

THE ORIGIN AND WORLDWIDE DISTRIBUTION OF RAGWEED – A REVIEW

LÁSZLÓ MAKRA¹, ISTVÁN MATYASOVSKY²,
KÁROLY BODNÁR¹, GÁBOR TUSNÁDY³

¹Institute of Economics and Rural Development, Faculty of Agriculture, University of Szeged, HU-6800 Hódmezővásárhely, Andrassy út 15, Hungary

²Department of Meteorology, Eötvös Loránd University, HU-1117 Budapest, Pázmány Péter st. 1/A, Hungary

³Mathematical Institute of the Hungarian Academy of Sciences, HU-1364 Budapest, P.O.B. 127, Hungary

makra@geo.u-szeged.hu; matya@ludens.elte.hu; bodnar@mgk.u-szeged.hu;
tusnady.gabor@renyi.mta.hu

ABSTRACT

The aim of the study is to provide a survey on the history of ragweed worldwide. Its climate dependence, impacts in agriculture, health effects and social costs are also presented. In Europe common ragweed (*Ambrosia artemisiifolia*) is predominant of all *Ambrosia* species that is supported by population genetic data. The most important habitat areas of ragweed and the highest pollen concentrations occur, in decreasing order of the pollen levels (1) in the south-western part of the European Russia, (2) in the southern and eastern parts of Ukraine, (3) in the Pannonian Plain in Central Europe, (4) in the Rhône-Alpes region in France, furthermore (5) in the Po River valley in Italy. Besides Europe, ragweed occurs in China, India, Japan and in other Asian countries, furthermore in Australia and the United States of America. However, beyond the USA little information is available. Warming trends due to the climate change favours the expansion of ragweed, producing higher pollen levels worldwide. In association with the warming, increasing ambient CO₂ levels generate greater biomass and increased pollen production. Hence, ragweed pollen production can be expected to increase significantly under predicted future climate conditions, bringing severe impacts to areas that have yet been suffering slightly.

Keywords: origin of ragweed, social costs of ragweed, distribution of ragweed, climate change, respiratory allergy

INTRODUCTION

Origin of ragweed

Common ragweed (*Ambrosia artemisiifolia*) (Asteraceae family) is an annual species, native to North America, which has been introduced and subsequently naturalized in many countries including a large part of Europe (JÄGER, 1998; JUHÁSZ, 1998; RYBNÍČEK and JÄGER, 2001; BULLOCK ET AL., 2010), Asia and Australia (LAWALRÉE, 1953; PRISZTER, 1960) following its introduction to many places in the world. The name *Ambrosia* is the same as that of the delicious food eaten by the mythical Greek gods that conferred them immortality (MAKRA ET AL., 2004). The term might refer to the tenacity of the plants, which makes it hard to rid an area of them if they occur as invasive weeds. The genus is best known for the severe and widespread allergies caused by its pollen (BÉRES, 2003). *Ambrosia artemisiifolia* belongs to the phylum of angiosperms (Angiospermatophyta), to the class of Dicotyledonous (Dicotyledonopsida), to the order of Composites (Asterales), to the family of Daisies (Asteraceae), to the subfamily of disc-florets (Tubuliflorae) and to the genus of ragweeds (*Ambrosia* spp.). This genus comprises 42 species. The most species occur in the United States, some of them in Central- and South America, while *Ambrosia senegalensis* Dc. is native in Africa (BÉRES ET AL., 2005).

The Sonora desert in Arizona (USA), north and west of the Bay of California, is considered the gene centre of *Ambrosia* species (BOHÁR, 1996), where about 10 species occur (BOHÁR, 1996). *Ambrosia artemisiifolia* was discovered in the USA before 1838 (WAGNER and BEALS, 1958), while in Canada in 1860 (BASSETT and CROMPTON, 1975). There are 41 species worldwide. In Europe, introductions of *A. artemisiifolia* stems from two different regions of their native area. Namely, populations established in Central Europe appear to have originated from eastern North America and Eastern European populations from more western North America. This may result from differential commercial exchanges between these geographic regions (GAUDEUL ET AL., 2011).

Ambrosia pollen has been found in deposits of over sixty thousand years in Canada. Nevertheless, its amount in peat deposits, except for the last 250 years, is small. However, due to deforestation and land use changes associated with the incursion of the western civilization, this amount increased over 100-fold. Recently, ragweed has extended areas in North-America until the southern part of Canada (SZIGETVÁRI AND BENKŐ, 2004).

Climatic associations

Ambrosia species are adapted to the arid climates of the desert. Ragweed favours temperate climate and prefers dry, sunny and grassy plains, sandy soils, river banks, roadsides, and ruderal sites (disturbed soils) such as vacant lots and abandoned fields (ZISKA ET AL., 2006; KAZINCZI ET AL., 2008a, 2008b).

Ragweed can take hold up and prosper if the temperature sum exceeds the threshold of 1400 °C, necessary for its floral and seed development (CUNZE ET AL., 2013). Below this threshold, under maritime climate (north-eastern Spain, Netherlands), ragweed populations seem only survive. At the same time, if the temperature sum is too high, for example in the Mediterranean, summers are hot and dry that involves a substantial decline of pollen release. However, the species is widely distributed in countries that are largely unsuitable for ragweed but import lots of seed, such as Netherlands or Belgium. In these countries, the distribution overstates the very low impact of the casual introductions (BULLOCK ET AL., 2010).

The northern and high-elevation range margin of ragweed is regulated by thermal and photoperiod constraints. Beyond their habitat areas, ragweed occurs casually and is unable to set seeds (DAHL ET AL., 1999; SAAR ET AL., 2000). In the northern range of its habitat area, even though the populations can produce seed, low temperatures or the cold climate promotes extinction. In general, over these areas ragweed grows to adulthood but fails to reproduce properly because it is too cold. At the same time, in the southern edge of its habitat, drought is considered a major factor limiting the invasion. This is the main aspect explaining a lack of ragweed pollen records from Spain and Portugal, where seed import rates should cause many introductions to occur (BULLOCK ET AL., 2010).

Long-range transport of ragweed pollen (traveling more than 100 km distance between the source area and the arrival point) can deliver pollen over less polluted areas, e.g. from the Pannonian Plain in Central Europe over the Basin of Vienna, northern Slovakia, Poland, Balkans or northern Greece and in the same way, from Ukraine over Poland (ŠIKOPARIJA ET AL., 2009; MAKRA ET AL., 2010; KASPRZYK ET AL., 2011; ŠIKOPARIJA ET AL., 2013).

Impacts on agricultural activity

The extensive spread of *A. artemisiifolia* can be associated to the political transitions in 1990s that led to the formation of young democracies in Eastern Europe. During these processes, the structure and the size of the cultivated areas, as well as land use changed. Namely, co-operatives were cut into smaller parcels due to privatization. Thus large,

formerly well-kept agricultural fields were abandoned and quickly colonised by *A. artemisiifolia* (KISS and BÉRES, 2006).

Ambrosia is a noxious agricultural weed. It grows frequently on roadsides, railway embankments, waste places and in cultivated lands. It can overgrow alfalfa and purple clover entirely, cause severe damages in potato fields and occurs often in sunflower and corn fields, as well. *Ambrosia* appears in large quantities in stubbles, effectively utilizes large amounts of fertilizer, has high productivity, and regenerates well in dry and infertile soils. Their ability to block sunlight causes reduced crop productivity (XIE ET AL., 2001). Furthermore, 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; MAKRA ET AL., 2014).

Health effects

Climate change in association with an extended urbanization, with high levels of vehicle emissions in urban areas, living in artificial environment with little movement may contribute to increasing frequency of respiratory allergy and asthma (D'AMATO, 2011). Pollen is an important trigger of respiratory diseases. Greater concentrations of carbon dioxide and, consequently, higher temperatures may increase pollen quantity and induce longer pollen seasons (ZISKA ET AL., 2003; Clot, 2008). Pollen allergenicity can also increase as a result of these changes in climate. Furthermore, there is evidence that high levels of traffic-derived air pollutants may interact with pollen and bring about more intense respiratory allergy symptoms (HJELMROOS ET AL., 1999; ANDERSEN ET AL., 2007; DÍAZ ET AL., 2007; ALVES ET AL., 2010). Accordingly, global warming may induce a wide pollen-related public health problem, for which the societies should be prepared in time. Symptoms due to common ragweed include a runny nose, sneezing, puffy or irritated eyes, and a stuffy or itchy nose and throat, as well as hay-fever allergies (MATYASOVSKY ET AL., 2011). Furthermore, *A. artemisiifolia* has a wide ecological tolerance and can colonize a large range of disturbed habitats (KAZINCZI ET AL., 2008a; PINKE ET AL., 2011; MAKRA ET AL., 2014). Its invasion is also facilitated by its resistance to certain herbicides (KAZINCZI ET AL., 2008b), the lack of natural enemies (MACKAY and KOTANEN, 2008) and the high genetic variability of invasive populations (GENTON ET AL., 2005; CHUN ET AL., 2010). These harmful effects, with its potential for rapid spread has made ragweed one of the most dangerous invasive non-native species in Europe. The European Commission has identified the species as a significant problem for many Member States of the EU and a very serious threat for others.

Social costs

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Common ragweed and its pollen cause serious losses in the economy and several fields of the everyday life. The current costs of *A. artemisiifolia* in terms of human health and agriculture were estimated by BULLOCK ET AL. (2010) for 40 European countries. All the costs are given in Euros at 2011 prices. The human health impacts were estimated to affect around 4 million people with total estimated medical costs of €2,136 million per year. Furthermore, total estimated workforce productivity losses and agricultural costs due to *A. artemisiifolia* as high estimates were €529 million and €3,559 million, respectively. The estimated total costs are valued at €6.224 billion per year. Over 80% of these impacts are lost crop yields. Estimated agricultural, human health, workforce and total costs are the highest in Ukraine, Romania and Hungary with €995, €770 and €605 million, respectively (BULLOCK ET AL., 2010). At the same time, in the USA, allergic disorders represent an

important group of chronic diseases with estimated costs at approximately \$21 billion per year. Among twenty-five of the most harmful invasive species of China, economic losses due to ragweed, found in most of the provinces, amount to 397.9 million USD, taking ragweed the 2nd most harmful species in the country (DING ET AL., 2004; LI ET AL., 2014). Realizing the danger, those countries polluted with ragweed, have introduced anti-*Ambrosia* campaigns under the control of the National Ministries of either Health Affairs or Agriculture.

DISTRIBUTION OF RAGWEED IN EUROPE

A limitation of ragweed pollen observations is that the pollen of *A. artemisiifolia* cannot be distinguished from other species of the *Ambrosia* genus. In Western Europe, the first temporary colonization of *Ambrosia* was reported from Brandenburg and Pfaffendorf (Germany) in 1863 (HEGL, 1906; PRISZTER, 1960; HODIŞAN and MORAR, 2007). In Western Europe, four American species have established: *A. artemisiifolia*, *A. psilostachya*, *A. tenuifolia* and *A. trifida* (JÁRAI-KOMLÓDI and JUHÁSZ, 1993; MAKRA ET AL., 2004). However, in Europe, common ragweed (*A. artemisiifolia*) is predominant of all *Ambrosia* species (MAKRA ET AL., 2005; BULLOCK ET AL., 2010; VINOGRADOVA ET AL., 2010) that is supported by the population genetic data of MÁTYÁS and VIGNESH (2012).

The only two native species of ragweed in Europe can only be found in some maritime locations around the Mediterranean coastal area. The earliest described colonization of seaside *Ambrosia* (*Ambrosia maritima*) occurred in Dalmatia (Croatia) in 1842 near Dubrovnik (Croatia) and Budva (Montenegro) areas and on the neighbouring islands (DE VISIANI, 1842). While, in the western basin of the Mediterranean, *A. maritima* (Balearic Islands) and *A. tenuifolia* (Minorca Island) are autochthon species (FRAGA AND GARCÍA, 2004). According to some botanists they are native, while others consider them as an annual variant of *A. psilostachya* or a variant of *A. artemisiifolia*. *A. psilostachya* occurs only sporadically in Europe (SZIGETVÁRI AND BENKŐ, 2004).

The distribution of *A. artemisiifolia* in Europe started after the First World War (MAKRA ET AL., 2014). Seeds of different *Ambrosia* species were transported to Europe from America by purple clover seed shipments, and grain imports. Major nodes of its distribution pathways are European ports, namely Rijeka (Croatia) towards Croatia and the western part of Hungary (JÁRAI-KOMLÓDI AND JUHÁSZ, 1993; MAKRA ET AL., 2005), Trieste and Genoa (Italy) towards Northern Italy (JÁRAI-KOMLÓDI AND JUHÁSZ, 1993; MAKRA ET AL., 2005), Marseille (France) towards the Rhône valley in France (JÁRAI-KOMLÓDI AND JUHÁSZ, 1993; COMTOIS, 1998; MAKRA ET AL., 2005) and Odessa (Ukraine) towards southern and eastern Ukraine (RODINKOVA ET AL., 2012).

The most important habitat areas of ragweed and the highest pollen concentrations occur, in decreasing order of the pollen levels, (1) in the southern, eastern and the northern-eastern parts of Ukraine (RODINKOVA ET AL., 2012), (2) in the Pannonian Plain in Central Europe including Hungary and some parts of Serbia, Croatia, Slovenia, Slovakia and Romania (MAKRA ET AL., 2005; 2014), (3) in the Rhône valley in France (DÉCHAMP AND COUR, 1987; LAAIDI AND LAAIDI, 1999; CHAUVEL ET AL., 2006; GLADIEUX ET AL., 2011), (4) in the south-western part of the European Russia (REZNIK, 2009), furthermore (5) in north-western Milan and south Varese (Lombardy, Po valley) in Italy (CAROSSO and GALLESIO, 2000; BONINI ET AL., 2012). Less extended habitat areas with smaller pollen levels occur in the Balkan Peninsula (YANKOVA ET AL., 2000; DIMITROV AND TZONEV, 2002; ŠIKOPARIJA ET AL., 2009), in the remaining part of the European Russia (REZNIK, 2009), Switzerland (CLOT ET AL., 2002), Germany (ZINK ET AL., 2012), Czech Republic

(RYBNÍČEK ET AL., 2000), Poland (KASPRZYK ET AL., 2011), Bulgaria (YANKOVA ET AL., 2000), the Baltic States (SAAR ET AL., 2000), Spain (FERNANDEZ-LLAMAZARES ET AL., 2012) and they even occur casually in Sweden (DAHL ET AL., 1999). At the same time, the northern border of its permanent occurrence is the 55°N latitude in Europe, namely the southern parts of Poland and Germany (SZIGETVÁRI and BENKŐ, 2004). Historic spread of *A. artemisiifolia* for the European countries is reported by BUTTENSCHØN ET AL. (2009) and BULLOCK ET AL. (2010) in detail.

BULLOCK ET AL. (2010) synthesised and reviewed (1) the information on the current extent of ragweed infestation in Europe; (2) the measures controlling ragweed spread and (3) the economic, social and environmental aspects of harmful effects in all economic sectors.

RAGWEED IN INDIVIDUAL COUNTRIES, WORLDWIDE

Ragweed in Hungary may have originated in Canada, rather than the United States (CSEH ET AL., 2008). Here, *A. artemisiifolia* was firstly described in Budapest in 1888 (THAISZ, 1910) then in Orsova (Lower-Danube region) in 1908 (JÁVORKA, 1910). As an arable weed, its first appearance in the South-Transdanubian part of Hungary (i.e. on the south-western part of the Pannonian Plain) was proved near Somogyvár (Somogy county) in 1922 in the south-western part of Hungary (LENGYEL, 1923). Since then, it has been spread rapidly towards the north-east parts of the country. Between the Danube and Tisza rivers *A. artemisiifolia* was spread from Szeged city, in the middle of the Pannonian Plain, towards North-Hungary (TÍMÁR, 1955). Recently the annual ragweed pollen level is 36-45% of the total annual pollen release in Szeged (JUHÁSZ, 1998). East from the Danube, the northern part of Pannonian Plain was infected from Szeged city (KAZINCZI ET AL., 2008a). By the end of the last century, Hungary was fully occupied by ragweed excluding the mountainous areas. In the 1950s, based on the Hungarian National Weed Survey, the species was ranked 21st in the weed list and has since risen to: 8th in the 1970s and to 4th by the 1980s (JÁRAI-KOMLÓDI, 1998; NOVÁK ET AL., 2009; BULLOCK ET AL., 2010). The phases of its distribution in Hungary have been mapped by PRISZTER (1957; 1960) and BÉRES and HUNYADI (1991). SONG and PROTS (1998) reconstructed the invasion of *Ambrosia artemisiifolia* in the Pannonian Plain in Central Europe and the Ukrainian Carpathians Mountains on the basis of floristic records. They found that the spreading speed of the species was around 70 km/year (on the average) since the middle of the 20th century.

The species was first recorded in Serbia around 1935 in the village of Osojci, near Derventa (MALY, 1940). The species was then recorded in 1953 around Sremski Karlovci, Petrovaradin and Novi Sad. It is believed that the species arrived from Romania on ships that sailed on the Danube (SLAVNIĆ, 1953). From the 1970s to the present, *A. artemisiifolia* has spread across a wide area of Serbia and recently it is considered to be a widespread ruderal weed species in Vojvodina often forming large, compact communities in sandy and ruderal habitats (KONSTANTINOVIĆ ET AL., 2004; BULLOCK ET AL., 2010).

In Croatia, the first records of *A. artemisiifolia* were collected in the 1940s around Pitomaca in Central Croatia. Inland parts of the country are highly infested with *A. artemisiifolia*, while in the coastal areas it is mainly concentrated in some districts (PETERNEL ET AL., 2006; GALZINA ET AL., 2010). *A. artemisiifolia* is expanding towards west, at a rate of between 6 and 20 km per year (GALZINA ET AL., 2010).

In Slovenia, *A. artemisiifolia* was introduced at the end of the Second World War. It is now well established and spreads widely and fast in the lowlands of the country (KOFOL SELIGER, 1998). Spreading of *A. artemisiifolia* towards both Serbia (ŠIKOPARIJA ET AL.,

2009) and Bosnia and Herzegovina (SOLJAN AND MURATOVIĆ, 2004) occurred from north, i.e. from the Pannonian Plain.

Until 1995, no data were available on the distribution of *Ambrosia* species in Bulgaria. YANKOVA ET AL. (1996; 1998) published the first results on *Ambrosia* pollen measurements in the air of Sofia, Bulgaria, that started in 1981. Here, ragweed colonization is extended in the Danubian Plain and Sofia region only (DIMITROV and TZONEV, 2002) and peak annual pollen concentrations here are very high, exceeding 10,000 pollen grains·m⁻³ of air in several years (YANKOVA ET AL., 1996).

The source region of *A. artemisiifolia* in Slovakia is Csallóköz and eastern Slovakia. The first description of its presence (Komarno, Southwest Slovakia) dated back to 1949. *A. artemisiifolia* is partly native and partly transported either by southerly winds from Hungary or arrived via cereal transports from the former Soviet Union (MAKOVCOVÁ ET AL., 1998).

The first record for Austria is a herbarium specimen collected in 1883, while the first naturalized population was recorded in Lower Austria, Burgenland and Linz in 1952 (ESSL ET AL., 2009). Furthermore, fields have been colonized by the 1970s (ESSL ET AL., 2009). *Ambrosia* pollen can be transported from the Pannonian Plain to eastern Austria and Vienna during August and September, when south-eastern winds are predominant in the region (ESSL ET AL., 2009; KARRER, 2010). JÄGER and LITSCHAUER (1998) detected pollen of *Ambrosia* coming from western Hungary in the air of Vienna. Native *Ambrosia* is also found in the Austrian countryside (JÄGER and BERGER, 2000). The migration velocity of new plant occurrences from east to west is 6-20 km per year (JÄGER and LITSCHAUER, 1998).

In the Czech Republic, the species was first recorded in 1883 in clover fields near Třeboň and a field near Doudlevice u Plzně (SLAVÍK and ŠTĚPÁNKOVÁ, 2004). Over the past 30 years *A. artemisiifolia* has spread from harbours, grain houses, silos, mills and transport links to lowland areas of south and north east Moravia, as well as along the Elbe valley (SLAVÍK and ŠTĚPÁNKOVÁ, 2004).

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, as well (CLOT ET AL., 2002). In the country, *Ambrosia* pollen was firstly observed in Basel in 1970 by LEUSCHNER (1974).

In France, *A. artemisiifolia* occurred in at least three botanical gardens in the 18th century (Lyon, 1763; Paris, 1775; and Poitier, 1791) and during the first half of the 19th century in at least five gardens, namely in: Alençon, Angers, Avignon, Montpellier and Strasbourg. The earliest herbarium record in Europe also comes from France in 1863 (CHAUVEL ET AL., 2006; BULLOCK ET AL., 2010). The species showed a gradual but continuous spread in this region, demonstrating its continuous presence in the area of Lyon, which seems to be the focus of its current French distribution (THIBAUDON, 1998; CHAUVEL ET AL., 2006; GLADIEUX ET AL., 2011). The agricultural trade between America and Europe in the 19th century and the First World War facilitated the introduction and spread of *A. artemisiifolia* in France. The plant is spreading from north to south in the mid-Rhone valley area and it is more dominant in rural than in urban areas (DÉCHAMP AND PENEL, 2002). The temporal and spatial spread of the species in France has speeded up in the last 30 years with a number of sub-regions being free of *A. artemisiifolia* declining dramatically from 54 in 1982; to 38 in 2004; and 9 in 2011 (CHAUVEL ET AL., 2006; BULLOCK ET AL., 2010; PETERMANN, 2011).

In Italy, the species was first recorded in 1901-1902 from Piedmont. *A. artemisiifolia* has been naturalized in the province of Milan (Lombardy) since the 1940s (STUCCHI, 1942; ZANON ET AL., 1998); however, it has been spreading rapidly since the 1980s. Currently,

the north-western Milan and south Varese (Lombardy, Po valley) are the most polluted areas with ragweed pollen in Italy (BONINI ET AL., 2012).

In Spain, *Ambrosia* species occur only over some areas, namely northern Spain (LAÍN Z and LORIENTE, 1983), the Basque Country, the Cantabric coasts and Galice (FERNÁNDEZ-LLAMAZARES ET AL., 2012), as well as central Spain (AMOR ET AL., 2006). The first record of the genus *Ambrosia* here dates back to the 19th century and corresponds to *A. maritima*, the only native species in the Peninsula (PÉREZ, 1887). The major ragweed colonies in Spain and Portugal are closely associated with some of the most important harbours, such as Barcelona, Bilbao, Lisbon, Porto, Santander or Valencia (FERNÁNDEZ-LLAMAZARES ET AL., 2012).

In the United Kingdom, the species was first recorded as a casual species in 1836. It is considered to be increasing in range and abundance, but most records are still classed as casual (CASARINI, 2002; BULLOCK ET AL., 2010).

In Germany, *A. artemisiifolia* was first recorded in 1860, in Hamburg. It is believed that *A. artemisiifolia* was introduced with grain and seed shipments from the USA. Up until the 1970s, *A. artemisiifolia* was found in only a few areas but since the 1990s it has spread eastward. The species is mostly found in the south and east of the country (ALBERTERNST ET AL., 2006) in areas where anthropogenic activity is the highest (BULLOCK ET AL., 2010). ZINK ET AL. (2012) found that in north-eastern Germany the majority of the pollen originated in local areas; however, up to 20% of the total pollen load came via long-range transport from Hungary. Furthermore, according to BOEHME ET AL. (2009) a substantial ratio of children was sensitized by ragweed pollen in Baden Wurttemberg.

In Belgium the species was first recorded in 1883 and has since become widely spread with most records from the north of the Sambre-Meuse river corridor. The majority of the records are found in the more urbanised regions (MARTIN AND LAMBINON, 2008; BULLOCK ET AL., 2010).

For Denmark, the earliest record of *A. artemisiifolia* dates from 1865 but today it has only a limited distribution in the country. However, the species has been noted as spreading from the established areas (BULLOCK ET AL., 2010).

In Poland, *A. artemisiifolia* was first introduced into Szczepanowice (Silesian Lowland - south-western Poland) in 1873. It is also possible that the species may have been introduced as early as 1613 (TOKARSKA-GUZIŁ, 2005). The species has since spread to southern and central-eastern Poland (CHŁOPEK ET AL., 2011). The spreading rate is poorly understood since both the species and incidence of biological recording in the country are increasing. However, in southern Poland *A. artemisiifolia* is supposed to have spread 30 km in the period 2007-2010 (BULLOCK ET AL., 2010; CHŁOPEK ET AL., 2011). Ragweed pollen arrives in Poland from Slovakia, the Czech Republic and Austria (KASPRZYK ET AL., 2011). However, its most important source areas are the Pannonian Plain (MAKRA ET AL., 2010; ŠIKOPARIJA ET AL., 2009; 2013) and the Ukraine (RODINKOVA ET AL., 2012) not only for Poland but for all Central European countries. Their distribution here is limited to ruderal places, waste lands, lawns, sea ports, places near roads and railway tracks (KASPRZYK ET AL., 2011).

Concerning the Baltic area, ragweed is considered a casual species and the spreading rate is considered to be very low. *A. artemisiifolia* was first found in Lithuania in 1884, in Latvia in 1936 and in Estonia in 1954 (TABAKA ET AL., 1988; GUDŽINSKAS, 1993; SAAR ET AL., 2000). *A. artemisiifolia* is mostly recorded along railways and close to major cities (Herbarium of Institute of Biology of the University of Latvia) (BULLOCK ET AL., 2010; ŠAULIENĖ AND VERIANKAITĖ, 2012).

On the territory of Romania the species was first recorded in 1908 in Orsova (south-western Romania), the area belonged to the Austro-Hungarian Empire at the time

(JÁVORKA, 1910). Recently common ragweed has extended its range across the entire country with the exception of the mountainous regions (HODIŞAN AND MORAR, 2008; BULLOCK ET AL., 2010). The agricultural areas have been greatly infested. *Ambrosia* has extended from the west and north-west towards the central and southern part of Romania and continues to extend to the east and north-east (IANOVICI AND SIRBU, 2007; SKJØTH ET AL., 2010; IANOVICI ET AL., 2013).

In Moldova, *A. artemisiifolia* was first reported at Ungheni (BORZA AND ARVAT, 1935), downstream of the Nistru River (MARZA, 2010). Since its introduction, the species has spread in the south-eastern part of the country (BULLOCK ET AL., 2010; MARZA, 2010).

Ambrosia was introduced to Ukraine through a few trade routes in different years. A German pharmacist Krikker grew ragweed in the Dnipropetrovsk region as a medicinal plant (substitute for quinine and as an anthelmintic remedy) in 1914 (MAR'YUSHKINA, 1986). Ragweed was first described in the Kyiv region in 1925. The army of General Denikin brought *Ambrosia* with seeds of alfalfa to Eastern Ukraine, so this weed was spread in Zaporozhye, Donetsk and Lugansk regions (RODINKOVA ET AL., 2012). The next ragweed intervention to Ukraine was registered in 1946 when the first wheat consignment was shipped to USSR from USA.

This allergenic weed is currently found in all over the country. Ragweed is usually spread from southern and eastern parts of Ukraine toward north-west by transportation, with sunflower seeds contaminated by seeds of ragweed while they are transported from steppe to forest-steppe zone of Ukraine. Sensitivity of compromised children to *Ambrosia* pollen in 2000 was 3%, and in 2009 it was already 10% in the western part of Ukraine (BESH ET AL., 2011), which is consistent with a significant increase in *Ambrosia* pollen abundance (PALAMARCHUK ET AL., 2012).

In Russia, *Ambrosia artemisiifolia* was first recorded in the southern European part of the country in 1918 (KOVALEV, 1989). The first occasional introductions were possibly connected with the increasing international trade via the Black Sea ports (KOVALEV, 1989) and rail roads (MAR'YUSHKINA, 1986). However, until the mid-sixties, there was no information on allergic properties of ragweed pollen in the USSR (OSTROUMOV, 1964). Recently, almost 80% of the total square infested by common ragweed in Russia falls in Krasnodar territory (MOSKALENKO, 2002). Also Stavropol' territory, Rostov province and the Russian North Caucasus are highly infested extending southwards to Georgia. Furthermore, Primorsk and Khabarovsk territories (Russian Far East) are another, relatively small, isolated areas of common ragweed invasion (REZNIK, 2009).

Israel is also infected with *Ambrosia*. The invasion of new species of *Ambrosia* into Israel is still in progress, mainly in the eastern Galilee and in the Sharon plain (WASEL ET AL., 2008).

A. artemisiifolia is extensively distributed in Asia, North and South America and Australia (LAWALRÉE, 1953; PRISZTER, 1960). The dynamic spread of *A. artemisiifolia* in Turkey is a serious environmental issue (KAPLAN ET AL., 2003; ZEMMER ET AL., 2012). *Ambrosia* species extensively occur in large areas of India (SINGH ET AL., 2004; SAHA and MISHRA, 2009), while BALLARD ET AL. (1995) reported that *A. artemisiifolia* and *A. trifida* are important weeds of soybean plantations here. Ragweed invaded South Korea from Europe and North America (KIL ET AL., 2004), while Japan from North America (FUKANO and YAHARA, 2012). In Japan, pollen allergy due to *A. artemisiifolia* is the 2nd most important following Cryptomeria (KAZINCZI AND NOVÁK, 2012). In China, common ragweed was first documented in 1935 both in the north-eastern part of the country (CHEN ET AL., 2007a; 2007b) and in Eastern China (Hangzhou, Jiangsu Province). Since that time on, ragweed has rapidly spread to northern, central and eastern China including over 15 provinces. Giant ragweed reportedly invaded Northeast China in the 1950s. By 1989, ragweed had

expanded from centres in Shenyang, Nanjing, Nanchang and Wuhan to include 12 provinces (WAN ET AL., 1993; LI, 1997; XIE ET AL., 2001). The suitable areas for ragweed include almost exclusively the eastern, most populated part of the country with the Sichuan basin, supplemented with parts of Xinjiang Uygur Autonomous Region. This suggests that ragweed may be able to invade these areas in the future (CHEN ET AL., 2007b). *A. artemisiifolia* is in abundance in the reaches of the Changjiang (Yangtze) River and along roadsides, while *A. trifida* along village paths and riverbanks in northeastern China (WANG ET AL., 1985). The species continue their southward spread into the subtropical regions of the country (QIN ET AL., 2012). The reason of the large-scale invasion of *A. artemisiifolia* in China is its great germination success over the highly variable climatic conditions (SANG ET AL., 2011). LI ET AL. (2012) found that high levels of genetic variation in China indicate that there has been no erosion of genetic variance due to a bottleneck during the introduction process. They also suggest that the successful invasion of *A. artemisiifolia* into Asia was facilitated by repeated introductions from multiple source populations in the native range creating a diverse gene pool within Chinese populations.

In the United States, the suitable region for ragweed involves almost exactly the eastern half of the country, including the Pacific coastal areas (CHEN ET AL., 2007b). Here, in the home of *Ambrosia* spp., duration of the ragweed pollen season has been increasing in recent decades as a function of latitude, in association with an enhanced warming (ZISKA ET AL., 2011). In southern Québec (Canada), *A. artemisiifolia* has been present since at least 200 years but the species was probably restricted to the Montréal area during the 19th century (LAVOIE ET AL., 2007). It is unclear whether common ragweed is native here or has been introduced from the Canadian Prairies (ROUSSEAU, 1974; BASSETT AND CROMPTON, 1975). However, this species is clearly more widespread here today than at the beginning of the 20th century (ROUSSEAU, 1974).

In South America, *Ambrosia* species are widely prevalent weeds (SULSEN ET AL., 2011; MASCIADRI ET AL., 2013).

In Australia, ragweed pollen is in the air in abundance for a sufficient length of time and its concentration to sensitize and provoke fall hay fever and asthma exacerbations (BASS ET AL., 2000).

PERSPECTIVES

At high CO₂ levels, *A. artemisiifolia* showed substantially greater biomass, as well as increased pollen production compared to those in ambient CO₂. Hence, ragweed pollen production can be expected to increase significantly under predicted future climate conditions (WAYNE ET AL., 2002; ROGERS ET AL., 2006).

Warming trends in long-term climate change involve greater exposure times to seasonal allergens that lead to higher risk potential of public health incidences (D'AMATO and CECCHI, 2008; SHEA ET AL., 2008).

In North America, duration of the ragweed pollen season has been increasing in recent decades as a function of latitude (ZISKA ET AL., 2011). For Europe, future spread of ragweed will depend on the climate and land use change. Based on different models, ragweed will spread north (e.g. Germany, Poland, northern part of the European Russia) with a warmer climate compared to its current range, bringing severe impacts to areas that have yet been suffering slightly (BULLOCK ET AL., 2010; CUNZE ET AL., 2013).

Nevertheless, there is some evidence to suppose that very high temperatures are harmful for ragweed. The highest increase in the mean temperature, especially in summer time (August), represents a limit for pollen production of *Ambrosia*. In this period, the loss of

water makes a difficulty for phyto-physiological processes, so in order to save water the plant reduces its pollen production. This effect will limit the climate change related expansion of ragweed (MAKRA ET AL., 2011).

Concerning future economic expenses of *A. artemisiifolia* for Europe, without controls the influence of climate change will increase the medical and work productivity costs, but the agricultural costs will reduce. This suggests that, due to the climate change, agricultural areas will reduce and pollen sensitivity will increase in the population (BULLOCK ET AL., 2010).

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