Prospects for the search for weed biocontrol agents in Russia


Summary

Invasive weeds of Palaearctic origin constitute a major portion of weed problems in the Nearctic region and elsewhere. Specifically, 33 of 37 noxious invasive North American weed species recorded in 10 or more US states originated from the Palaearctic. In the Palaearctic region, these species are almost evenly distributed between three regions: (1) western and central Europe, (2) eastern Europe and the Middle East, and (3) the European part of Russia, including the northern Caucasus. A little less often, south-western Siberia, and rarely, south-eastern Siberia are included as a “cradle land” of North American weeds. In contrast, the overwhelming majority of field explorations aimed at the classical biocontrol of weeds have been conducted in western and central Europe (ca. 75%) and in eastern Europe and the Middle East (ca. 20%). Only 2% of past explorations were conducted in Russia and other republics of the former Soviet Union. Overcoming this imbalance, will provide new opportunities for both old and new weed targets of the Palaearctic origin. To support this conclusion, the results from exploration and research in Russia, which has targeted several invasive weed species, are described. The potential for new weed research programs in Russia is extraordinary.

Key words: biological control, explorations, Palaearctic, Russia, weeds.

Introduction

Exotic invasive weeds are a major problem in agriculture, forestry and natural areas, posing a threat to biodiversity conservation (Pimentel et al. 2000; Mirkin & Naumova 2002). Introduction of natural enemies from the native area of a target weed is considered one of the most efficient and biologically safe methods to control these plants (Strong & Pemberton 2000). However, biological control of weeds has a rather low “success rate”. The percentage of research programs resulting in successful introductions and efficient control of invasive weeds is about 10% by the estimation of different authors (Harris 1991, 1993, Gassmann 1995, Williamson & Fitter 1996), although it is rather difficult to define a biocontrol program’s success or failure. Finding a potential biocontrol agent with the required host specificity and efficacy is difficult, time consuming, and increasingly expensive. However, when a suitable biocontrol agent is collected, investigated and successfully introduced, it will pay for the research and the benefit:cost ratio could be quite high (McFadyen 1998). Thus, the advantage of a weed biocontrol project markedly decreases with increase in the number of investigated, but rejected or ineffective agents studied. Various selection methods and “scoring systems” have been proposed to predict efficiency and to avoid the time, effort and expense involved with the study of inappropriate candidates (Harris & Zwölfer 1968, Harris 1973, Goeden 1983, Lawton 1985). Most of the authors agree that the probability of quickly finding effective control agents clearly increases when searching on the target weed in its native range (Harris & Zwölfer 1968, Harris 1973, Goeden 1983, Lawton 1985, Schroeder & Goeden 1986, Gassmann 1995, McFadyen 1998), although Hokkanen & Pimentel (1984) stated that the success rate could be higher for agents collected from plants other than target species.
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(but see also Goeden & Kok 1986). Hence, it could be expected that native areas of the greatest number of invasive weeds would be explored more frequently. In the present paper, we attempted to check this hypothesis with invasive weeds originating from the Palaearctic, one of the largest biogeographic regions including Europe, northern and central Asia.

Materials and methods

The list of invasive weeds of USA and Canada was taken from the INVADERS database supported by the USDA Agricultural Research Service and available on the Internet at http://invader.dbs.umt.edu (Skinner et al. 2000). Data on introductions of weed biocontrol agents were taken from Biological control of weeds: a world catalogue of agents and their target weeds fourth edition (Julien & Griffiths 1999). In the case where a single species was repeatedly introduced, each introduction was included in this analysis. The native distribution range of Palaearctic plants was taken from the comprehensive Flora of the USSR (1934–1964).

Results and discussion

To limit the number of weeds under consideration, we selected from the database only the “top” invasive weeds recorded in 10 or more states of the USA. Forty records met this requirement, but three of them, Cuscuta spp., Cardaria spp., and Brassica spp. were excluded from consideration, as these weeds comprise a complex of species. Notwithstanding, we did include the species, Cardaria draba in our analysis. Of the remaining 37 invasive weed species, only 4 (Solanum carolinense, S. elaeagnifolium, Nassella trichotoma, and Sorghum almum) originated from outside the Palaearctic region. Thus, 33 from the 37 most widespread invasive American weeds are native to the Palaearctic and are the subject of our consideration. This distribution is not surprising as it is well known that plants of the Palaearctic origin constitute a major portion of exotic invasive weed species in the Nearctic region and elsewhere (Gassmann 1995; Pimentel et al. 2000).

For further analysis, we divided the wide Palaearctic region into four zones divided not only by their biogeographical characteristics, but also by political boundaries: western and central Europe; eastern Europe (including the Balkans and Asia Minor); Russia and other former Soviet Union republics; and other Palaearctic.

Analysis of the native distribution of the selected 33 plant species in these four main regions of the Palaearctic showed (Fig. 1) that western and central Europe, eastern Europe, and Russia are almost equal in the number of native plant species that have become weeds (note that the native area of a species may be spread over several parts of the Palaearctic region). Less often, other parts of the Palaearctic are included as a “cradle” land of North American weeds. Inside Russia, the European part of Russia (including the northern Caucasus and lower Volga) is the richest in native plants which have been introduced and subsequently become invasive in North America (32 species), while western Siberia (including the Urals) has 25 species, and Eastern Siberia (including the Russian Far East) has 12 species.

Further, we estimated the intensity of field explorations for weed biocontrol agents conducted in the above listed parts of the Palaearctic. The number of introductions (Julien & Griffiths 1999) was used to measure this intensity. At this stage of analysis we considered not only introductions into the Nearctic region, but also releases of biocontrol agents in Australia, New Zealand, Africa, and South America, where invasive weeds originating from Eurasia, have become a part of the local flora.

![Figure 1](image-url) Origins of Palaearctic species that are important weeds in the Nearctic region: number of weed species from four native areas (bars) and percentage of biocontrol explorations conducted in each area (line).
A total of 398 introductions of 181 biocontrol agents against 45 invasive weeds originating from the Palaearctic were considered. Almost half of biocontrol agents fall into two coleopteran families; both popular and successful in weed biocontrol: Chrysomelidae (21%) and Curculionidae (22%). The remaining 57% are other insect species, mites, nematodes, and fungi. A majority of the introductions (65%) occurred in North America, 28% in Australia and New Zealand, and the remaining 7% on other continents.

The areas where exploration was conducted and biocontrol agents collected were unevenly distributed over the Palaearctic region. Overwhelming, the majority of field collections (76%) occurred in western and central Europe: primarily in France, Italy, Switzerland, Germany, and Austria. Only 19% of the collecting was done in eastern Europe, the Balkans and Asia Minor (mainly Hungary, Greece, and Turkey). The remaining 5% of the collections was equally shared by the vast territories of the former Soviet Union and other Palaearctic countries (Pakistan, China etc.).

Thus, the current distribution of native areas of invasive plant species and the areas of search for biocontrol agents for the same plants that have become noxious weeds in naturalized areas are markedly different (Fig. 1). The western Palaearctic was studied much more frequently, while the eastern Palaearctic remains much less explored than would be expected given the above bio-geographical data. This imbalance is obviously a result of the former political divisions that no longer exist. The necessity to increase the intensity of field explorations in this sparsely investigated part of the world was noted some time ago (e.g. Schroeder & Goeden 1986, Pemberton 1990). The country of Russia comprises a considerable part of the Palaearctic region and includes a number of biomes from tundra to desert and various climates from mild sea regions to sharp continental areas in eastern Siberia. These many different biomes have given rise to a multitude of plant and animal species; providing substantial opportunities for biocontrol exploration and research. In the past 10 years, numerous projects aimed at biological control of various weeds have expanded their field research to include Russia.

Leafy spurge (Euphorbia esula), an aggressive deep-rooted perennial weed of Eurasian origin, is one example. Fourteen or more insect species have been released in North America for leafy spurge biological control (Julien & Griffiths 1999). Economic losses caused by this noxious weed are still extremely high (Gassmann & Schroeder 1995, Gassmann 1996, Gassmann et al. 1996). Hence, a search for additional biocontrol agents was conducted in 1998–1999 in Krasnodar territory (south-east Russian lowlands and the Caucasus), Novosibirsk province (south-west Siberia), and Irkutsk province (south-east Siberia). As a result of these field explorations, numerous new natural enemies of leafy spurge were discovered. Among these potential new biocontrol agents, one genus, Aphthona (Coleoptera: Chrysomelidae), yielded six species feeding on E. esula from climatically similar areas to the major leafy spurge infestation in North America (Konstantinov et al. 2000). Aphthona russica Konst., found in the Taman Peninsula and described as a new species, is considered a promising candidate for the biological control of leafy spurge (Konstantinov et al. 2001). The biology of this flea beetle was investigated both in the field and under laboratory conditions (Volkovitsh et al. 2000). Strict host specificity and a detrimental impact on the host in its native range, suggest a high potential for the control of leafy spurge in areas where it has become naturalized and weedy.

Among other insects worth mentioning is the spurge sawfly, Arge beckeri Tournier (Hymenoptera: Argidae), which was also collected in Krasnodar territory and investigated under laboratory conditions in the Zoological Institute (St Petersburg, Russia). The preliminary data suggest that A. beckeri deserves further intensive studies as a potential agent for the biological control of leafy spurge. In addition to the insect species, several pathogenic fungi were isolated from diseased Euphorbia plants collected under natural conditions and tested in the same laboratory (Dolgovskaya et al. 2000). However, recent explorations aimed at the search for new biocontrol agents in Russia are not limited to leafy spurge.

Since 1999, an international USDA-funded team has conducted field and laboratory studies aimed at biological control of Yellow starthistle, Centaurea solstitialis (YST), a noxious invasive weed in the USA, Chile, Australia, and South Africa. Among the insects found feeding on YST, is a flea beetle Psylliodes chalcodera with stem-boring larvae and leaf-feeding adults. This insect has been repeatedly collected from YST and Scotch thistle, Onopordum acanthium, another invasive thistle. Field observations suggested each of the plants is being attacked by different “ecological forms” of this flea beetle. Laboratory tests have shown these insects to be very host specific. Taxonomic research is being conducted at the Systematic Entomology Laboratory (USDA, ARS, Washington, DC) to investigate whether these “forms” may represent sibling species. Quantitative field sampling demonstrated significant impact on the host, suggesting that P. chalcodera may be an important biocontrol agent for YST in areas where it have become invasive (see also paper by Cristofaro et al. in this volume).

More recently, purple loosestrife, Lythrum salicaria, another exotic invasive weed in North America has become the object of studies conducted by the same Russian team working in cooperation with the USDA/ARS in Ithaca, New York, USA. In Russia, purple loosestrife is widespread in wet meadows, riverbanks and other moist habitats from the Baltic region to the Black sea and Eastern Siberia. Field explorations and studies of museum collections revealed a number of flea beetle
species feeding on *L. salicaria*. *Aphthona lutescens* collected in Krasnodar territory and studied under laboratory conditions seems to be particularly promising as a potential biocontrol agent due to narrow host specificity and (in contrast to biocontrol agents earlier introduced against purple loosestrife) two-fold impact on the host with root-feeding larvae and leaf-feeding adults (see also paper by Dolgovskaya *et al.* in this volume).

Hoary cress, *Cardaria draba*, is another invasive weed of western North America, listed among the 37 most invasive weed species of the United States. In cooperation with the Northern Plains Agricultural Research Laboratory in Sidney, Montana, numerous phytophagous insects were collected from *C. draba* during field trips in southern Russia. A flea beetle *Psylliodes wrasei* Leonardi and Arnold, not considered as a potential *C. draba* biocontrol agent earlier because its host range was unknown, looks promising. *Psylliodes wrasei* was collected in Krasnodar territory at the end of May and adults were frequently observed feeding on *C. draba* under natural conditions. Host-specificity tests conducted in the laboratory with field-collected beetles demonstrated that adults strongly prefer *C. draba*. Field observations support this conclusion: no adults of this species were found on other neighbouring cruciferous plants. In combination, these preliminary data suggest that *P. wrasei* definitely needs further investigation.

Last year, black and pale swallow-worts (*Vincetoxicum nigrum* and *V. rossicum*) were also included among our targets. Both species originated in the east Palaearctic region. *Vincetoxicum rossicum* is reportedly endemic to southern Russia. Black and pale swallow-worts are serious, highly aggressive, exotic weed species, rapidly increasing in area infested in both the US and Canada (Christensen 1998). A literature search and data from insect collections of the Zoological Institute suggest that some leaf beetles collected feeding on *Vincetoxicum* spp. in the northern Caucasus and southern Siberia are potential biocontrol agents (see also Spencer *et al.* 2003).

Gaint hogweed (*Heracleum mantegazzianum*) is the target for another new weed biocontrol project supported by the European Community. This project began with literature and museum research and then moved into intensive field exploration in the Russian northern Caucasus, reported to be the centre of origin of this highly aggressive and dangerous invasive plant (visit the project home page at [http://www.flec.kvl.dk](http://www.flec.kvl.dk/giant-alien/)).

The opportunities for significant weed population reduction using environmentally benign biological methods against both old and new weed targets of Palaearctic origin have not been exhausted by this short review. The large expanse of the country of Russia across Europe and Asia and the many endemic plants and animals to be found there, provides excellent opportunities for reducing the impact of many naturalized weeds, native to the Palaearctic region, through the introduction of host-specific biocontrol agents. Today, Russia is a country opening itself to the world, with a strong background in science and an interest in partnerships.

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### References


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