europe, the common ragweed started expanding in the latter decades of the 19th century from Hungary, the country where ragweed is most abundant (Jarai-Komlodi and Juhasz 1993), Austria (Jäger 2000), Croatia (Peternel et al. 2006), some parts of France (Laaidi et al. 2003) and of Italy (Bonini and Pellino 2003, Corsico et al. 2000), and in general covers the area at medium latitude characterized by continental climate (Déchamp and Méon 2009). The severity of ragweed pollinosis varies according to the geographical region. Positive results to ragweed allergens in the skin prick test (SPT) of allergic patients is more than 80% in Hungary, 30% in France, Austria and Czech Republic, 17% in southern Switzerland (D'Amato et al. 1998; Mezei et al. 1995; Thibaudon and Oliver 2008). In heavily infested areas in France (Thibaudon et al. 2004) and Italy (Bonini et al. 2009), up to 12% of the population suffers from respiratory allergies to ragweed pollen. However, very low concentrations of ragweed pollen grains are sufficient to trigger allergic reactions in sensitive subjects (Taramarcaz 2006). In Croatia, the increased number of subjects hypersensitive to ragweed allergens is in correlation with the increase in air pollen grain count (Špehar et al. 2010), and *A. artemisiifolia* is an important cause of seasonal allergic rhinitis and asthma in this country (Cvitanović et al. 2007). In northern regions of Italy, ragweed allergy has become a serious problem over the last two decades. In Italy, pollen from ragweed is responsible for allergies during the period from July to October and represents a major problem for the health service, especially in Lombardy where the plant is widespread. After the first sparse cases reported at the end of the 80s, ragweed now represents the second most frequent cause of respiratory allergy in this area after grass pollen (Asero 2007). Its diffusion increases each year in the north of Italy (Mandrioli et al. 1998). In addition to this, the ragweed pollen in the Parma area comes from neighboring regions (Lombardy). Yet, the ragweed pollen is transported over long distances in our area (Cecchi et al. 2007). In the Parma area, the analysis of weather charts and the calculations of back trajectories showed that during the peak periods, the wind direction is often from North-Northeast. The importance of transport of ragweed pollen over long distances has been shown in other European countries (Stach et al. 2007; Clot et al. 2002; Kasprzyk et al. 2011). In the Parma area, the plant has not been identified as anything other than sporadic. The aim of our study was to analyze the ragweed pollen pattern in the Parma area from 1992 to 2008 to determine the incidence of sensitization (Ridolo et al. 2007) to this pollen in patients with seasonal respiratory allergy and to alert physicians to the environmental and health threats of common ragweed in Italian regions where the presence of this plant has not yet been identified extensively.

2 Materials and methods

The study was carried out in Parma, a city with a population of 180,000 inhabitants which lies in the Po valley, to the South of the Po river, 100 km from the Tyrrhenian coast and 200 km from the Adriatic coast, 52 m above sea level, latitude 44°48′15″ North, longitude 10°19′ East.

2.1 Aerobiological data

We checked aerobiological data regarding total ragweed pollen concentration and peak. The pollen was monitored by our survey center (Italian Centre: PR1) in accordance with standard methods of the Italian Monitoring Network in Aerobiology (R.I.M.A.®) of the Italian Aerobiology Association (AIA), (Travaglini et al. 2009). Airborne pollen grains were collected using a Burkard 7-day recording volumetric Spore-Trap, the standard equipment used for aerobiological sampling worldwide. The device was placed at 18.2 m above ground level on the meteorological tower of Parma University in the town center near "Parco Ducale", the city's main park. Mean daily pollen concentration values and peaks (P/m^3 air) were recorded, and the sum of values gave an estimate of the annual amount of ragweed pollen.

2.2 Meteorological data

Average data on annual temperature (°C) and total rainfall (mm rain) were obtained from the Meteorological Station (Physics Department) of the University of Parma.

2.3 Patients

The study included patients who were non-smokers, mainly adults, living in the city or province of Parma, with verified skin prick test (SPT) sensitization to ragweed and/or mugwort pollen allergen. The patients were examined for respiratory pathologies (rhinoconjunctivitis and/or asthma) with a seasonal occurrence of symptoms at the Allergy Unit of Parma Hospital, following a referral to our center by their general practitioner. A detailed clinical history was obtained, and a complete physical examination was carried out for each patient. Asthma was diagnosed according to the Global Initiative for Asthma (GINA) (Guidelines by clinical and functional features Global Initiative for Asthma 2009 and previous). The diagnosis of rhinoconjunctivitis was made according to a patient's clinical history and international guidelines ARIA (Dykewicz and Fineman 1998, Guidelines for Allergic Rhinitis and Impact on Asthma 2009 and previous).

The SPT was carried out using ALK-Abello SpA diagnostic allergens. Histamine chloride at 10 mg/ml and glycerosaline solution were used as positive and negative controls. The tests were given out on the volar side of the forearm with Dome-Hollister-Stier Prick Lancettes; one sterile device was used for each test (Malling, position paper 1993). After 15 min, weal diameters >3 mm, compared with positive and negative controls, were considered positive.

2.4 Statistics

The non-parametric Cox-Stuart test was used in order to detect the existence of significant statistical trends in data investigated between 1992 and 2008. Kendall's "τ" and Spearmann's "ρ" correlation tests were used to establish whether there was any correlation between various parameters (Zar 1999). The tests were performed using SPSS software.

3 Results

3.1 Pollen data

Our observations have shown that from 1995 to the present year, ragweed pollen has been observed only sporadically in the air of Parma. Yet, there has been a significant increase in ragweed pollen grains and the peak values, Cox-Stuart $N = 8$, $r = 1$, $P = 0.035$ (Fig. 1a). These data are especially evident in the 1996–2003 period. On the other hand, mugwort pollen has been decreasing, Cox-Stuart $N = 8$, $r = 1$, $P = 0.035$; $N = 8$, $r = 0$, $P = 0.004$ (Fig. 1b).

3.2 Patients

Between January 1, 1992 and December 31, 2008, a total of 19,468 patients were admitted to our clinical center: 12,403 (63.7%) of these patients had positive SPT for respiratory allergens, with 18.3% being monosensitized and 81.7% polysensitized. Of the 876 patients (7.1%) who showed results positive to ragweed and had respiratory diseases during the months of July, August and September, 492 were men and 384 women, with an average age of 28.7 years (min. 5 and max. 79). As for the disease, 44% of the patients sensitized to the ragweed had rhinitis symptoms only, 9% asthmatic symptoms only, and 47% both rhinitis and asthma. All the patients who were SPT positive to ragweed were polysensitized. Many subjects were polysensitized to 4 other allergens (median).

We found a significant increase in the number of polysensitized patients with positive SPT to ragweed and, among these, a noticeable increase in asthma symptoms (Cox-Stuart $N = 8$, $r = 0$, $P = 0.004$) (Fig. 2). Both moving average and real data of clinical evolution are reported in the figure. In addition, we found a significant correlation between the concentrations of pollen grains and patients with positive SPT to ragweed (Kendall τ 0.627, $P = 0.001$, $N = 17$, 1 tail; Spearmann ρ 0.820, $P = 0.001$, $N = 17$, 1 tail), and among those between the concentrations of pollen grains and asthma (Kendall τ 0.530, $P = 0.002$, $N = 17$, 1 tail; Spearmann ρ 0.715, $P = 0.001$, $N = 17$, 1 tail), (Fig. 2). However, asthma has not increased significantly for the whole of the allergic patients with respiratory diseases (data not shown). Among the polysensitized patients, the number of subjects with SPT positive to mugwort has been decreasing (data not shown), while subjects with SPT positive to ragweed have been increasing.

We found a correlation between the percentage of ragweed polysensitized and yearly total pollen of ragweed (Kendall τ 0.400, $P = 0.0142$, $N = 17$, 1 tail; Spearmann ρ 0.576, $P = 0.008$, $N = 17$, 1 tail; Fig. 3).

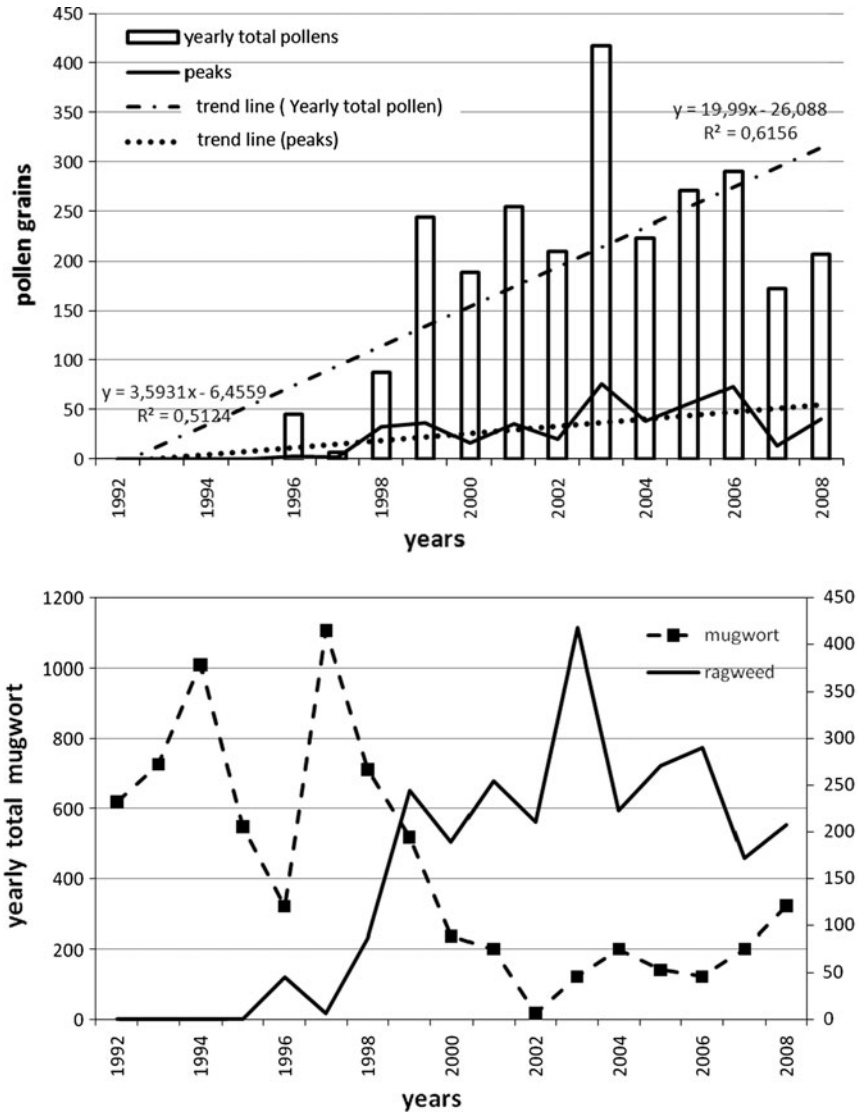

Fig. 1 **a** Significant increase in yearly total ragweed pollen count and the respective peak values (Cox-Stuart $N = 8$, $r = 1$, $P = 0.035$) **b** Significant yearly total pollen count showing increasing and decreasing trends of ragweed and mugwort pollen, respectively, from 1992 to 2008 (Cox-Stuart $N = 8$, $r = 1$, $P = 0.035$; $N = 8$, $r = 0$, $P = 0.004$)

Among the patients SPT positive to ragweed, we found a significant increase in age (raising the average age from 25.9 to 31.6 Cox-Stuart $N = 8$, $r = 1$, $P = 0.035$; Fig. 4).

3.3 Meteorological data

We have identified a steady increase in average temperatures in Parma over the last century (Cox-Stuart $N = 7, r = 0, P = 0.008$). During the period of the study, there were no significant changes in temperatures and relative humidity with a fluctuating rainfall situation (data not shown).

4 Discussion

In this paper, we analyze the ragweed pollen distribution in our area from 1992 to 2008 and the related allergy clinical situation.

Ambrosia pollen first appeared in the air of Parma in the early 90s, and since 1995, their presence has become an established fact during the summer, just like the increasing trend of yearly total pollen and daily peak values (Fig. 1). The concentrations of ragweed pollen recorded in Parma are lower than those recorded in other European areas. In Parma, the yearly total pollen is <400 pollen grains versus <2,000 in

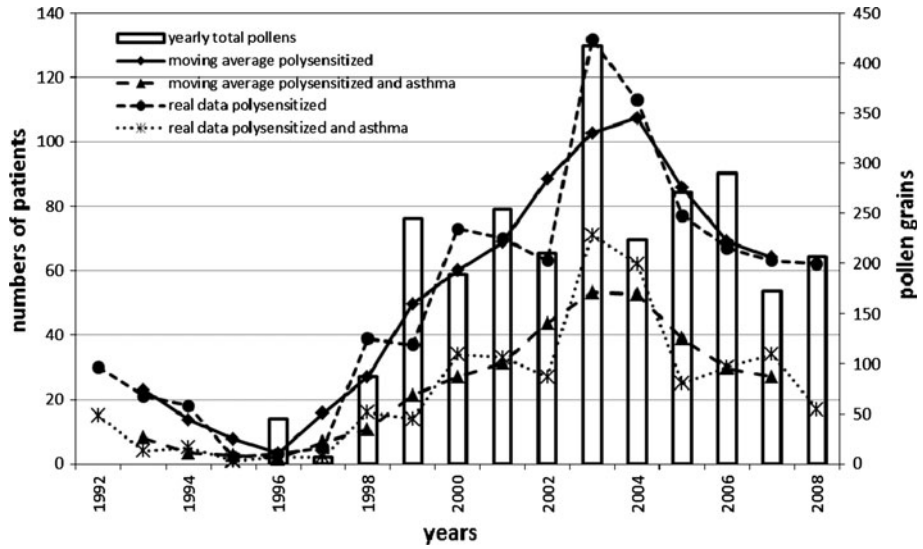

Fig. 2 Number of patients polysensitized to ragweed and among these the number of SPT positive patients with asthma every year (real data and moving average). Significantly increasing trends of patients SPT positive to ragweed with asthma (Cox-Stuart $N = 8$, $r = 0$, $P = 0.004$); significant correlation between total pollen concentrations and patients polysensitized to ragweed (Kendall τ 0.627, $P = 0.001$, $N = 17$, 1 tail; Spearmann ρ 0.820, $P = 0.001$, $N = 17$, 1 tail), and between total pollen concentrations of ragweed and patients SPT positive to ragweed pollen, with asthma (Kendall τ 0.530, $P = 0.002$, $N = 17$, 1 tail; Spearmann ρ 0.715, $P = 0.001$, $N = 17$, 1 tail)

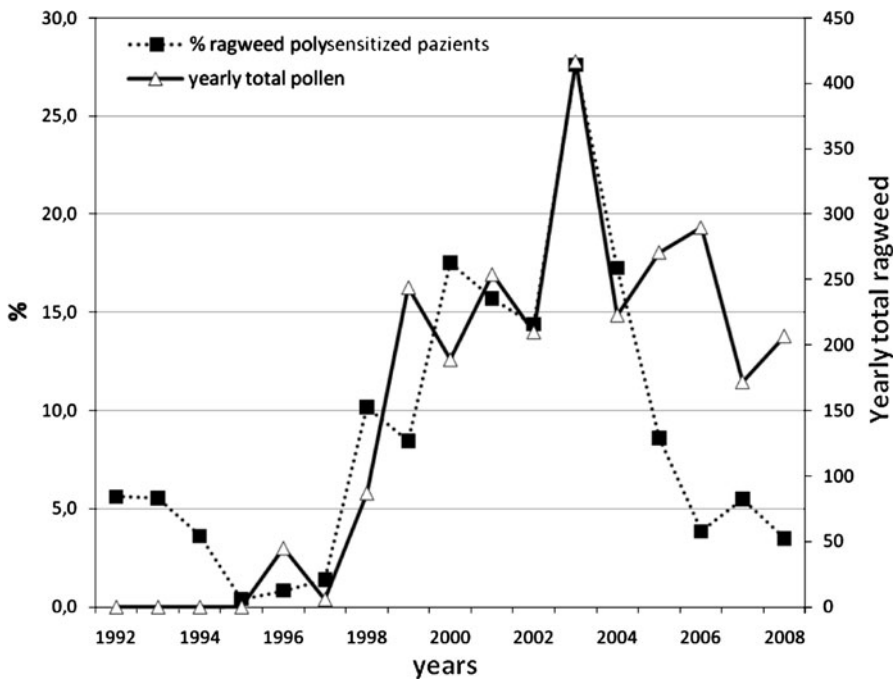

Fig. 3 Percentage of patients polysensitized to ragweed in comparison with the total number of pollen sensitized patients each year, related to yearly total pollen of ragweed (Kendall τ 0,400, $P = 0.0142$, $N = 17$, 1 tail; Spearmann ρ 0.576, $P = 0.008$, $N = 17$, 1 tail)

Austria (Jäger 2000), <4,000 in Croatia (Peternel et al. 2006), or <6,000 in France (Thibaudon 2010). Hungary shows even higher yearly total pollen, close to 20,000 (Apatini et al. 2008). In comparison with the rest of Italy, concentrations in Parma are lower than in the province of Milan (Lombardy) in the northwest,

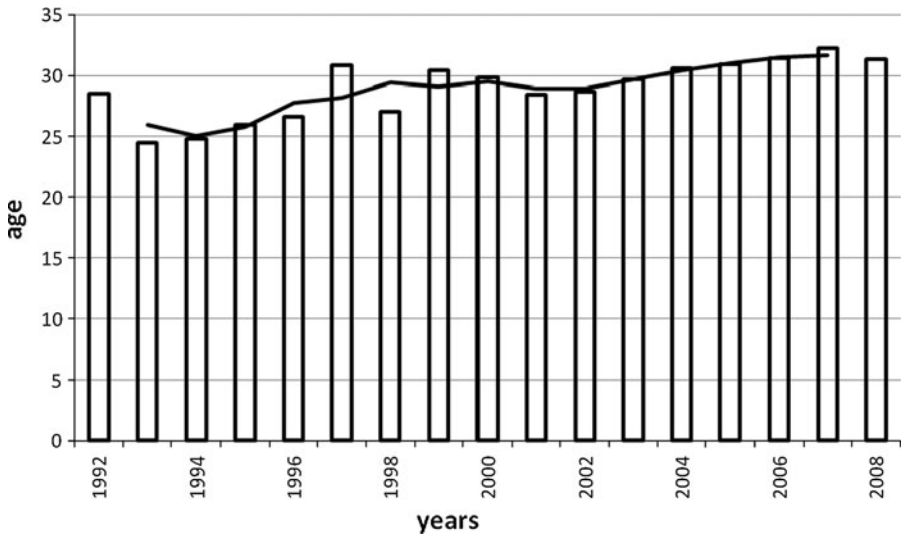

Fig. 4 Yearly average age and related moving average age of patients polysensitized to ragweed. Significant increase in age (moving average age from 25.9 up to 31.6 (Cox-Stuart $N = 8$, $r = 1$, $P = 0.035$)

where yearly total pollen is approximately 5,000, but higher than many other areas, e.g., Central Italy where yearly value is lower than 100 (R.I.M.A.®). However, the values do indicate a phenomenon which is evolving. The ragweed pollen in our area is actually still low but can reach local peaks that induce sensitization and symptoms in allergic individuals (Figs. 1a, 2). The increase in concentrations of ragweed pollen grains with a corresponding decrease in the concentrations of mugwort pollen (Fig. 1b) can be probably related, as with other weeds (e.g., grasses) (Ridolo et al. 2007), to the urban development in the Parma area and disuse of industrial areas which may have favored the spread of *Ambrosia*. Indeed, the surface area of urbanization has increased from 12,354 hectares to 22,325 hectares in the last 28 years, and the green belt has been reduced from 56.2 to 46.8% of the total existing area (Pileri 2009). The construction of the new high-speed rail line has had a major impact on the area close to the city over the past 15 years, with enormous amounts of soil being moved and many buildings (once homes, farms and industrial units) having been vacated and now derelict. The existence of *Ambrosia* is still considered sporadic in the Parma area, but this definition may be reviewed in light of a systematic census which could affect all the territory of the province of Parma, most of all in the plain. The trend of reduction related to the total annual pollen from *Artemisia* and the trend of increase related to the total annual pollen from *Ambrosia* are similar to those in the areas nearby in the Po valley, according to data from the R.I.M.A.®. However, the increase in pollen grains from ragweed causes an adverse clinical effect on the patients who live in the Parma area not yet infested by *Ambrosia* plants. We found a correlation between concentrations of ragweed pollen grains and the increase in sensitized subjects (Fig. 2) according to other data (Jäger 2000). The fact that the subjects with positive SPT to the ragweed are exclusively polysensitized might explain the increase in asthmatic symptoms (Fig. 2; Cirillo et al. 2005), and calls for a future study of the role of the pan-allergens (Villalta and Asero 2011) and the presence of specific IgE. Our results are in many respects similar to those obtained for other Italian regions for both transformation of territory (urbanization and disused industrial areas) and clinical aspects (e.g., observation of mainly polysensitized subjects, often with asthma (Gallesio and Caramiello-Lomagno 1987; Bottero et al. 1990), which described the situation in Lombardy and Piedmont approximately 25 years ago. The correlation between the percentage of ragweed polysensitized patients and yearly total pollen of ragweed is further evidence of health problems related to the presence of ragweed pollen in Parma. This is particularly evident in the 1996–2003 period, when the presence of ragweed pollen in the air of Parma established itself rapidly (Fig. 3).

The results shown in our study (Fig. 4) about the age of the patients could be read as a phenomenon typical of the situations at the beginning of the spread of *Ambrosia* pollen in a specific area. An analogous situation was

seen in Lombardy at the beginning of the 1980s. The arrival of new allergens tends to sensitize both the population who are naturally present in these areas and those potentially sensitive, and provoke symptoms encompassing all the age groups that come into contact with these allergens. In this sense, the phenomenon is more evident in the adult population. On the contrary, an allergen which is already established in the area naturally tends to affect the younger members of the population, together with those who come into contact with these allergens (Asero 2007; Arbes et al. 2005). Another aspect to be dealt with in the near future is represented by the study of the concentrations of ragweed pollen grains transported over long distances, in order to understand the real incidence of the phenomenon day by day (Testi et al. 2009).

However, with the increase in the concentrations of ragweed pollen and the start of the underlying phenomenon caused by *Ambrosia,* i.e., increasing sensitization in the allergic population, it would be interesting to develop and increase monitoring systems and forecasts of pollen distribution (Makra et al. 2011) with the aim of providing information and reducing exposure. It is necessary to develop the territory mapping to determine whether ragweed is already present in the region of Parma, and if so, how large the populations of ragweed are. On the basis of our results, we expect, in the absence of intervention from public authorities, a more significant increase in the positive subjects and an aggravation of the symptoms related to the presence of ragweed pollen (Comtois 2008; Burbach et al. 2009) in the air of Parma, as was seen in Lombardy and in other areas of northern Italy. This situation will also determine an increase in the direct and indirect medical costs following the increase in allergic symptoms due to *Ambrosia* pollen on our territory. The case of northern Italy is cautionary, as almost nothing was done despite the numerous warnings to fight ragweed at an early stage of the invasion (Makra et al. 2005; Bonini and Colombo 2009). After 10–15 years, the authorities' lack of action has resulted in ragweed being present almost everywhere. The consequence in terms of public health and health costs may be dramatic, not only in regions where *Ambrosia* plants are already widespread.

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