Could knotweed's reign of terror be over?

Introduced into Europe almost 200 years ago, Japanese knotweed has been naturalised since the 1880s. It is highly invasive and difficult to eradicate and is dreaded by horticulturalists and homeowners alike. ***Djami Djeddour*** *and* ***Richard Shaw*** *of CABI now report a promising new biocontrol agent. Could this spell the end for Japanese knotweed?*

The scourge of Britain's gardeners, land managers and developers alike, Japanese knotweed (*Fallopia japonica*), famously dubbed by the press as the 'concrete-cracking superweed', has very few admirers. Native to Eastern Asia, this hardy, herbaceous perennial is thought to have been introduced to the United Kingdom from Japan, by Phillip Von Siebold, in the early nineteenth century and it soon became a highly sought after, fashionable ornamental. In the UK, its history and fall from grace has been well documented[1]; By the late 1880's it had naturalised in the wild and subsequently its expansion has been rapid and widespread and it is now present in most regions of the country[2]. Japanese knotweed's invasive success can be attributed in part to its opportunistic nature and physical adaptability; in Japan it is equally at home on lowland riverine gravel, roadside ditches and rich pastureland as on high altitude, inhospitable volcanic lava fields where it is often the primary coloniser. This innate tolerance is exaggerated further in its new environment because the natural predators, competitors, and pathogens which keep it in check in its native range are absent in the area of introduction, affording it a superior competitive advantage over our native species.

Its spread in the UK is all the more impressive when one considers that it has been achieved by vegetative reproduction; University of Leicester biologists established that the Japanese knotweed introduced to Europe was one of the biggest females in the world – a male-sterile clone which has spread solely through rhizome and stem fragments, usually as a consequence of disturbances like flood events as well as human activity and movement of contaminated soil.

Japanese knotweed is 'illegal to cause to grow in the wild' under the 1981 UK Wildlife and Countryside Act, and its disposal is subject to legislation. An official Environment Agency knotweed management best practice guide has been issued in the UK[3,4] to help deal with the challenging minefield of available control options. So dreaded is knotweed that some bank policies preclude money lending to house buyers if it has been detected on the land or even within a set distance[5,6].

A recent economic review[7] of the cost of invasive non native species to the British economy estimated the total annual cost of Japanese knotweed as £179 million whilst the cost of national control, were it to be attempted, is estimated to exceed £1.5 billion[8]. Its invasiveness also poses significant problems to the rest of Europe and to the United States. Knotweed's impacts are as diverse as the habitats it invades – not only does it pose structural and aesthetic problems in the built environment and affect floral and faunal biodiversity and ecosystem functions by forming dominant monocultures, it can also exacerbate flood risk and undermine riverbank protection in riparian systems. The European Union Water Framework Directive demands that member nations' waterways achieve 'good ecological status' by 2015. Whilst there will always be some debate over what 'good' means and whether invasive non-native species should be included in assessments there is no getting away from the fact that a canal with a 30cm, bank-to-bank mat of a floating weed stretching for kilometres cannot attain this benchmark. The arsenal of available chemicals for use near water is limited and the numbers of countries permitting any chemical use near water even smaller. Furthermore, chemical treatments often prove to be ineffective unless treatment is judiciously and laboriously repeated for several years. With conventional methods of control proving costly and largely ineffective and a sway of opinion calling for reduced use of pesticides in the environment, a project to investigate the potential for biological control was initiated in 2003 with funding from a consortium of sponsors.

Typical urban knotweed invasion in the UK
Photo: CABI

The insect psyllid, Aphalara itadori*, was released into the wild at specific sites.* *Photo: CABI*

Predators versus aliens

Classical biological control of weeds, or 'classical biocontrol,' is a management approach that involves the introduction of specialist plant-feeding insects or fungal pathogens to temper the growth or spread of an invasive plant. It is based on the principle that specialized, co-evolved natural enemies keep a plant species in check in the native range and can be deliberately released in the invasive range, to help restore the balance and reduce the abundance of a weed below an ecological or economic threshold. Although a relatively new weed management approach for Europe it is one which has been successfully implemented for over a century in over 70 countries, on more than 1,300 occasions, against more than 130 weed targets and has proved a highly efficient and cost-effective approach. For example, an economic review of Australian classical weed biocontrol programmes[9] highlights an outstanding benefit/cost ratio of 23:1. Despite these successes and the absence of any non target effects that had not been predicted by the science, there is an unfortunate but natural tendency for the disastrous and unregulated introductions of the past to be confused with contemporary biocontrol efforts. Today's programmes are based on extensive and rigorous scientific studies which are vetted by regulatory peer reviews and subject to stringent international protocols and risk assessments before any releases can be authorised.

History of the project

From 2000 to 2007, repeated survey missions to Japan were carried out, concentrating on the Island of Kyushu from 2003 onwards, after it was confirmed by Leicester University that Nagasaki Prefecture was the likely origin of the clonal biotype introduced into the UK and Europe. Working in collaboration with Kyushu University, these expeditions, coupled with thorough literature reviews, revealed that over 186 species of phytophagous insects and more than 40 species of fungi were recorded from knotweed in its native range. For an organism even to be considered a potential biocontrol, it must first be proven to be highly host-specific, but before this laborious process can begin, a test plant list must be drawn up based primarily on the phylogeny of the target plant, representing all native related species, and historically including species which have economic or commercial importance and may be more distantly related. This internationally recognized process for prioritizing test plants, the 'Centrifugal Phylogenetic System' of Wapshere[10], resulted in the selection of 89 plant species. Those natural enemies which showed the most promise in the field were then subjected to host range testing in a Defra-licensed quarantine facility in the UK[11]. These studies establish the agent's suitability by demonstrating that it is effective against the target invasive and poses no threat to other non target plants.

After years of testing, during which time many species failed the rigorous testing, two potential agents, one fungus and one insect, were found to be consistently specific to knotweed. With the fungus proving a challenging organism to work with, faster progress was made with the research on the insect psyllid (*Aphala itadori*) such that in 2009, an application was made to release it into the wild in Great Britain under the Wildlife and Countryside Act 1981, as well as under the Plant Health Regulations through a Pest Risk Analysis. In March 2010, in a huge milestone for biocontrol of weeds in Europe, and following public and scientific consultation periods as well as peer review, approval was granted by the UK governement's Department for Food, Agricuture and Rural Affairs (Defra) for the psyllid to be released at specially chosen sites. Up until then, no official releases of biocontrol agents against weeds had been made in the EU and as such, the regulatory framework in the UK was far from straightforward and, at times, less than appropriate.

What can we expect?

The psyllid is a sap–sucking insect and it is the nymph stages which cause the most damage to knotweed plants. Impact studies in the laboratory have shown that even in relatively low numbers they are able to stunt growth and reduce photosynthetic ability. Knotweed's strength lies in its powerhouse of reserves below ground which it accumulates throughout the season and stores in its extensive rhizome system; by interfering with its nutrient assimilation and storage system, the psyllids should cause the plants to grow less vigorously, lose their competitive edge and be much more susceptible to management.

Following their release in April, a spell of unseasonably cold weather meant that knotweed plants in the release sites were compromised and the release had to be repeated later in the year. Monitoring at the sites indicated that the number of psyllids was low however and consequently additional field-caged studies were carried out to record non-target impact, if any, under conditions with higher psyllid density than was established in the field. Results continued to confirm the insect's host specificity and the absence of non-target impact, particularly on the native red data book species, *Fallopia dumetorum.*

The psyllid's progress will continue to be monitored, but as with all biocontrol programmes it will take time before we know if it has established successfully, and the overall effect on the wider knotweed problem could take up to ten years to be become evident. In effect the same rules apply to the psyllid as to all non-native species following introduction into a new area; their establishment and spread will be subject to a number of limiting abiotic and biotic factors or 'barriers'[12]. Indeed, many new arrivals fail to establish and it reportedly took eight attempts for the grey squirrel to be established in the UK and we all know how successful and widespread it subsequently became.

A weakness with classical biological control of weeds lies in its unpredictability, not in safety but in efficacy. Biocontrol history is strewn with both promising agents which failed to live up to their potential as well as candidates which exceeded all expectations turning out to be 'silver bullets'. In the case of the knotweed psyllid the scientific evidence suggests that it will be a safe and effective agent but the proof of the pudding will be in the eating. If the psyllid reduces the impact of knotweed on the UK economy by 1% it will have paid for the research in one year. It is hoped that it will in fact have a much bigger impact and that traditional management techniques will be made more effective against a weaker foe. In the built environment however, where developers need rapid results and eradication is the stated aim rather than the control the psyllid would deliver, it is anticipated that additional control measures will still be needed. Further releases are planned for 2011 (subject to approval) on a wider scale, so there is a good chance that Japanese knotweed in Britain will eventually lose the upper hand after almost 200 years of dominance[13].

Other targets for biocontrol

There are plenty of other good targets for classical biocontrol in Europe[14] and work is focusing on aquatic and riparian weeds driven by the demands of the EU's Water Framework Directive and strengthened by the restriction on chemical use on or near water. Targets in the sights of European biocontrollers include the following (their potential biocontrol agents in brackets): Himalayan balsam (rust fungus), Floating pennywort (weevil, fly, rust), Australian swamp stonecrop (weevil), Curly water weed (fly), Floating fairy fern (ordinarily resident weevil) and giant hogweed (different strains of a leafspot fungus).

Using nature to control nature can seem both illogical and frightening to people but the use of natural enemies to control weeds around the world has been shown to be a worthwhile and safe endeavour. This technique provides an alternative and sustainable tool to limit our reliance on chemical and physical control of large scale invasions of environmental weeds and challenges the temptation to just give up in the face of unfavourable odds and limitless expenditure.

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