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General News

Life's Getting Tougher for Toadflax: a New Biocontrol Agent Released in Canada

The release of the stem-galling weevil *Rhinusa pilosa* from Serbia on yellow toadflax (*Linaria vulgaris*, Plantaginaceae) in Canada in April 2014 could prove a landmark event in attempts to control invasive toadflaxes in North America. *Linaria* species, introduced as ornamentals in previous centuries, are now invasive in rangeland and natural areas throughout temperate North America. Success has been achieved against Dalmatian toadflax (*Linaria dalmatica*) in the northwestern USA and British Columbia with the stem-mining weevil *Mecinus janthiniformis*. Originally released in North America in 1991 as *Mecinus janthinus,* a recent molecular study has shown that there are actually two closely related species, *M. janthiniformis* specialized on Dalmatian toadflax and *M. janthinus* on yellow toadflax. *Mecinus janthinus* has so far been much less successful, although recently some larger populations have been reported in Alberta, Montana and Idaho.

The new release is the first since 1996 and is mainly based on work conducted by Ivo Toševski and André Gassmann from CABI in Switzerland, financially supported by a consortium of Canadian and US entities. Between 2006 and 2011, they tested over 100 plant species and populations (60 native to North America) to assess the host specificity of *R. pilosa*. Adult feeding and survival was minimal on native North American species in the same tribe as the target, the Antirrhineae, oviposition on native North American plants was limited to four species, and while a few larvae developed to adult in one of these species (*Sairocarpus virga*) there was no impact on the growth of this non-target plant. Risks to the native flora were therefore judged to be minimal[1]. Predicting impact of biological control agents is of increasing concern, so this aspect was tackled by MSc student Emily Barnewall from the University of Lethbridge in Alberta, supervised by Rosemarie De Clerck-Floate from Agriculture and Agri-Food Canada (AAFC), Lethbridge. Emily found that the Canadian quarantine colony of *R. pilosa* originating from Serbia was able to induce galls equally effectively on populations of *L. vulgaris* from four geographically distinct localities in Canada[2]. She concluded that releasing Serbian *R. pilosa* had good potential for impacting on *L. vulgaris* across North America.

In March 2012, a petition for field release for the weevil against *L. vulgaris* in Canada and the USA was jointly submitted by Rosemarie De Clerck-Floate, and Sharlene Sing from the US Department of Agriculture – Forest Service (USFS), Rocky Mountain Research Station, Bozeman, Montana. In September 2013 the USDA-APHIS (US Department of Agriculture – Animal and Plant Health Inspection Service) Technical Advisory Group for the Biological Control of Weeds and the Canadian Biological Control Review Committee recommended its release, and in April 2014, the Canadian Food Inspection Agency gave the go-ahead for field releases in Canada. This paved the way for the first release of *R. pilosa* on yellow toadflax in North America to be made in southeastern British Columbia (BC) on 8 May, followed by five further releases in northern BC and Alberta over the next few weeks. Happily, approval came in time for releases to be made when toadflax plants were at a perfect stage of development for the weevil – partly aided by an otherwise unwelcome cold, wet and even snowy spring – although there was no time to lose and considerable effort went into matching the insects being released with the appropriate, but rapidly changing and variable, growth stage of their host plants to give them the best chance of establishing.

The taxonomic investigations by project and other scientists in recent years that are underpinning this release, and potential future releases of weevil species still in the research pipeline, have involved comparing the results of morphological and molecular-based methods, along with field, biological and host-specificity data. This process has revealed the complex nature of interactions between weevils and toadflaxes, including hybridization between toadflax species in both Europe and North America and geographic variation and host plant-related cryptic speciation in weevils[3,4]. The high degree of host plant specialization found in both *Rhinusa* and *Mecinus* species helps to explain the host plant preferences and ecological host ranges of different populations of weevils in Europe. It also helps to explain why the shoot-boring weevil *Mecinus janthiniformis* in North America has had significant impact only on Dalmatian toadflax. It is anticipated that this better understanding of insect–host plant relations and preferences will help with selecting the optimum suite of biological control agents to introduce against invasive toadflaxes in North America.

While the team waits to see whether *R. pilosa* establishes permanently and what impact it has in the field, work continues with other prospective agents. Host-specificity testing for a second *Rhinusa* species, *R. rara* on Dalmatian toadflax, is almost complete and a petition for its release is at the planning stage, while research on three *Mecinus* species on Dalmatian and yellow toadflaxes is progressing. Stakeholders in North America are particularly interested in more cold adapted insects for some of the more northern regions with harsh winter conditions.

[1]Gassmann, A., De Clerck-Floate, R., Sing, S., Toševski, I., Mitrović, M. and Krstić, O. (2014) Biology and host specificity of *Rhinusa pilosa*, a recommended biological control agent of *Linaria vulgaris*. *BioControl*. DOI: 10.1007/s10526-014-9578-7

[2]Barnewall, E.C. (2011) Plant–insect interactions between yellow toadflax and Dalmatian toadflax, and a potential biocontrol agent, the gall-forming weevil, *Rhinusa pilosa*. MSc thesis, University of Lethbridge, Lethbridge, Alberta, Canada.

[3]Toševski, I., Caldara, R., Jović, J., Hernandez-Vera, G., Baviera, C., Gassmann, A. and Emerson, E. (2011) Morphological, molecular and biological evidence reveal two cryptic species in *Mecinus janthinus* Germar (Coleoptera, Curculionidae), a successful biological control agent of Dalmatian toadflax, *Linaria dalmatica* (Lamiales, Plantaginaceae). *Systematic Entomology* 36, 741–753.

[4]Toševski, I., Caldara, R., Jović, J., Baviera, C., Hernandez-Vera, G., Gassmann, A. and Emerson, B.C. (2014) Revision of *Mecinus heydenii* species complex (Curculionidae): integrative taxonomy reveals multiple species exhibiting host specialization. *Zoologica Scripta* 43, 34–51.

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Progress towards the Biological Control of *Impatiens glandulifera* for the UK

Himalayan balsam (*Impatiens glandulifera*) has rapidly become one of the UK's most widespread invasive weed species, colonizing river-banks, waste land, damp woodlands, roadways and railways. It reaches well over 2.5 metres in height, and is a major weed problem. Growing and spreading rapidly, it successfully competes with native plant species for space, light, nutrients and pollinators, excludes other plant growth (through shading and smothering) and reduces native biodiversity. As an annual plant, Himalayan balsam dies back in the winter and can leave areas bare of vegetation and river-banks at risk of erosion. Dead plant material falling into the river also exacerbates the risk of local flooding.

Current methods used for control in the UK are inadequate because the plant often grows along river-banks and, to be successful, control would need to be undertaken on a catchment scale. Also, many areas colonized by Himalayan balsam are inaccessible, or of high conservation status where chemical and/or manual control is not really an option. Economically, using existing measures, the UK's Environment Agency estimates it would cost up to UK£300 million to eradicate Himalayan balsam from the UK.

Since 2006, CABI has conducted surveys throughout the plant's native range in order to identify natural enemies that could be considered as biocontrol agents in the introduced range. Many of the fungal and insect species collected and identified during these surveys were rejected as potential control agents after safety testing procedures in our UK quarantine facility found that they were able to attack other plants closely related to Himalayan balsam. However, we found a rust fungus, a *Puccinia* species, which we deem safe for release.

This rust fungus was found causing significant impacts on Himalayan balsam in the foothills of the Himalayas. The rust is a true specialist of Himalayan balsam and is very impressive as a natural control agent as it attacks the plant twice during the growing season; once, early in the season, when it infects the stem of seedlings, and then again, later in the season, when it infects the leaves of the plant.

Through literature reviews, database searching and scientific research conducted in both India and the UK, it quickly became apparent that our rust was new to science. The most striking evidence was that our rust was identified as *Puccinia komarovii*, the rust species that infects *I. parviflora* in mainland Europe. However, our rust did not infect *I. parviflora*, and the rust collected from *I. parviflora*, likewise, did not infect Himalayan balsam. So, through cross inoculations, we discovered that there are species-specific varieties of *P. komarovii* that attack different *Impatiens* species. We have therefore suggested that our rust collected from Himalayan balsam is renamed as a variety of *P. komarovii*; naming it *Puccinia komarovii* var. *glanduliferae*.

The rust is an obligate biotrophic fungus, meaning it can only live on living tissue. It is an autoecious (it completes its life cycle on Himalayan balsam), macrocyclic (all five spore types are present in the life cycle) rust fungus that, as indicated above, infects the stem and leaves of Himalayan balsam throughout the growing season, but its life cycle is complex: the five spore types occur on the plant at different times during the growing season. The first visible spores (aeciospores) occur in the spring and erupt from the stems of seedlings below the leaves. Infected plants are clearly identified as the infection causes the stem to elongate, warp and bend as the rust develops. The aeciospores are spread by wind and go on to infect the leaves of Himalayan balsam. They enter the leaf through its stomata when it rains or through the formation of dew and feed and develop on the internal cells. No symptoms of this infection are visible until chlorotic (whitening or yellowing) spots are seen on the leaves after 7–8 days, following which brown pustules containing the next spore types, urediniospores, erupt from the underside of the leaf after about 14 days. These spores are the 'cycling' stage and cause significant damage to the plants by reducing leaf photosynthetic area. Large numbers of urediniospores are produced throughout late spring and summer. As these spores are wind borne, they are able disperse and allow the rust to move between populations of the weed – often many miles apart. In autumn, Himalayan balsam leaves begin to age and teliospores begin to form. This overwintering spore stage has thick walls and dark pigments to help the spores survive in adverse weather. When Himalayan balsam dies back, the teliospores, embedded in the leaves, fall to the ground to become part of the leaf litter, where they overwinter until the following spring along with Himalayan balsam seeds. The increase in ambient spring temperature encourages Himalayan balsam seedlings to germinate, and at the same time teliospores germinate to produce the fourth spore stage, basidiospores, which are propelled onto the germinating seedling. The basidiospore infects the stem and grows within the developing plant to produce the fifth spore type, spermagonia.

We have assessed the safety of the rust using a test plant list of 75 species selected according to strict internationally recognized testing procedures. Known as the centrifugal phylogenetic method, this model for test plant selection has been used to great effect for over 30 years. It focuses on the most closely related species to the target weed in the area of introduction, gradually expanding the number of species to include more distantly related plants until specificity is established. Within a framework of risk assessment, further plants considered to be at potential risk can also be added to the test list. This allows plants that have a similar habitat or are ecologically similar to the target weed to be tested to ensure they will not be affected. Finally, plant species that are known to be attacked by organisms related to the proposed biological control agent, in either the plant's native or introduced ranges, are also included. This approach continues to serve as the basis of current host-range testing protocols as recognized by the *Code of Conduct for the Import and Release of Exotic Biological Control Agents* (ISPM No.3; www.ippc.int/standards).

Himalayan balsam belongs to the order Ericales: family Balsaminaceae: genus *Impatiens*. The genus *Impatiens* contains over 1200 species worldwide. In the UK, some of the species most closely related to Himalayan balsam are themselves invasive non-native species, such as *I. capensis* and *I. parviflora*. Others are popular ornamental garden species grown widely in parks and gardens. These include 'busy lizzies' and the New Guinea hybrids. All native plant species within the genus *Impatiens*, and those that occur in the UK as either garden ornamental and/or economically important species were included in the testing procedure. We then looked at other genera within the family Balsaminaceae. However, our job was straightforward here, as Balsaminaceae includes only two genera, *Impatiens* and *Hydrocera*, and the latter genus contains just one species, the aquatic *H. triflora*, native to the Asian subcontinent and absent from the UK. In total, 31 species of *Impatiens* were tested during the safety testing procedure, including the only native *Impatiens* species in the UK, *I. noli-tangere*. Plants from two geographically separated populations of this important native species were tested.

We then selected plant species from other families within the order Ericales which are either native to the UK, present as ornamental species or of economic importance. Economically important species comprised plant species that are grown as crop or fruiting plants such as cranberry and blueberry.

One *Impatiens* species, *I. balsamina*, was fully susceptible to the rust, producing viable urediniospores following inoculation with the same spore type that we propose releasing against Himalayan balsam. In addition, one individual *I. scabrida* plant was weakly susceptible to the rust; we believe that this was a result of the high inoculum load used during the host-range testing. All other test plants were immune to the rust. A pest risk analysis (PRA) was compiled, detailing all of the research conducted during the project, including ecological comparative studies of the plant in its native and introduced ranges, and impact studies of Himalayan balsam on native (UK) biodiversity. The PRA was assessed by the Food and Environment Research Agency (Fera), followed by an independent peer review process and finally presented to the European Union, Standing Committee on Plant Health; the PRA was accepted by all of these processes. The rust has been approved for release by the UK government making this the first release of a fungal pathogen as a classical biological control agent against a weed in Europe.

Follow the progress of the project, including regular updates and additional information about the plant at: http://himalayanbalsam.cabi.org

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Seeking Rare Insects for an Invasive Rush

A biological control project to tackle the invasive aquatic weed flowering rush (*Butomus umbellatus*) in North America has been spearheaded by Jennifer Andreas, Integrated Weed Control Project/Washington State University Extension, in the USA. As the only species and genus within the family Butomaceae, it seems an ideal candidate for classical biological control.

Flowering rush was first recorded in North America in 1897 on the St Lawrence in Canada, and has spread eastward and westward in the century since to invade waterbodies throughout southern Canada and the northern USA. It increases waterway maintenance costs, hampers recreational use, and also supports populations of great pond snail (*Lymnaea stagnalis*), which hosts parasites that cause "swimmers' itch". By forming dense stands in previously unvegetated or sparsely vegetated aquatic environments it benefits introduced fish such as largemouth bass, yellow perch and northern pike that spawn in vegetated substrata to the disadvantage of native cutthroat and bull trout that require open water to spawn; the stands also threaten shallow water emergents such as wild rice (*Zizania aquatica*).

The plant is recognized as an increasing problem in midwestern and western US states and conventional control methods (mechanical, chemical) are currently not providing satisfactory results. The biocontrol project therefore instantly attracted a lot of interest, and was funded in 2013 by a consortium of donors including Washington State Departments of Agriculture and Ecology and the Montana Weed Trust Fund through the University of Montana in the USA and the British Columbia Ministry of Forests, Lands and Natural Resource Operations in Canada. Research on natural enemies from the plant's native range in Europe is being undertaken by CABI's project scientist Patrick Häfliger, based in Switzerland. A first consortium meeting was held in conjunction with the annual Wyoming Weed and Pest Council Meeting in Jackson, Wyoming, in October 2013.

Diploid and triploid populations of flowering rush occur in both Europe and North America. However, while triploids appear to be more common in Europe, diploid populations are more frequently found in North America. Flowering rush has a curious reproductive biology and is able to reproduce and disperse in four forms: seeds, vegetative bulbils formed in inflorescences, small vegetative bulbils formed on the side of rhizomes, and rhizome fragments. Despite heavy investment in seed production by diploids, little or no evidence of sexual recruitment was found in North America, suggesting predominantly clonal reproduction via bulbils, whereas North American triploids invest in large rhizomes and rely on fragments being broken off by water disturbance for dispersal.

In contrast to its aggressive invasiveness in North America, flowering rush – and therefore its associated fauna – is quite rare in Europe, and listed as endangered in some areas where it is largely confined to protected habitats. Survey planning had to take account of the need to comply with collecting regulations and acquire permits, and the 2013 surveys were restricted to sites outside protected areas. To further complicate matters, widespread flooding of the River Elbe in spring 2013 affected large parts of eastern Europe including the main area of distribution of the weevil *Bagous nodulosus*, currently considered the most promising candidate agent.

Although delayed, surveys in northern Germany, the Czech Republic and the Slovak Republic in summer 2013 found *B. nodulosus* at flowering rush sites in all three countries, where observations on the weevil's field biology were recorded. From these and subsequent laboratory studies, it emerged that adult weevils spend most of their lives underwater, which could mean that this rare and endangered species in Europe may be more abundant and widespread than currently thought. Again in contrast to literature reports, the larvae were observed mining down to the rhizome or the rhizome–leaf interface; this would be a useful attribute against the predominantly triploid populations found in western North America, which rely on rhizome fragments for reproduction and dispersal. A small rearing colony was subsequently established at CABI's centre at Delémont, allowing host-specificity testing to begin in 2014.

One other candidate species, the agromyzid fly *Phytoliriomyza ornata*, was among natural enemies found on flowering rush in 2013, but it needs to be established how much impact this species has on the plant. Surveys in 2014 will continue to collect information on *B. nodulosus* and *P. ornata*, and also focus on finding collection sites for a second *Bagous* species, *B. validus*, with return visits to areas surveyed in 2013 and surveys extended to Hungary and potentially Serbia.

In parallel, a test plant list is being developed to guide host-specificity testing; the absence of closely related native congeners in North America limits the number of plant species that need to be tested, and increases the likelihood of finding a host-specific biological control agent. A first shipment of test plant species of four native North American species was received in autumn 2013 in preparation for host-specificity tests in 2014.

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Dr T. Sankaran: 1928–2014

Dr T. Sankaran was born on 16 June 1928 in Nagapattinam in the Indian state of Tamil Nadu to Sri Thiagarajan (a legal luminary) and Smt. Sundari Ammal. After his schooling in the port city of Nagapattinam, he studied for a BSc degree in Zoology at the prestigious Presidency College in Madras (now renamed Chennai). He won several gold medals and came first in the university examinations. He later moved to Banaras Hindu University where he obtained his MSc and PhD degrees with a specialization in entomology. After securing his PhD in 1952, Dr Sankaran started his career in the Directorate of Plant Protection, Quarantine and Storage, Government of India, where he served in various capacities for more than a decade. In 1963, his services were initially loaned to the Commonwealth Agricultural Bureaux, where he served as Principal Entomologist at the Indian Station, Commonwealth Institute of Biological Control (CIBC), Bangalore, up to 1967 and then returned to the Government of India. Dr Sankaran later re-joined CIBC as a permanent employee in 1968 and subsequently succeeded Dr V.P. Rao as Entomologist-in-Charge of the Indian Station in March 1973. He took voluntary retirement from CIBC in 1986.

At CIBC, Dr Sankaran did some pioneering work on biological control of several weeds including water hyacinth (*Eichhornia crassipes*), floating fern (*Salvinia molesta*), *Eupatorium*, *Lantana* and *Striga*. In addition, he was responsible for coordinating, along with Dr V. P. Rao, several biological control projects, mostly under the US PL-480 scheme, on key pests of Indian crops including rice, sugarcane, cotton, vegetables, coconut, tea and coffee, and discovering a large number of natural enemies and studying their bioecology and breeding techniques. He was involved in overseeing the legal supply of some these natural enemies to other countries such as the USA, Pacific island nations, Australia and Malaysia, and also the introduction of a number of exotic natural enemies into India for control of several weeds and insect pests. During the course of these projects he travelled widely in India and in Europe, the UK, the USA and Southeast Asia. In 1969/70, Dr Sankaran spent a year in the Malaysian state of Sabah investigating the potential for biological control of oil palm bagworms. During the 1980s, he led research into biological control of the mango leaf-gall midge (*Procontarinia matteiana*) in the Sultanate of Oman, and oversaw the introduction of a biocontrol agent to control citrus blackfly (*Aleurocanthus woglumi*) in that country. In 1979, Dr B. R. Subba Rao (British

Museum [Natural History], London) named an encyrtid scale parasitoid after him, *Thomsonisca sankarani*, in appreciation of his contribution to biological control. In 1980, with CIBC's Dr David Greathead, he organized the 'First International Training Course in Biological Control of Pests', whose emphasis on the practice of biological control meant the trainees from 11 countries returned home equipped to undertake and promote biological control.

As Head of the CIBC Indian Station, Dr Sankaran left a lasting impression, and a valuable legacy for India in the staff he trained. Dr T. M. Manjunath (who established India's first commercial insectary namely 'Bio-Control Research Laboratories' for Pest Control India Ltd, and later retired as Director – R&D, Monsanto Research Centre, Bangalore) and Dr (Mrs) Chandish R. Ballal (Principal Scientist and Head, Division of Insect Ecology, National Bureau of Agriculturally Important Insects, Bangalore) both worked closely with Dr Sankaran at CIBC. They describe him as "a simple man" who was highly respected by his peers, and highlight in particular his encouragement of young scientists. Dr Manjunath, who "had the privilege of working with Dr Sankaran and being guided by him at CIBC for about 15 years," recalls his dynamic leadership and how he inspired many young entomologists who themselves later became leading lights in the field. He adds that Dr Sankaran had "great pride in his profession, was highly principled, an excellent writer and editor, and had a penchant for perfection in whatever he did." Dr Ballal, who worked as a research assistant under Dr Sankaran's guidance when he was Principal Entomologist at the CIBC Indian Station describes him as "a true teacher who held his principles high", remembering how his students saw him as "an excellent scientist and a wonderful human being." She recalls how he taught his students not only to plan and execute the experiments, but also to interpret the results appropriately. She says that she is "truly indebted" to Dr Sankaran for initiating her into the field of biological control in 1984 when she was working with him on the project for biological control of the mango leaf-gall midge in the Sultanate of Oman. Dr (Mrs) Sudha Nagarkatti (the first Project Co-ordinator of the All India Co-ordinated Research Project on Biological Control, now long-settled in the USA) and the late Dr H. Nagaraja (world-renowned *Trichogramma* taxonomist who, as well as CIBC, worked on the *Trichogramma*-based biocontrol programmes in the Philippines and Papua New Guinea) were earlier very close associates of Dr Sankaran at CIBC for over 15 years.

Dr Sankaran sat on a number of advisory bodies, including for the Indian Council of Agricultural Research, and the Coffee Board of India. He was a Fellow of both the Royal Entomological Society of London and the Entomological Society of India. He published many interesting papers and reviews, spoke at a number of conferences in his career, and in 1982 organized the first meeting of the South-East Asian Regional Section of the International Organization for Biological Control, subsequently becoming its Vice-President. He was well-versed in the French and German languages too.

The gratitude of Dr Sankaran's former students is reflected in the many who maintained contact with their mentor in his later years. Together with Dr Manjunath and Dr Ballal, Dr (Mrs) Geetha Bai (retired Divisional Chief, Sericulture Division, Karnataka State Sericulture Research and Development Institute, Bangalore), Dr (Mrs) Uma Narasimham, ex-entomologist, CIBC Indian Station), Dr M. V. Srinivasa (Assistant Director & Central Insecticide Inspector, Central Integrated Pest Management Centre, Bangalore), Dr (Mrs) Ganga Visalakshy (Principal Scientist, Indian Institute of Horticultural Research, Bangalore) and Dr Geetha Viswanathan (retired Head, Department of Zoology, St Joseph's College, Bangalore), all kept in touch with him even after his retirement from active service and until his last days. Dr Ballal says: "It was always a pleasure to listen to him narrate with precision about all his old students, their names, research topics, etc."

Dr Sankaran passed away in his residence at Bangalore on 8 January 2014. He was 86 and led a distinguished and satisfying professional and personal life. He is survived by his wife Mrs Ganga, son Dr S. Sundar (a renowned nephrologist) and daughter Mrs Sujatha Balakrishnan and their spouses, his grandchildren and a great-grandson.

Compiled by the Editor from contributions by Dr T. M. Manjunath and Dr Chandish R. Ballal, and CIBC reports.

Dieter Schroeder: 1935–2014

Dr Dieter Schroeder, former Director and Weed Section Leader of the CABI centre in Switzerland, passed away on 28 March 2014. Dieter led a rich and fulfilled life and his sudden death caught all of us at CABI by surprise since we had never seen him sick and he did not appear to age, even after his retirement.

Dieter was born in Magdeburg, Germany on 12 September 1935 and spent his youth in the eastern sector of Germany after the Second World War. His wish to study biology could not be realized under the new socialist conditions in which he was living, but since he was a trained lumberjack he was ordered to study forestry. Three months before his final examinations he was forced to leave the eastern sector of Germany prior to the construction of the wall separating East and West Germany. Arriving in West Germany with little more than his briefcase, he finished his Diploma studies in Göttingen. In 1960 he accepted an offer to become junior entomologist at what was known back then as the European Station of the Commonwealth Institute of Biological Control, at Delémont in Switzerland, working on biological control of forest pests, which also became the subject of his PhD thesis in 1965.

In 1969 he joined Helmut Zwölfer, the leader of the Weeds Section at that time, in his work on biological control of invasive plants. In October 1969, however, he took a temporary posting to Ghana where he set up the new West African Sub-station of CIBC at Kumasi and instigated work on pests of maize, rice, cocoa and water weeds, returning to Delémont in August 1970. He took over responsibility for the Weeds Section in 1973, and from the late 1970s concentrated on weed biological control, which developed into a major programme at CABI in Switzerland, involving six research scientists and several Diploma and PhD students. With the support of Peter Harris, another pioneer of weed biological control, affiliated with what is now Agriculture and Agri-Food Canada, Dieter put a lot of effort into encouraging Canadian and US scientists and sponsors to join forces and form funding consortia to enable projects to be carried out in the area of biological control of invasive weeds. The consortia approach continues today, with 14 currently providing financial support to the Weeds Section at CABI in Switzerland.

Soon after taking over as Weeds Section leader, Dieter established close cooperation with the USDA-ARS (US Department of Agriculture – Agricultural Research Service) EBCL (European Biological Control Laboratory and its forerunners) and the CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia) European Laboratory in France. Together with Paul Dunn of the EBCL, he initiated annual meetings of the three groups to exchange information and prevent duplication of work. These regular 'tripartite meetings' between CABI, USDA-ARS and CSIRO continue to this day.

From 1996 until 2000, Dieter was the Director of CABI in Switzerland during which time he helped the centre to grow by 'pushing through' the construction of an extension to the building that increased the available space by 50%. Under his leadership, the weed biocontrol programme made important contributions to biological control of leafy spurge (*Euphorbia esula*), spotted and diffuse knapweeds (*Centaurea* spp.), purple loosestrife (*Lythrum salicaria*) and Dalmatian toadflax (*Linaria dalmatica*). After four successful years of steering the centre, Dieter retired in 2000.

Apart from his weed work, Dieter travelled the world, teaching on CABI's international training courses in biological control held in India, Trinidad, Pakistan and Kenya, and providing expert input to projects and organizations. He participated in many symposia in numerous countries, and was proud to have attended every International Symposium on Biological Control of Weeds from the first, which he co-organized in 1969, until he retired, after being an honouree at the X Symposium in Montana in 1999. He was founder and chairman of the Biological Weed Control working group of the European Weed Research Society from 1983 to 1989. He wrote and co-authored over 120 publications that have greatly stimulated ecological thinking in the area of biological control.

Dieter will be remembered by all of us for his strong opinions and his strong will, but also for his inexhaustible enthusiasm and humour, his worldly wisdom, his charisma and last but not least his great story telling. Dieter was a real character and the kind of person that left a deep impression on most people he met. There is rarely a meeting in North America we go to where somebody does not ask about Dieter. The many students that he introduced to biological control and that he mentored, including some of us, are some of his most indelible footprints.

We have lost a great man and one of the last pioneers of weed biological control.

The following messages are among those that reached us from colleagues all over the world. They speak for themselves.

Cliff Moran (retired, University of Cape Town, South Africa): "I had, and have, the greatest respect and admiration for Dieter as a role-model scientist and as a man of utmost integrity."

John Hoffmann (University of Cape Town, South Africa): "He will long be remembered as a larger than life gentleman and a scholar of the highest order. I feel especially privileged to have known him and to have interacted with him. He will be sorely missed by many of his associates. His life stories were legendary."

Heinz Müller-Schärer (University of Fribourg, Switzerland): "He was my great ideal for my scientific work, he introduced me to entomology and biological control, to weeds and to ecology. More importantly, I learnt so much from him for my life, and his thoughts, ideas and views, and his great mission, enthusiasm and good mood will hopefully continue through us who had the great luck to pass some time with him. I will surely miss him a lot."

Andy Sheppard (CSIRO, Australia): "Dieter affected all our lives in such a profound way. The passion, the wit, the honesty, the story telling, the open armed nature of his welcome, the pure character and charisma. I have many Dieter stories that still make me laugh and you knew there was never a dull moment with Dieter in the room. Dieter was one of the people who made my first few years as a biocontrol scientist a special time when I felt privileged to be working in such a collaborative international scientific fraternity. I will sorely miss him as he was one of a kind."

By: Hariet L. Hinz and colleagues of the CABI centre in Switzerland.

The 'Bible' of Weed Biological Control Revised

Almost every weed biocontrol scientist and practitioner but also many other professionals will inevitably have used Julien and Griffiths' *Biological Control of Weeds: a World Catalogue of Agents and Their Target Weeds* at least once during their career if not on a much more frequent basis. The catalogue lists all intentional and accidental weed biological control introductions worldwide, and also those organisms utilized for weed biocontrol in their native ranges. In addition, the catalogue provides data on the establishment and degree of control and information on factors that may limit biocontrol agents. It is, therefore, the most important resource when checking for the status of a specific biocontrol agent in a specific country or checking for patterns in the establishment and success rate of agents. However, the quality of the data in the catalogue relies on regular updating. In this respect, the fourth edition of the catalogue, published in 1998, was in dire need of a revision. In 2007, during the XII International Symposium of Biological Control of Weeds in Montpellier, France, this was discussed with Mic Julien (now retired from CSIRO, Australia), who had collated and edited the previous four editions. The two bottlenecks at the time were funding and time and it took another two years before work on the revision could actually begin.

Starting in 2009, Mark Schwarzländer (University of Idaho, USA), was able to secure funding from the US Forest Service (Carol Randall and Richard Reardon) and engaged Rachel Winston and Michelle Lewis, two consultants with MIA Consulting based in Shelley, Idaho. Rachel and Michelle took on the colossal task of first entering all hardcopy data from the fourth edition of the catalogue into an enormous Excel® spreadsheet, getting hold of any and all references and scanning them for relevant content, and finally contacting weed biocontrol scientists and practitioners around the world for help with the update of information for specific weeds. Rachel and Michelle were assisted by Mic, Mark, Hariet Hinz (Head of the Weed Biocontrol Section at CABI in Switzerland), Matthew Cock (Chief Scientist at CABI) and Michael Day (Queensland Department of Agriculture, Fisheries and Forestry, Australia). In order to make the most of the revision, it was decided not only to systematically structure all data in a more organized manner (e.g. record data on establishment, abundance and impact in qualitative categories), but also to make the catalogue available online, as a fully queryable open access database. The latter will be facilitated by Chuck Bargeron at the Center for Invasive Species and Ecosystem Health, University of Georgia, USA, and will contain – provided sufficient funding is available – additional data on the biology of the target weed and the agents.

At the moment, the hardcopy version of this monumental task is being set for print, which is taking some time, considering that it is going to include 224 target weed species, 551 biocontrol agent species and more than 2800 references on nearly 1000 pages. Compared to the fourth edition this is an increase of 69% in the number of weeds targeted, a 54% increase in the number of agent organisms, a 115% increase in the number of individual entries and a 181% increase in the number of references cited! And if all this wouldn't be great enough, hardcopies of the catalogue will be available free of charge. Provided additional funding can be secured, the plan is to update the catalogue continuously and not to wait for another 16 years!

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A Cautionary Tale: Historic New Zealand Biocontrol Record Found To Be Spurious

The introduction of the ladybird *Coccinella undecimpunctata* L. to New Zealand in 1874 has been widely cited as the first importation of an insect for biological control in that country and one of the first anywhere. However, an analysis of historical sources by entomologist turned historian Ross Galbreath and biocontrol entomologist Peter Cameron concludes that the record is spurious, and reveals how the erroneous record has arisen and become embedded in the literature.[1]

Twenty-five years ago Peter Cameron was lead editor for the authoritative *Review of Biological Control of Invertebrate Pests and Weeds in New Zealand 1874 to 1987* published by CAB International in 1989. The 1874 introduction of *C. undecimpunctata* provided the starting point for that review, although, as the entry on it commented, "There is little information available on the circumstances of this, probably the first, purposeful introduction into New Zealand of an insect for biological control".[2] That eventually prompted Galbreath and Cameron to look for any further records concerning the historic introduction. But the results were a surprise: extensive searches of contemporary published papers, newspaper reports, records of entomological and acclimatization societies, unpublished archives and correspondence of entomologists, revealed no evidence of any attempt to introduce *C. undecimpunctata* to New Zealand. Instead, Galbreath and Cameron found clear evidence that the accepted record of such an introduction had been created by a process of cumulative misreporting or "Chinese whispers" as successive authors from the 1870s to the 1960s misquoted and modified previous reports.

Are scientists today any more careful when reporting earlier results? It is salutary to look at the way that relatively small errors by reputable scientists were enough in combination to create a plausible but entirely spurious record.

According to Galbreath and Cameron the record has its origins in discussions in the Entomological Society of London in December 1873 about possible introductions of useful insects to New Zealand. The discussions arose from two separate inquiries from New Zealand: from T. Nottidge asking about the possibility of introducing bumble bees to fertilize red clover, and parasitic ichneumonids to control lepidopteran pests; and from F.W. Hutton asking about the possibility of introducing the predaceous neuropteran *Chrysopa* to control aphids. These discussions were widely reported at the time in journals and newspapers. A few months later there was a further report that efforts to send bumble bees to New Zealand had already begun.

Galbreath and Cameron trace the initial misstatement of these reports to the American entomologist Charles Valentine Riley. In 1874, when his position as Missouri State Entomologist was under threat from legislators seeking to cut costs, Riley opened his annual report with an optimistic account of the international importance and progress of his field of economic entomology. But he expressed himself rather too optimistically: his comments on introductions of insects to New Zealand gave an exaggerated impression of progress (and muddled some of the insects involved – parasites of lepidopteran pests and predators of aphids):

We have, during the year [1874], witnessed Australia and New Zealand discussing and attempting the introduction from Europe of Aphis parasites to check the alarming increase of those plant pests; and of bumble bees to enable the farmers to grow their own clover seed.[3]

Riley went on to become chief entomologist in the US Department of Agriculture and a leading figure in economic entomology. In 1893, not long before his untimely demise, he reviewed the use of insects for biological control. Riley included the New Zealand record from his 1874 report, but restated it in more definite terms:

In 1874 efforts were made to send over from England to New Zealand certain Aphid parasites to check the alarming increase of those plant pests there, and while I have no records at hand to show with what success, the later successful introduction of bumble-bees to the latter country to fertilize the red clover is well-known history.[4]

Many subsequent authors made use of Riley's review, including his version of efforts to introduce aphid parasites to New Zealand. But in 1909 one author, the Italian entomologist Filippo Silvestri, went further. There had been a report by Riley and his assistant Leland Howard that a ladybird found in New Zealand and initially described as a new species was in fact the European *C. undecimpunctata*, which was evidently established in New Zealand.[5] For some reason – perhaps a misunderstanding – Silvestri linked the two records as cause and effect:

In 1874 efforts were also made to send from England to New Zealand several parasites of Aphids which had multiplied in the latter to an alarming degree, with the result that the 11-pointed Coccinella *L. became acclimated.*[6] (Silvestri wrote first in Italian but his paper was immediately republished in English translation – in which even the Latin specific name *undecimpunctata* has been translated).

In 1911 Silvestri's extended and more specific version of Riley's record was adopted by Leland Howard, though with some reservation:

In 1874 efforts were made to send certain parasites of plant-lice from England to New Zealand, but without recorded results of value, although Coccinella undecimpunctata *L. is said to have become established.*[7]

However, the next author to cite the record, the French entomologist Bernard Trouvelot, listed it in 1925 omitting the reservation "it is said" and the apparently incongruous reference to aphid "parasites", making the record sound clear and unequivocal.[8]

Entomologists in New Zealand up to this time had described *C. undecimpunctata* as accidentally introduced there, but eventually the Riley/Silvestri version was noticed – 60 years after the supposed introduction, when no-one with direct knowledge of events of that time was still living. The new generation of New Zealand entomologists accepted it without question. The first to quote it was Jack Dumbleton, in 1936.[9] New Zealand publication gave the record added authority and subsequently when authors began to give a reference for the record (which was not until the 1960s) it has usually been Dumbleton's paper that is cited.

But the record still continued to be modified further. Once it was accepted that *C. undecimpunctata* had been introduced in 1874, it was all too easy to infer that the discussions in London in December 1873 must have been preliminary to that introduction. Thus later authors attributed the introduction of *C. undecimpunctata* to Nottidge and Hutton, the two men whose inquiries prompted those preliminary discussions.[10] Even in recent years authors have continued to add more details by drawing further inferences from the same false premise.

Despite the widespread quoting of the record of the introduction of *C. undecimpunctata* to New Zealand in 1874, and the appearance of supporting circumstantial detail, Galbreath and Cameron conclude that it is without foundation, an illusory record created by an accumulation of errors. It should thus be deleted from databases and historical reviews of biocontrol introductions. The case stands as a warning of how easily earlier records can become modified in restatement by subsequent authors.

[1]Galbreath, R.A. and Cameron, P.J. (2013) The introduction of the eleven-spotted ladybird *Coccinella undecimpunctata* to New Zealand in 1874: the first use of a ladybird for biological control, or a spurious record created by cumulative misreporting? *Archives of Natural History* 40(2), 277–293.

[2]Thomas, W.P. (1989) Aphididae, aphids (Homoptera). In: Cameron, P.J., Hill, R.L., Bain, J. and Thomas, W.P. (eds) *A Review of Biological Control of Invertebrate Pests and Weeds in New Zealand 1874 to 1987*. CAB International, Wallingford, UK.

[3]Riley, C.V. (1875) Preface. *Annual Report on the Noxious, Beneficial and Other Insects of the State of Missouri* 7, iii–vi.

[4]Riley, C.V. (1893) Parasitic and predaceous insects in applied entomology. *Insect Life* 6, 130–141.

[5]Riley, C.V. and Howard, L.O. (1891) *Coccinella nova-zealandica* a synonym. *Insect Life* 3, 352.

[6]Silvestri, F. (1909) A survey of the actual state of agricultural entomology in the United States of America. *Hawaiian Forester and Agriculturalist* 6, 287–336.

[7]Howard, L.O. and Fiske, W.F. (1911) *The Importation into the United States of the Parasites of the Gypsy Moth and the Brown-Tail Moth*. Bureau of

Entomology, US Department of Agriculture, Washington, DC.

[8]Trouvelot, B. (1925) Directives a suivre dans l'importation pour les besoins de l'agriculture, d'insectes entomophages étrangers. *Revue de zoologie agricole et appliquée* 24, 125–148.

[9]Dumbleton, L.J. (1936) Biological control of noxious insects and weeds in New Zealand. IV Biological control of fruit pests. *New Zealand Journal of Science and Technology* 18, 588–592.

[10]Miller, D. (1964) Historical synopsis of biological control practice in New Zealand. *New Zealand Science Review* 22, 4–6.

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Mexican Biopesticide Nominated for Prize

A biopesticide for controlling postharvest anthracnose on mango, Fungifree AB, whose development and commercialization was described in the September 2013 issue of BNI (see: www.cabi.org/uploads/bni/news/bni-news-34-3.pdf), has been selected as a finalist in the 'Enterprise' category of the 'Innovadores de América' awards, which recognize the most important innovations made by Latin American researchers. The results were due just after this issue went to press but will be available here: www.innovadoresdeamerica.org

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Biocontrol of Plant Diseases in Latin America and the Caribbean

The history, current status and prospects for biological control of plant diseases in Latin America and the Caribbean are presented in a new well-referenced Spanish-language book.[1] The information it contains makes it a valuable resource for anyone interested in this field, and could provide a basis for the implementation of public policies to promote biological control, as it covers the experiences, successes and difficulties faced by researchers and implementers in the isolation, evaluation, registration and application of biocontrol agents in the region, written by authors who have worked in the development of these technologies. Chapters on Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, the Dominican Republic, Ecuador, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela were written by in-country specialists, while a chapter on the Caribbean was synthesized from material collected or published in Caribbean countries.

[1]Bettiol, W., Rivera, M., Mondino, P., Montealegre, J. and Colmenárez, Y. (eds) (2014) *Control Biológico de Enfermedades de Plantas en América Latina y el Caribe*. Facultad de Agronomía, Montevideo, Uruguay, 404 pp.

Web: http://portal.fagro.edu.uy/index.php/intensific-agr/file/367-control-biologico-de-enfermedades-de-plantas-en-america-latina-y-el-caribe.html

New Semiochemical Biopesticide for Cotton

A new biopesticide for cotton pests is at an advanced stage of commercialization by Innnovate Ag in Australia according to the authors of a paper in *Entomologia Experimentalis et Applicata*[1]. They say there is a need for new technologies to protect Australian (predominantly *Bt* Bollguard® II) cotton from sucking pests and the threat of emergence of resistance in lepidopteran *Helicoverpa* spp. Oviposition and larval survival trials, set up to look at potential plant sources for a semiochemical product, indicated that a native member of the Fabaceae, *Clitoria ternatea*, merited further investigation. Four of six fractions of *C. ternatea* extract obtained by solid phase extraction subsequently demonstrated oviposition and feeding deterrence as well as direct toxicity against *Helicoverpa* spp. These fractions were developed into the product, Sero-X®, which the authors report is effective against both *Helicoverpa* spp. and sucking pests.

[1]Mensah, R., Moore, C., Watts, N., Deseo, M.A., Glennie, P. and Pitt, A. (2014) Discovery and development of a new semiochemical biopesticide for cotton pest management: assessment of extract effects on the cotton pest *Helicoverpa* spp. *Entomologia Experimentalis et Applicata* 152(1), 1–15.

Learning from Biological Control

A paper in *Restoration Ecology*[1] suggests that taxon substitution could benefit from the kind of regulatory guidelines used in biological control. Taxon substitution is a controversial approach that seeks to restore ecological functions, which are lost when a species becomes extinct, by introducing non-native species that serve similar functions elsewhere. Its implementation has been rare because of potential non-target effects, but where it has been done it has, according to the authors, successfully restored functions. They point to the similarity between this approach and classical biological control, and suggest that the safety and efficacy of taxon substitution could be improved by following the regulatory route developed for the introduction of classical biological control agents.

[1]Aslan, C.E., Aslan, A, Croll, D., Tershy, B and Zavaleta, E. (2014) Building taxon substitution guidelines on a biological control foundation *Restoration Ecology* 22(4), 437–441.

Communicating Effectively about Pests and Invasive Alien Plants

The European and Mediterranean Plant Protection Organization (EPPO) has reported on a workshop convened to improve understanding of what makes communication about pests and invasive alien plants effective. The workshop abstracts and conclusions are available on the EPPO website, while an article explaining the background to the workshop, reporting fully on the sessions and giving the final conclusions and recommendations is available in the *EPPO Bulletin* as open access content.[1]

The meeting was convened in recognition of the problems different stakeholders experience in either explaining or understanding what these species and their impacts are, and of the importance of raising levels of awareness in society if effective action is to be achieved. Held in Portugal in October 2013 under the auspices of EPPO, the Council of Europe and the International Union for the Conservation of Nature – Invasive Species Specialist Group, the workshop was aimed at the wide range of people – including civil servants, scientists, NGO staff, land managers and journalists – responsible for communicating with the public about pests and invasive alien plants that have agricultural or environmental impacts; sessions focused on (i) how international institutions communicate about these species, (ii) the difficulties of communicating about them and the need for an interdisciplinary approach, (iii) experiences that did and did not work, and (iv) adapting messages for different stakeholder group and citizen science.

[1]Brunel, S. (2014) How to communicate on pests and invasive alien plants? Conclusions of the EPPO/CoE/IUCN-ISSG/DGAV/UC/ESAC Workshop. *Bulletin OEPP/EPPO Bulletin* 44(2), 205–211. Web: http://onlinelibrary.wiley.com/doi/10.1111/epp.12110/pdf

EPPO/CoE/IUCN-ISSG Workshop:
Web: http://archives.eppo.int/MEETINGS/2013_conferences/communication_pt.htm

Non-native Plants DO Benefit from Disturbance

Although disturbances such as fire and grazing are often claimed to facilitate plant invasions the empirical evidence is contradictory. A meta-analysis published in *Oikos*[1] that synthesized the literature on how disturbances affect non-native plant species found that, overall, disturbance increases diversity and abundance of non-native plant species present in the community, and the type of disturbance is the most significant factor affecting the size of the impact; grazing and anthropogenic disturbances have the largest effects.

[1]Jauni, M., Gripenberg, S. and Ramula, S. (2014) Non-native plant species benefit from disturbance: a meta-analysis. *Oikos* Early View. doi:10.1111/oik.01416.

Invasive Insect is a 'Time Sink' for a Native Natural Enemy

A paper in *Biological Invasions*[1] uses the example of the brown marmorated stink bug (*Halyomorpha halys*) in North America to describe the evolutionary trap that an introduced species can present to native generalist natural enemies, and why this is particularly significant when a parasitic or predatory species invests time in protecting its reproductive investment. The authors describe how eggs of *H. halys* and the North American native pentatomid species *Podisus maculiventris* were accepted to a similar extent by the native generalist scelionid parasitoid *Telenomus podisi*. However, while successful development occurred in some 98% of the native pentatomid's eggs, none developed in the non-native species (although the developmental success of *H. halys* embryos was reduced at least 24% by parasitism).

Halyomorpha halys, first detected in North America in Pennsylvania in 1996, is now present in 40 US states and was discovered for the first time in Canada in 2012 in Ontario. The authors suggest that as it spreads and becomes more abundant in North America, it is likely to have a detrimental impact on the *T. podisi* populations it encounters and thereby indirectly cause an increase in native pentatomid populations. They introduce the concept of 'time sink' to explain the additional cost of the introduced species to *T. podisi*, which invests considerable time in reproductive activities, arguing that this could tilt the fitness balance between time spent versus its profitability, which evolved in the context of the native pentatomid fauna.

[1]Abram, P.K., Gariepy, T.D., Boivin, G. and Brodeur, J. (2014) An invasive stink bug as an evolutionary trap for an indigenous egg parasitoid. *Biological Invasions* 16(7), 1387–1395.

Conservation Biological Control in Greenhouses

An open access review in *BioControl*[1] looks at methods in current use or being researched for optimizing the establishment and persistence of biocontrol agents in greenhouse crops and increasing resilience to pest infestations, pointing out in particular the opportunities this presents in high value crops. The authors identify knowledge gaps and make recommendations for future research.

[1]Messelink, G.J., Bennison, J., Alomar, O., Ingegno, B.L., Tavella, L., Shipp, L., Palevsky, E. and Wäckers, F.L. (2014) Approaches to conserving natural enemy populations in greenhouse crops: current methods and future prospects *BioControl* 59(4), 377–393.