10 Why is Biocontrol of Common Ragweed, the Most Allergenic Weed in Eastern Europe, Still Only a Hope?

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Overview: This chapter presents the story of a long and as yet unsuccessful struggle to find suitable fungal and/or insect biocontrol agents for ragweed, a plant that became a widespread allergenic weed in Eastern Europe. This effort illustrates why biocontrol initiatives, although desirable, sometimes cannot be implemented into practical control strategies, in spite of the fact that they might represent a realistic solution to problems affecting human health, the environment and agricultural productivity.

Introduction

Ambrosia artemisiifolia (Fig. 10.1), or common ragweed, has in the last decade become the best-recognized weed species in Eastern Europe. This arose because so many people developed allergies to the air-borne pollen of this weed that the governments had to initiate programmes to bring attention to this noxious weed. They did this through a series of advertisement campaigns utilizing huge posters, brochures, magazine articles, school programmes, and other methods (Figs 10.2 and 10.3). Current estimates suggest that between 10 and 15% of the population are now allergic to ragweed where it has established in Eastern Europe. In North America, where this weed originates from, ragweed allergies are well recognized (Bassett and Crompton, 1975) but until the 1990s this illness was relatively rare in Europe. In the affected Eastern European countries, the health costs associated with ragweed allergies are paid by the national health insurance systems and the costs of cont rol in urban areas by the local councils. These costs were of such magnitude that it forced authorities to act at both the regional and national levels to deal with the problem. For example, the Hungarian Parliament identified ragweed as a national health threat and made control of ragweed a law. Furthermore, in 2003 the Hungarian taxpayers were given the opportunity to direct 1% of their annual tax for ragweed control. Unfortunately, none of these actions have resulted in a decrease of ragweed pollen or ragweed populations, as these continue to spread along with the number of people developing allergies.

Fig. 10.1. A ragweed plant in the front of Pont du Gard, a famous Roman aqueduct belonging to the UNESCO World Heritage. Ragweed has only recently colonized this area, which is a popular natural reserve in southern France.

Spread of Common Ragweed in Europe: an Example for Biological Invasion Caused by an Alien Weed Introduced to a New Environment

The seeds of *A. artemisiifolia* were introduced in large numbers into Europe, starting from the 19th century as contaminants of agricultural products, such as cereals, imported from the USA and Canada, where ragweed is native. Ragweed plants are poor competitors compared to many other weed species and they only produce seeds late in the season. They probably did not establish well in most parts of Europe but some must have survived in a few places, from where they slowly spread without causing much trouble or notice. Until the 1970s, ragweed was just one among many weed species present in agricultural fields in some parts of Europe. Mechanical and herbicide treatments controlled its populations in cultivated fields and it created no noticeable issues outside of agricultural areas. This is not surprising as ragweed is a primary colonizer of disturbed and abandoned fields (Bassett and Crompton, 1975), and such sites were not common in either Western or Eastern Europe until the end of the 20th century.

A boom in its spread in Eastern and Western Europe, which started approximately 15 years ago, was facilitated by socio-economic factors. In Eastern Europe,

Fig. 10.2. 'National ragweed control project for everyone's health' says a huge poster exhibited by the National Ragweed Control Committee in the middle of a weedy area in Hungary. *Artemisia vulgaris,* another highly allergenic weed, is growing in the front of the poster. The efficacy of this kind of propaganda is extremely doubtful.

these could be linked with the deep political changes that led to the formation of young democracies in that region. During this process, many socialist-type agricultural cooperatives were closed and their lands were subdivided and redistributed to their former owners or descendants, who, in many cases, did not continue to cultivate them for years. Thus, large, formerly well-kept agricultural fields became abandoned and were quickly colonized by ragweed. In addition, construction of new roads, motorways, shopping centres, etc. soon followed, but with little effort spent on landscape management. This also created large disturbed areas, where ragweed readily became established. In less than a decade, ragweed became the most widespread weed species within both agricultural and urban areas in Hungary, as well as in many neighbouring countries except Austria, where landscape management standards remained in place.

Parallel to the explosion in the spread of ragweed in Eastern Europe, its populations have been found to be rapidly expanding along the Rhône River in France, as well. This was thought to be an unwanted result of a policy of the European Community, established in 1994, which required French farmers to either stop growing crops in certain lands or grow sunflowers (Déchamp and Méon, 2002). Both requirements facilitated the spread of ragweed as its control is particularly difficult in sunflower fields.

The massive spread of ragweed in different parts of the world was always correlated with an increase in areas disturbed by humans. For example, analysis

Fig. 10.3. 'Ragweed-free street' announces a plate in Budapest in a street covered with asphalt.

of pollen in soils from Canada showed that in the 18th and 19th centuries the increased agricultural activity as result of settlement by the Europeans coincided with an increase in ragweed pollen in those regions (Bassett and Crompton, 1975).

Natural Enemies of Ragweed in Europe and North America

Biological invasions by alien plant species into newly occupied areas can sometimes be explained, at least in part, by their 'escape' from natural enemies (insect herbivores, fungal, bacterial and viral pathogens, etc.) that they would normally encounter in their native habitats (Evans *et al.*, 2001). Nothing, however, was known as to what natural enemies might exist in Europe that could control ragweed populations in the newly occupied areas. In 1994 my colleagues, Dr Gyula Bohár and Dr László Vajna, started to look for natural control agents of *A. artemisiifolia* in Hungary. I joined their project in 1997. Our studies showed that only a few plant pathogenic fungi infect ragweed in Hungary, some of which were identified on *Ambrosia* for the first time in Europe (e.g. Bohár and Kiss, 1999; Vajna *et al.*, 2000). In the USA, however, more than 25 fungal pathogens are listed as pathogens on *A. artemisiifolia* (Farr *et al.*, 1989). We found only a few polyphagous arthropods (insects that feed on many kinds of food) that fed on ragweed in Hungary or in other European countries (Balázs Kiss, unpublished data). More than 200 species, however, are known to damage *A. artemisiifolia* in North America, including a large number of polyphagous species and some oligo- and monophagous arthropods, as well (Harris and Piper, 1970). Recently, a reciprocal transplant assay showed that experimental ragweed plants suffer much less herbivore damage in France than in Canada (Genton *et al.*, 2005).

Biocontrol of Ragweed in Europe: a Reasonable Approach to the Problem

All the data we and others accumulated suggested that the European ragweed population escaped from most of their natural enemies. Specialized fungal pathogens found in North America, such as rusts and powdery mildews, or arthropods that feed mostly or exclusively on ragweed were not present in Europe. Our field surveys conducted regularly since 1994 in Hungary confirmed that ragweed plants remained perfectly healthy in the field, except for outbreaks of epidemics caused by two fungal pathogens, *Phyllachora ambrosiae* in 1999 (Vajna *et al.*, 2000) and *Plasmopara halstedii,* (a downy mildew) in 2002 (Vajna, 2002). However, similar epidemics were not observed in other years and we couldn't find any other biotic factors causing damage to ragweed in Europe.

Noxious alien weeds have been successfully controlled in some newly invaded areas by artificial release of selected natural enemies, such as insects and plant pathogens, called biocontrol agents (BCAs) (e.g. Evans *et al.*, 2001). These are generally collected from the countries of origin of the invasive species. The release of BCAs requires the accumulation of data ensuring that the BCAs are, indeed, specialized to the target species and won't attack other plants (Seier, 2005).

Speculations about Potential BCAs of Ragweed in Europe

Based on information from the literature, our initial idea was to identify and to release a rust fungus, such as *Puccinia xanthii*, to reduce the spread of ragweed in Europe (Bohár, 1996). This fungus produces only teliospores (blackish, thick-walled spores of some rusts) and occurs on *Xanthium* spp. in North America, parts of Europe and Australia (Morin *et al.*, 1993). In addition, it is known to infect *A. artemisiifolia* and *Ambrosia trifida* in the USA (Batra, 1981; Farr *et al.*, 1989). However, neither *P. xanthii* nor any other rust species have been recorded on ragweed outside North America thus far. Although *P. xanthii* is present in Hungary on *Xanthium italicum* (Dávid *et al.*, 2003), our efforts to infect *A. artemisiifolia* with this rust either in the greenhouse or in the field have always failed (Dávid and Kiss, unpublished results). Thus, the release of an American strain of *P. xanthii* specific to *A. artemisiifolia* could be envisaged in Europe. Another form of *P. xanthii* has already been recommended as a classical BCA of *A. trifida* outside North America (Batra, 1981).

Some other fungal pathogens that could be considered as potential BCAs of ragweed in Europe include *Protomyces gravidus*, a North American fungus specialized to *A. artemisiifolia* and *A. trifida*. This pathogen sometimes causes serious epidemics on ragweed, and it was evaluated as a mycoherbicide against the two *Ambrosia* species. However, the results obtained showed no control (Cartwright and Templeton, 1988) and this aspect of the project was discontinued. *Sclerotinia sclerotiorum* (Bohár and Kiss, 1999) or a *Phoma* sp. (Teshler *et al*., 2002), two broad-spectrum fungal pathogens, were also considered as BCAs of ragweed, but their use would have to be limited to specific non-agricultural conditions.

The North American insect herbivores of ragweed have been studied for biocontrol purposes far more intensively than plant pathogens, and a number have been released as control agents in different parts of the world (Julien and Griffith, 1998). The most studied BCA of ragweed, a monophagous North American leaf beetle, *Zygogramma suturalis*, was released at locations in the former Soviet Union (Kovalev, 1989), Croatia (Igrc *et al*., 1995), China (Wan *et al*., 1995) and Australia (Julien and Griffith, 1998). They successfully established and spread in the former Soviet Union and the initial results were promising (e.g. Kovalev, 1989). However, their populations remained low and their overall impact was minimal (Reznik *et al*., 1994). In areas of China 30,000 beetles were released from 1988 to 1991, but only a few individuals were recovered, indicating a poor establishment (Wan *et al*., 1995). Similar results were obtained in Croatia (Igrc *et al*., 1995). Thus, *Z. suturalis* did not fulfil expectations as a BCA against *A. artemisiifolia*.

A Search for Natural Enemies of Ragweed in North America and the Missing Rusts

To our knowledge, there have been no attempts to find BCAs for ragweed in North America thus far, except for Dr Kovalev's survey in the 1970s, which led to the release of a leaf-eating beetle, *Z. suturalis*, in the former Soviet Union in 1978 (Kovalev, 1989; Reznik *et al*., 1994). In 2003, I received an OECD fellowship allowing me to spend 3 months in Canada and the USA to look for potential BCAs of *A. artemisiifolia*. I travelled over 13,000 km, from Québec to North Carolina and back along the eastern coast of North America, and from Québec to Wisconsin, searching for both plant pathogens and arthropods that could be considered as potential BCAs of ragweed for Europe. Much to my surprise, I did not find any ragweed plants infected with rusts, although this was a priority for my explorations. I was specifically looking for *P. xanthii*, a fungus reported to infect ragweed in the USA (Batra, 1981; Farr *et al*., 1989). When I realized that this task could not be achieved, I contacted over 20 colleagues working at universities, USDA and extension services in Canada and the USA and asked them to look for rusts and other fungal diseases on ragweed. In addition, I published a similar request in *Inoculum*, the newsletter of the Mycological Society of America (vol. 54 (5), page 23, 2003). Though I received numerous replies and many searches were made, no rust fungi were found on ragweed by anyone.

To assure myself that *P. xanthii* does infect *A. artemisiifolia* in North America, as reported, I borrowed and examined all the herbarium materials of *A. artemisiifolia* infected with rust fungi from U.S. National Fungus Collections (abbreviated as BPI and located at USDA-ARS, Systematic Botany and Mycology Laboratory, Beltsville, MD). Based on the morphology of the telia and teliospores found on the dried leaves, I identified 11 BPI specimens collected between 1855 and 1963 in five states of the USA (FL, KS, OK, SC and TX) as *A. artemisiifolia* plants infected by *P. xanthii* (Fig. 10.4). This supported the published information on the occurrence of *P. xanthii* on common ragweed in these places (Farr *et al*., 1989). Unfortunately, the limits of my budget did not permit me to re-visit the places where these herbarium materials came from. However, rust fungi can easily spread for long distances, so we cannot explain why was *P. xanthii* missing from *A. artemisiifolia* in the searched regions of the USA and Canada, although it was found between 1855 and 1963 in Florida, Kansas, Oklahoma, South Carolina and Texas by those who have deposited herbarium specimens at BPI.

The Most Promising BCA: *Ophraella communa*, a Leaf Beetle

During my survey in Canada and USA, the most widespread natural enemy of *A. artemisiifolia* turned out to be a leaf-eating beetle, *Ophraella communa*. Its larvae, pupae and adults were present on ragweed everywhere I went. Sometimes the larvae caused serious damage to plants in the field. *Z. suturalis* was also present on ragweed but its population densities were much lower than those of *O. communa*. Although I am a plant pathologist, I became interested in *O. communa* and have started to learn more about it. This species, known from North America only, was recently discovered in Japan (Yamazaki *et al*., 2000). It has been investigated as a potential BCA of ragweed in Australia, but Palmer and Goeden (1991) did not recommend its release there because it caused some damage to sunflower plants in a no-choice test. This report excluded *O. communa* from the list of potential BCAs for ragweed outside North America. However, their conclusions came from results of a single small-scale no-choice test and placing such exclusion on this insect may have been premature. Palmer and Goeden (1991) themselves noted that *O. communa* has never been recorded as an insect pest of sunflower in North America, where both *A. artemisiifolia* (and sunflower are found) in abundance. Recently, Dernovÿci *et al*. (2006) re-examined the feeding behaviour of *O. communa* on sunflower and *A. artemisiifolia* in more detail using choice and no-choice tests and found that ragweed is the main host plant of this beetle. This study showed that *O. communa* cannot complete its life cycle and cannot increase its population on sunflower plants, although under no-choice tests it can cause some damage to sunflower. In Japan, where *O. communa* was first found in 1996, detailed studies of the feeding behaviour of this beetle also showed that *A. artemisiifolia* is the preferred host plant (Yamazaki *et al*., 2000) and that no damage occurs to sunflower.

O. communa has performed well as an inundative BCA of ragweed in cabbage and carrot fields in Canada (Teshler *et al*., 2002). A special device was designed for its collection, storage and delivery (Teshler *et al*., 2004), which was used in inundative biocontrol experiments. I used this device during my trip in 2003 to Canada and the USA to collect and transport many individuals, and

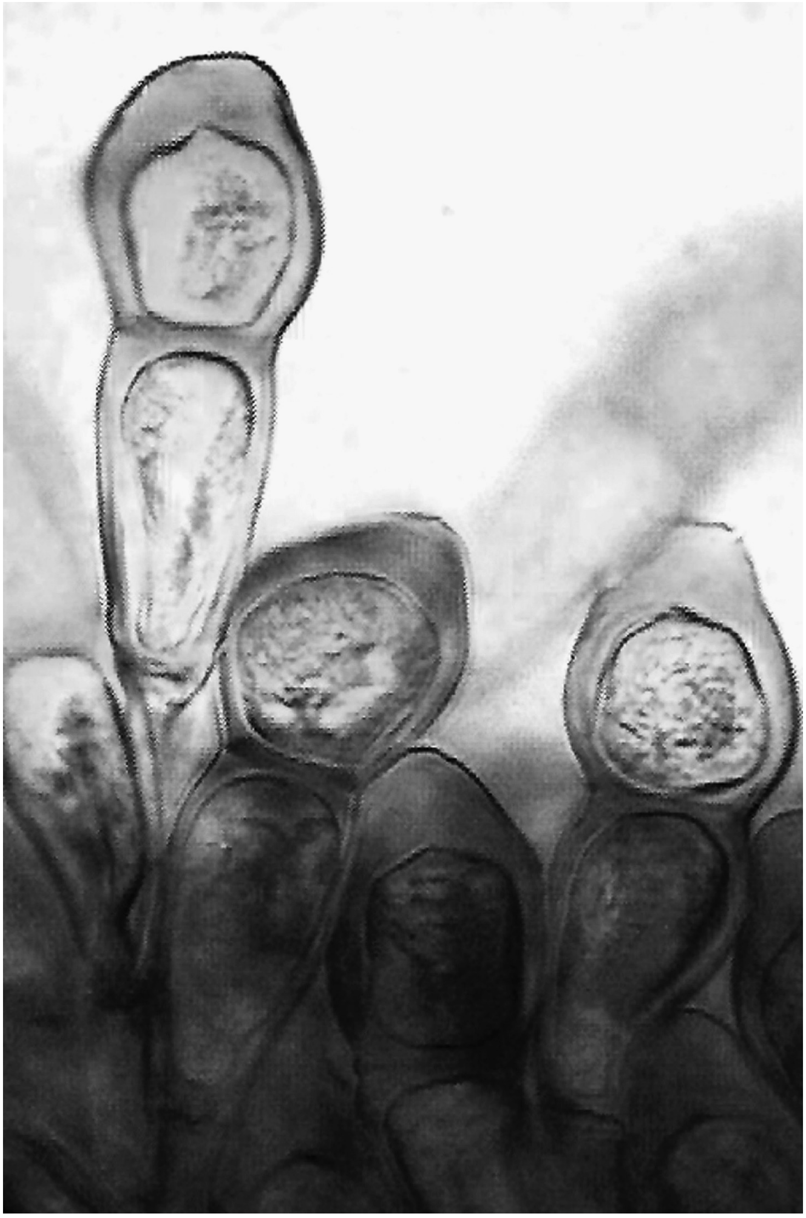

Fig. 10.4. Teliospores of *P. xanthii* from a herbarium specimen of *P. xanthii* infecting *A. artemisiifolia* collected in Texas in 1915.

thanks to Dr Teshler's guidance, I learned a simple mass-rearing technique for *O. communa*. Within a few weeks I obtained hundreds of beetles at McGill University, which I planned to take back with me to Hungary to continue my studies in a quarantine laboratory. However, this did not happen, as the permit

(a)

(b)

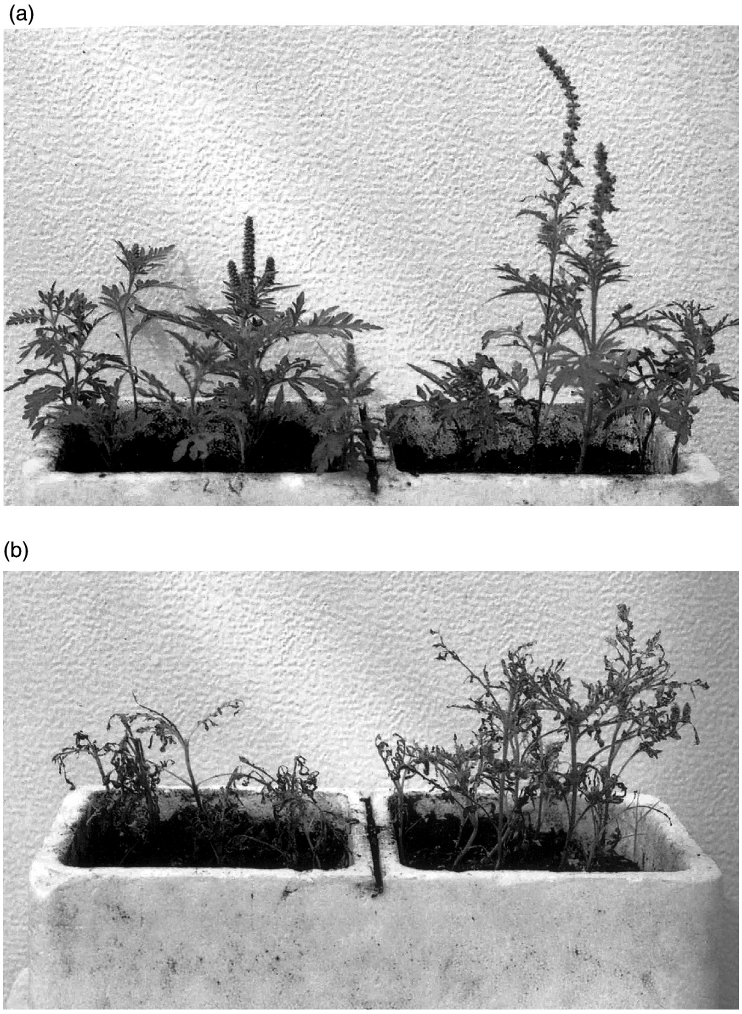

Fig. 10.5. Potted ragweed plants used to test the efficacy of *O. communa*, a leaf-eating North American beetle specialized to *A. artemisiifolia*, against this noxious weed. **a.** Healthy plants. **b.** The same plants defoliated by *O. communa* larvae in 2 weeks.

necessary for their import was not issued. At this stage, I think *O. communa* could be one of the most promising candidates for a BCA of ragweed for Europe (Fig. 10.5).

The Role of Media in Popularization of a Planned Biocontrol Project

Soon after our first proposals to implement a biocontrol project against ragweed were rejected in Hungary, my colleagues and I started to write articles in Hungarian journals of popular science to spread the idea of the concepts of biocontrol of ragweed. Journalists became very interested in this initiative and we received extensive coverage on TV, radio, popular daily and weekly papers, women's magazines, etc. Titles of articles written by journalists (not by us!) included: 'Who will defeat ragweed?', 'Operation against weeds', 'Only natural enemies can help', and so on. Our proposals to adopt BCAs against ragweed are still widely cited by the Hungarian media. However, this did not help us to receive funding for this project.

Frustrating Experiences with Authorities and Funding Agencies

Based on the magnitude of the problems caused by ragweed in Eastern and Western Europe, one might expect that all available control methods would be considered by the decision makers in charge of this issue. Although our initiatives concerning ragweed biocontrol were well known, all our applications for national and European Union (EU) grants were rejected. Moreover, our applications to obtain permits to import *O. communa, Z. suturalis* and *Pseudomonas syringae* pv. *tagetis* from North America, under strict quarantine conditions, were also refused by the Hungarian authorities. This was ironic in the case of *Zygogramma* beetle, as it was released in neighbouring Croatia many years ago (Igrc *et al*., 1995) and might have entered Hungary without a permit. The only import permit we were given was to import rust fungi under quarantine conditions, but rusts were not found in North America. The attitude towards our initiatives is probably due to a general fear of biological control methods of any kind, especially when it comes to introducing alien species (e.g. Seier, 2005). These concerns are sometimes valid but they can also mislead decision makers not to support any such proposals. Our efforts on ragweed biocontrol were supported by minor grants or by our own funds as this study has became a kind of hobby for us. Of course, no serious projects could be built up in this way.

In contrast to the USA, Australia, South Africa and New Zealand, where a number of successful classical biocontrol projects against introduced weeds have already shown the values of this method, Europe still lacks any experience with fungal BCAs of weeds (Seier, 2005). The first two projects on such topics have only recently started in the EU (Seier, 2005). This could also be a reason why authorities and funding agencies at national and European level haven't supported any initiatives to develop a biocontrol project against ragweed so far.

Concluding Remarks

At this stage we don't know whether it is possible to develop a biocontrol method to suppress ragweed populations in Europe. For many noxious weeds, no effective BCAs have yet been found, and *A. artemisiifolia* might be one of the species which simply cannot be controlled with BCAs. However, the list of potential insect and fungal BCAs of ragweed already identified suggests that it would worth trying.

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