# Biological control: a novel approach to managing Himalayan balsam, a troublesome invader in the UK

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Himalayan balsam (*Impatiens glandulifera*) was first introduced to the UK from the Himalayas in 1839 by Victorian plant hunters. If you are familiar with the plant, you will know why; it is an attractive annual which readily produces large numbers of showy, orchid-like flowers, in various shades of pink. Its appeal is not limited to gardeners; Himalayan balsam is well known for attracting bees, and beekeepers consider it a valuable source of late-season nectar. The bees, however, often visit Himalayan balsam in preference to native plants, reducing the latter's chances of pollination. This troublesome invader can inhabit riverine habitats, damp woodlands and disturbed areas. Since its introduction, our landscape has been transformed as Himalayan balsam has become more widespread, and it continues to extend its range rapidly along our river ways and into woodlands.

**Right:** The orchid-like flowers and many seed pods of Himalayan balsam. CABI

A dense monotypic stand of Himalayan balsam along the River Torridge, Devon. CABI

Vast expanses of Himalayan balsam are a familiar sight along the edges of British rivers in the summer months. While these may look beautiful, studies have shown that they can have a negative impact on the whole ecosystem, even down to beneficial fungi present in the soil. Owing to its prolific growth, this species can form monocultures which outcompete native vegetation, leading to a decline in native plant and invertebrate populations. Each plant can produce up to 2,500 seeds which are forcibly ejected from the seed pods for distances of up to 7m. These will often land in rivers, which act as 'balsam highways', transporting the seeds downstream to new sites. As an annual species, the plant dies back in the autumn, leading to bare river banks and an increased potential for erosion. The deposition of large quantities of plant material into rivers can also increase the risk of flooding.

## Current control methods

As a riparian weed, Himalayan balsam typically grows in close proximity to water, which means that there are restrictions on use of herbicides for its control. Manual control (hand-pulling and cutting back plants below the first node)

### Impacts of invasive species

Non-native invasive species can pose a major threat to the natural environment, destroying habitats and decreasing native biodiversity. There can also be significant economic impacts associated with invasive non-native species, including reductions in crop yields, increasing agricultural production costs and damage to infrastructure. In 2010, a study estimated the total cost of invasive non-native species to the British economy to be approximately £1.7 billion per annum (Williams *et al.* 2010).

CABI Emeritus Fellow Dr Harry Evans surveying for natural enemies of Himalayan balsam in the plant's native range in Pakistan. CABI

before flowering can be effective, but the technique is labour intensive and can only be maintained on small isolated populations. For control to be successful, removal of Himalayan balsam needs to take place on a catchment scale, which should ensure that seeds do not recolonise from farther upstream. Because of the difficulties associated with traditional control methods, CABI was commissioned to investigate the potential of a novel, sustainable and environmentally friendly solution: classical biological control (see box on right).

### The rust fungus, *Puccinia komarovii* var. *glanduliferae*

Surveys to look for natural enemies of Himalayan balsam were conducted from 2006 to 2009 in its native range, in the foothills of the Himalayas of India and Pakistan. The research revealed a suite of insects and fungi that can cause damage

### Biological control

Classical biological control is a method that uses highly specific, co-evolved natural enemies (such as insects, pathogens or mites) from the native range of the target pest for control in its introduced invasive range. The aim is to reduce the pest's vigour and, thereby, its competitiveness and fecundity, enabling natural restoration of the invaded environment. Biological control is a long-term solution and it can often take many years for its effects to show. However, it is an economical and self-sustaining approach which can be incorporated into any integrated weed management strategy. This management technique has been widely utilised for over 100 years around the world and requires a thorough assessment of a potential agent prior to release to ensure that it is safe and will not negatively affect any native species (Winston *et al.* 2014).

to the plant. Many of these natural enemies were dismissed in the field because they were observed to cause damage to other species of *Impatiens*, and were therefore considered likely to be generalists that could pose a threat to native plants, while others were deemed unsuitable after laboratory testing. However, a strain of the rust fungus *Puccinia komarovii* var. *glanduliferae* from India was prioritised for further testing, as this pathogen was observed to be highly damaging in the field and rusts have a good history of use in biological control programmes. Rusts are a group of co-evolved, biotrophic fungi (they can only survive on their host plant); each species usually has a very restricted number of plant species that it can infect. As the rust fungus grows intercellularly it draws nutrients away from the plant, which can decrease the fitness of the latter by limiting its growth and reducing its ability to produce seed. Subsequent research carried out in CABI's specialised high-level quarantine facilities in the UK concluded that the rust was reliable, effective, safe, and posed no risk to UK biodiversity (Tanner *et al.* 2015). A Pest Risk Analysis, which fully detailed this research, was submitted to the UK regulator (Defra) and presented to the European Commission Standing Committee on Plant Health in Brussels. In July 2014, permission to release the rust was granted; this was the first release of a fungal biological control agent for the control of an invasive weed in Europe.

## Field infection of the rust in the UK

The rust was released across the UK at 25 sites which had been carefully selected for the most suitable conditions for rust infection and overwintering. Favourable attributes in a site included high humidity and environmental stability, and a low likelihood of being affected by fast-flowing floodwater. These initial releases were experimental, since the rust's performance under natural conditions in the UK was largely unknown prior to its release from quarantine. Establishment of the rust as a self-sustaining population is the main priority, so that, over time, rust infection can reach sufficiently high levels to have a damaging impact on Himalayan balsam populations and spread naturally in wind currents to other balsam-invaded sites.

Initial results indicated that rust infection at different field sites was highly variable, despite them all having environmental conditions that were seemingly good for infection (Varia *et al.*

The rust fungus *Puccinia komarovii* var. *glanduliferae* infecting Himalayan balsam at a UK release site. CABI

2016). It was theorised that the populations of Himalayan balsam in the UK were not equally susceptible to the Indian rust strain that had been released and this was confirmed in experiments conducted under controlled conditions during the summer of 2016.

Fortuitously, a strain of the rust from Pakistan, collected during the original native range surveys in 2008, was retrieved from long-term storage in liquid nitrogen and was discovered to infect some, but not all, of the Himalayan balsam populations not infected by the original Indian strain. Approval to release the second strain was granted by the UK government in January 2017. Subsequent releases of the Pakistan strain into susceptible field populations of Himalayan balsam have been extremely successful.

The ultimate aim in a biological control programme is for the control agent to become established and provide self-sustaining control of the pest. In order to achieve this aim, CABI is carrying out work across the UK in collaboration with local action groups (LAGs), who are supporting the release programme and monitoring seasonal progression of the rust. Prior to releasing the rust into a new population of Himalayan balsam, plants are first tested for their susceptibility to the two rust strains and then the most virulent strain is released; or the site is declined if the plants there are resistant to both strains. After training provided by CABI staff, LAGs release the rust three times over the growing season, in June, July and August. The collaboration with LAGs enables the rust to be released and monitored at a greater number of sites across the UK than would otherwise be possible.

## What next?

The variability in infection rates of Himalayan balsam populations by the two rust strains released in the UK led CABI scientists to conduct a molecular analysis that compared plant samples from across the UK to others from the native range. The analysis found that Himalayan balsam from both India and Pakistan has been introduced into the UK on at least three separate occasions. This work also highlighted specific areas in the native range

CABI scientist Kate Pollard training Emily Iles (Tweed Forum) in the rust release protocol. CABI

Himalayan balsam is now common throughout the UK, but biocontrol could help to reduce the damage it causes to native plant communities and riverbanks. Mike J Thomas/FLPA

that could be surveyed by CABI scientists for further rust strains that would be a better genetic match to the UK populations. It is anticipated that strains from these areas will be more virulent and could infect a wider range of Himalayan balsam populations in the UK. However, overlaying the genetic variability in host resistance is the variability caused by natural infection of the plants by soil-dwelling mycorrhizal fungi and foliar endophyte fungi (fungi living within the tissues of a plant). These beneficial fungi can protect plants against a broad variety of pests and diseases, so we also need to find ways of breaking down this natural resistance barrier. CABI is collaborating with Royal Holloway University of London and Reading University to understand these complex fungal–fungal interactions.

While the establishment of the rust in the field has been slower than anticipated owing to the compatibility issues explained above, we now have a much better understanding of the complex interactions between the fungus and its host and how to achieve our goal to suppress the growth and reduce the seed production of Himalayan balsam in the UK. Over time, we anticipate a reduction in the need for other management options for this weed, and look forward to seeing the native flora flourish again in currently invaded areas.


## Acknowledgements

The authors would like to acknowledge the work of Daisuke Kurose, Robert Tanner, Marion Seier and Harry Evans in this project. We would also like to thank all our sponsors and partners involved in the programme.


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For more information about the biocontrol programme visit **https://himalayanbalsam.cabi.org**.