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General News

Storing Onions without Tears

A study in Australia has shown that the onion thrips, *Thrips tabaci,* which reduces crop yields and bulb quality worldwide, can be effectively and economically controlled by innundative releases of a commercially available predatory mite.

Despite intensive field spray programmes, harvested onion bulbs in Australia are invariably infested by onion thrips, which continue to colonize, reproduce and develop during on-farm onion storage, causing tissue scarring and loosening of the outer layers of the bulb, which in turn cause the onions to be downgraded in quality and thus market value. Red onions, a premium salad type, are particularly prone to thrips tissue scarring and resultant quality loss in storage. No in-storage control options currently exist, in Australia or overseas.

In 2006, Greg Baker and Kevin Powis (South Australian Research and Development Institute – SARDI) began by conducting a small laboratory trial to assess the potential of two commercially available predatory mite species, the phytoseiid *Neoseiulus cucumeris* and the ascid *Hypoaspis aculifer*, to limit onion thrips damage in stored red onions. The mites, which are used in greenhouses for thrips control, were obtained from Biological Services (Loxton, South Australia). Following encouraging results, a larger-scale on-farm trial was conducted in 2007 at Mypolonga, South Australia. Three rates of each species (0.25, 1.0 and 4.0 litres of vermiculite–mite mix containing ca. 40,000 *N. cucumeris* and ca. 15,000 *H. aculifer* per litre of mix) were added to 600-kg bins of red onions two weeks after harvest. The density of thrips per bulb in each treatment was monitored twice over the next 45 days.

The *H. aculifer* treatments had no apparent effect on the thrips, with pest numbers increasing in a manner similar to the untreated control (which increased from a pre-treatment density of 0.7 thrips per bulb to 6.0 thrips 45 days post-treatment). However, thrips numbers were reduced to very low levels in all three *N. cucumeris* treatments (to 0.4, 0.3 and 0.03 thrips at 45 days, with the increasing dose rates). The suppression of the thrips by *N. cucumeris* was reflected by an increased proportion of premium-grade bulbs assessed post-storage in these treatments (74–79%) compared with the *H. aculifer* treatments, and the control (42%). Thus some 35 % of the onions were upgraded to premium quality as a result of *N. cucumeris* treatment. Concerns about contamination were assuaged because the mites themselves declined to very low levels at all three dosages by six weeks after introduction.

The researchers calculated that the 35% increase in premium-grade onions represented a gain of nearly Au$150 per 600-kg bin, using the contemporary price differential between premium- and lower-grade onions. Depending on the dose rate used, this represented a 10- to 20-fold benefit:cost ratio. Furthermore, they suspected that the percentage increase in premium-grade onions could be improved if the mites were introduced soon after harvest, rather than a fortnight later as in this trial.

The results of a more recent trial, using a lower range of mite doses (0.1, 0.25 and 1.0 litres of vermiculite–mite mix per bin), and testing two methods of application (top dressing and incorporating, which proved equally effective) confirmed the impact of *N. cucumeris* on thrips numbers and onion quality. In this trial, the mites were added to the bins on the day of harvest, but the numbers of thrips in the harvested crop were particularly low (0.075 thrips/bulb) so although the results were even better than in the trial above, it is difficult to separate the effects of earlier treatment and the very low ‘starter’ pest population. The dearth of prey did not, however, prevent mite populations from sustaining themselves and exerting control; thrips densities were significantly suppressed by all six treatments and there was very little decline in the number of premium-quality bulbs over the trial period (from 97.0% at harvest to 93.8% and 95.0% in the 0.25- and 1.0-litre treatments at 45 days, respectively, with the 0.1-litre treatment giving a lesser but still significant effect, compared with a decline to 46.3% premium-rate bulbs at 45 days in the control).

These studies provide strong evidence that innundative release of *N. cucumeris* into onion bins at or soon after harvest provides reliable, cost-effective control of onion thrips in red onions for at least six weeks after harvest. On the basis of results so far and for South Australian conditions, the researchers recommend a rate of 0.25 litres vermiculite–mite mix (ca. 10,000 *N. cucumeris*) per 600-kg bin, applied as a top dressing (the simpler of the two methods tested). For an Australian grower and at current prices, an investment of approximately $6 per bin could give a saving of up to $279 per bin.

Australian growers are very pleased with the novel tactic, because they have no effective alternative and because of its benign nature and high benefit:cost ratio. The method is particularly applicable in countries, such as Australia and New Zealand, where much of the harvested onion crop is not cool stored (which would arrest thrips development and feeding).

For 2008–09, there are plans to see how the above recommended treatment works over a three-month period, and whether an additional ‘top-up’ treatment at six weeks is necessary to extend protection to three months.

This project has been funded by Horticulture Australia Limited (HAL) using the onion levy and matched funding from the Australian Government.

Main source: Baker, G.J., Powis, K. & Altmann, J. (2008) *Neoseiulus cucumeris* control of onion thrips in storage onions: new trick for an old dog. Paper presented at the First Australian and New Zealand Biocontrol Conference, Sydney, 10–14 February 2008.

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Asian Weevil Chews up Mile-a-Minute Weed in Northeastern USA

Mile-a-minute weed, *Persicaria perfoliata* (formerly known as *Polygonum perfoliatum*), invaded eastern North America beginning in the 1930s at a nursery in Pennsylvania, where it most likely established as a contaminant in holly seed from Japan. The annual prickly vine has since spread widely in disturbed sites in the Mid-Atlantic states, causing failure of tree regeneration by smothering seedlings, and making life miserable for land managers in wildlife preserves and other natural areas. Herbicides and mechanical controls can be effective, but huge annual seed production, spread by birds, deer, and water, and a seed bank that can last for as long as seven years make any sort of long-term control a challenge.

The US Department of Agriculture – Forest Service initiated a search for natural enemies in China, the presumed centre of origin of the weed, in 1996. Ding Jianqing (Institute of Biological Control, Chinese Academy of Agricultural Sciences, Beijing) and his associates found more than 100 insect species feeding on mile-a-minute weed in China. Host-specificity tests conducted in China and in quarantine in Delaware showed that one species, *Rhinoncomimus latipes*, was extremely host specific. This 2-mm long curculionid feeds internally in stems in the larval stage, and as an adult feeds on *P. perfoliata* leaves. The weevil is being reared very successfully at the Phillip Alampi Beneficial Insect Laboratory in Trenton, New Jersey. Between 2004 and 2007 more than 64,000 weevils were released at 37 sites throughout New Jersey, along with lower numbers in four other states.

Experimental releases of weevils at three sites in southeastern Pennsylvania showed significant reduction in mile-a-minute weed cover, numbers of seed clusters, and numbers of seeds per cluster three years after weevil release. Weevils went through three to four overlapping generations in the course of the summer, and overwintered as adults in the soil or leaf litter. Studies of plants in field cages showed that weevil feeding can change the phenology of seed production, delaying it by one to two months. In the presence of competition by other plants, weevil feeding caused mortality of mile-a-minute plants.

Mile-a-minute weed was shown to produce about five times as many seeds in full sun as in the shade. Clearly this plant is adapted for full sun, germinating early in the spring, growing rapidly, and scrambling up and over any available bushes, trees, or other substrates. Our hope is that with an integrated programme that combines several types of competitive and other stresses, with the ultimate goal of producing a shaded environment at sites currently overrun with mile-a-minute, the weevil will provide the 'tipping point' that will allow a sustainable diverse plant community to develop. Our next step will be to test this theory, and also determine whether it is possible to produce weevils in a field nursery rather than depending strictly on laboratory rearing.

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Rusty Future for Yellow Bells in South Africa

Tecoma stans is a large perennial shrub native from the Neotropics southwards to Argentina. It has been introduced as an ornamental to countries in many parts of the world. Its common names – yellow bells, yellow trumpetbush – indicate its attraction: large, showy, bright golden-yellow trumpet-shaped flowers, which attract nectar-feeding insects and birds but also produce thousands of papery, winged seeds. It is drought-tolerant and readily colonizes roadsides, urban open spaces, watercourses, natural savanna and rocky sites. These attributes have allowed it to become an invasive weed in many parts of its introduced range in southern South America, western Australia and southern Africa.

In South Africa, *T. stans* has become naturalized throughout much of the country and is emerging as an invasive alien weed in areas such as the Mpumalanga lowveld and the KwaZulu-Natal coast. It has been designated a category 1 plant (a declared weed), which makes it illegal to grow it anywhere in the country, and landowners are obliged to undertake control operations. A biological control programme was launched against it in 2003 under the Working for Water programme of the Department of Water Affairs and Forestry (DWAF).

A pathogen collected in 2003 has shown great promise. Host-specificity testing of the yellow bells gall rust fungus, *Prospodium transformans*, was completed during 2007 in the pathogen quarantine facility of ARC-PPRI (Agricultural Research Council – Plant Protection Research Institute) in Stellenbosch. It proved to be highly host specific, which was as anticipated as it had not been observed on any of the close relatives of the target weed in its natural range. It infects young growing tissues (leaves, stems, flowers and seed pods), causing growth distortions on which the fungus produces large quantities of spores. The fungus does not occur throughout the natural range of the weed, but is limited to Mexico and the Caribbean. In this range it is very common on various biotypes of the plant and frequently appears to be destructive.

An application to the Department of Agriculture for permission to release this agent has been submitted, and an application to the Department of Environment Affairs and Tourism is being prepared.

Two insects have been tested, the first a seed-feeding moth, *Clydonopteron sacculana,* which was collected in Baja California Sur, Mexico, by Stefan Neser in September 2005, and brought back and established in culture in the insect quarantine facility of ARC-PPRI in Pretoria. Unfortunately development was supported by various indigenous bignoniaceous plants, making *C. sacculana* unsuitable for use in Africa and consequently the culture was destroyed. The second insect is a leaf-mining fly, *Liriomyza* sp., that was discovered fortuitously in quarantine in 2005. The adults and larvae feed on the leaves of *T. stans*, and biology and host-specificity studies were undertaken in 2006. The results showed that the fly has a short lifecycle and is highly specific. Currently impact studies are in progress to determine its efficacy before application for release is made.

Two further potential biocontrol agents were collected on *T. stans* in Mexico during August and September 2007 by Stefan Neser, Alan Wood and Fritz Heystek. The first candidate is an orange and black coccinellid beetle. Both the adults and the spiky yellow larvae feed on the leaves. The feeding marks form contiguous arcs, resulting in extensive areas of skeletonization. This coccinellid has a short lifecycle, which contributes to its promise as a biocontrol agent. The second candidate is a brown chrysomelid flea beetle. The adults chew small shot holes between the leaf veins, causing extensive damage to the foliage. They lay their eggs on the soil, in clusters around the base of the plant. The larvae crawl down through the soil and feed on the plant roots, making it potentially highly damaging to the target weed. Both potential insect agents are being subjected to host-specificity testing to assess their suitability for introduction to South Africa.

Main source: *Plant Protection News*. Newsletter of the Plant Protection Research Institute (PPRI), an institute in the Natural Resources and Engineering Division of the Agricultural Research Council (ARC). Web: www.arc.agric.za/

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Nematodes Show Promise against Peach Pests

Peaches are a significant part of the southern USA's fresh-produce industry and face serious threats from several native insect pests. Entomologists David Shapiro-Ilan and Ted Cottrell of the US Department of Agriculture – Agricultural Research Service (USDA-ARS) Southeastern Fruit and Tree Nut Research Laboratory in Byron, Georgia, are conducting research in cooperation with Russ Mizell (University of Florida) and Dan Horton (University of Georgia) to evaluate two soil-dwelling nematodes as possible biological control agents. The key to developing successful control for growers, though, is in choosing the right nematode species or strain, and in refining application timing and methods for each pest.

Plum Curculio

Plum curculio, *Conotrachelus nenuphar*, is a curculionid weevil and major pest of stone fruits, including peaches. Adult insects damage peaches through feeding on and laying eggs in the fruit, resulting in characteristic crescent-shaped wounds on the fruit surface. Later, mature larvae emerge from the fruit and develop in the soil, completing the insect's lifecycle. Infested fruit often fall prematurely and the fruit is unmarketable even if it matures on the tree because of the pest infestation and feeding damage.

Field experiments had shown that soil applications of the nematode *Steinernema riobrave* could suppress plum curculio larvae by 78–100%. From more recent results published in *Biological Control*, the team reported that late-season applications of *S. riobrave* or *S. carpocapsae* (targeting the adult stage) had no impact, confirming laboratory findings that larvae are more susceptible than adults. They also reported results of treatments that targeted plum curculio larvae in wild plum (an alternative host) in which 88–100% control of the pest in a thicket of these trees was achieved using two strains of *S. riobrave*, again confirming laboratory results which had indicated the pest showed different susceptibility to different nematode strains, and pointing to a means of reducing pest migration into peach orchards. They note, however, that timing of application and choice of nematode species and strain are important.

Peachtree Borers

Stone fruits are also plagued by clear-winged sesiid moths: the peachtree borer, *Synanthedon exitiosa*, and the lesser peachtree borer, *S. pictipes*, which feed on the cambium, girdling roots and branches making them more susceptible to other pests, diseases and environmental stress. These two borers cause significant damage to peach in the eastern USA. Differences in their habits, however, mean approaches to their control need to differ.

- Larvae of the peachtree borer attack healthy trees. Most larval activity is confined to the trunk area just below ground level.
- Larvae of the lesser peachtree borer are found on trees above ground level. They cannot establish in healthy tissue thus females lay eggs on existing physical or disease wounds where larvae feed at the margins of an injured area.

Previous research by Cottrell and Shapiro-Ilan had shown *Steinernema carpocapsae* to be the more virulent nematode against both these borers. Treatment of peachtree borer was tackled first because it appeared more straightforward. Field applications of the nematode against this pest achieved high levels of control, in part because the nematodes were protected from desiccation and ultraviolet damage by their subsoil environment. A single application of *S. carpocapsae* provided 88% suppression when applied to infestations of mature peachtree borer larvae in springtime. In a subsequent field trial, three applications of *S. carpocapsae* during the peachtree borer's fall egg-laying season completely suppressed all damage.

It was anticipated that control of the lesser peachtree borer in the orchard would be more challenging, although laboratory studies had shown it to be highly susceptible to *S. carpocapsae*. Unlike its congeneric fellow pest, lesser peachtree borer attacks trees aboveground and feeds in galleries within trunks and limbs, which makes it more difficult to target nematodes effectively. Initial attempts to apply the nematodes to lesser peachtree borer wounds failed, as expected, to cause any significant suppression. In an effort to provide protection, wounds to which *S. carpocapsae* nematodes had been applied were immediately covered with moisture-holding bandages. The first trial of this method achieved 100% borer suppression five days after treatment, which suggests further research will help peach growers make significant headway against the troublesome pest.

This research is part of Crop Protection and Quarantine, an ARS national programme (#304).

Main sources: Durham, S (2008) Nimble nematodes: testing biocontrols for peach pests. USDA *Agricultural Research* magazine, March 2008.
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Cottrell, T.E. & Shapiro-Ilan, D.I. (2006) Susceptibility of the peachtree borer, *Synanthedon exitiosa*, to *Steinernema carpocapsae* and *Steinernema riobrave* in laboratory and field trials. *Journal of Invertebrate Pathology* **92**, 73–76.

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Does the Cane Toad Harbour its Own Nemesis?

The cane toad (*Bufo marinus*), so beloved of newspapers as the world's worst biocontrol agent, may have been hiding the means for its own destruction all along.

Existing methods for controlling cane toad numbers in Australia have included traps and fences but have mainly involved physically removing them from the environment, often by putting them in a plastic bag in the freezer. This has had little impact on numbers and has failed to slow the westward spread of the invasive pest. Classical biological control has until now been ruled out because searches in the toad's Neotropical area of origin have failed to uncover natural enemies that do not also hit the Australian fauna. But now Professor Rick Shine (University of Sydney), who has been studying the biology of cane toads in northern Australia, has announced the results of two lines of research which have uncovered potential control options that affect the cane toad but not native frogs.

Since the cane toad's ill-judged introduction to Queensland in 1935, its population has grown and spread steadily through the state and more recently into New South Wales and Northern Territory, migrating an estimated 40 km per year. The main impact of invasion has been on large native predators such as goannas, quolls, king brown snakes and death adders, owing to its toxicity. Shine says that his team has recorded some 90% mortality of large goannas and lizards in their study site, and this has knock-on effects on the ecosystem.

Take an Unsuspected Hitchhiker

Studying cane toads that lagged behind the invasion front in Queensland, Shine and his team found they were infected with a lungworm parasite which slowed down adults and, in laboratory tests, killed around 30% of the juveniles.

It was originally thought cane toads were introduced to Australia without any of the natural enemies from their Neotropical area of origin, and that the lungworm parasite came from Australian frogs. This has now been ruled out using DNA sequencing, which showed the parasite found in cane toad lungs to be *Rhabdias pseudosphaerocephala,* of Amazonian origin. Not only is it genetically distinct from nematodes found in Australian frogs, but it has not been possible to induce *R. pseudosphaerocephala* to infect the native frogs.

Little is known about spatial densities of the parasite in Queensland, how widespread it is, or what impact it has on cane toad populations where the two co-exist. Surveys are needed as a first step in answering these questions. The fact that the two *do* co-exist in Queensland does not mean the nematode is not an effective natural enemy under some circumstances, and it may turn out to be implicated in the unexplained collapse of some cane toad populations. The escape of others may be down to patchy distribution of cane toad populations across a large geographical area coupled with fast dispersal of toads that have escaped infection. Only careful research will tell.

And a Whiff of Danger

Shine's team has also discovered that cane toad tadpoles produce an alarm pheromone that has significant impacts on their size and survival. The pheromone, which is released into the water when a tadpole is alarmed or injured, acts as a warning signal for other toad tadpoles to flee the area. However, the signal stresses the toad tadpoles so much that in field trials around half of them died before they became adult toads, and those that became adults were half the size of toads not exposed to the pheromone. Importantly, from the point of view of developing it as a control technology, the pheromone was found to be different to that of Australian frogs and did not affect native species.

Using the lungworm parasite and the alarm pheromone together would be particularly powerful as the pheromone either kills toads or leads to smaller 'toadlets', and the parasite is more effective at killing these smaller toads.

In addition, an attractant pheromone found by Shine's team has the potential to be developed for lures to trap and remove toad tadpoles.

Professor Shine hopes to involve community groups in the development and use of these new control methods. He says that although there has been a huge effort to slow the toad front by communities in Western Australia and the Northern Territory, the toad front is progressing as fast as ever. He is critical of past efforts, saying that while over Au$15 million has been spent on cane toad research and control in Australia, very little of that was devoted to trying to understand what toads were doing. He argues that his team's work, which has focused on studying the detailed ecology and behaviour of the toad in northern Australia, has uncovered these very encouraging and previously unsuspected avenues.

In Support of Transparency

Shine feels one of the problems with the cane toad debate in Australia has been a lack of readily accessible information. The team has therefore developed a website, CaneToadsinOz.com, specifically so that members of the general public have access to the latest research and ideas, to help give the public debate about cane toads a much firmer evidence base.
See: www.canetoadsinoz.com

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Testing Agent Effectiveness: Is It Ever Done?

The first biological control agents for the control of groundsel bush (*Baccharis halimifolia*) were introduced into Australia in 1969. Thirty-five potential agents were introduced for testing over a period of 25 years. Just 14 species were eventually released and, of these, only seven are thought to have established.

So have these agents had any impact on groundsel bush populations? Surprisingly no one really knows. In the 39 years since the first agent was released there has been no quantitative assessment on the impact of the agents. Anecdotal evidence suggests that this noxious weed of Queensland and New South Wales is no longer a significant problem but can we attribute this to biological control? To answer this question we need to quantitatively assess the impact that the agents are having on groundsel bush.

Evaluation of the impact of a biological control agent on its target is one of the most important aspects in a biological control programme, and can be measured using a range of ecological, social and economic data. Unfortunately research and funding for evaluation of biological control programmes (particularly in the long term) rarely exist. McClay[1] reviewed 57 publications that supposedly evaluated the effectiveness of biological control organisms and found that little attention had been paid to the impact on the target weeds and their population dynamics – a glaring omission. In general, little assessment is conducted beyond agent establishment which is generally not indicative of overall biological control agent success. Some agents take up to ten years to build up to appreciable numbers[2] , so it is important to continue monitoring and evaluating a biological control programme long after it has ostensibly ceased.

There are a variety of methods that can be used to evaluate agent impact on weeds after their release. In the case of a rapid and obvious effect, before and after photos generally provide visual evidence of successful agent impact. Success, however, is not always instant or obvious so other methods are recommended. Some studies correlate changes in plant vital rates, such as growth, fecundity and survival, to agent abundance or damage levels. Alas, as every budding scientist knows, correlation does not equal causation. To overcome this problem, exclusion experiments can be used to compare plant vital rates between sites where the agents have been excluded (using cages, insecticides or fungicides) to those where they have not. Population models are also increasingly being used to evaluate potential impact of agents on weed populations using demographic data soon after agent release and from exclusion experiments. Below I outline the methods I used to evaluate the long-running biological programme for groundsel bush in Australia.

Groundsel Bush: a Case Study

Groundsel bush is a perennial shrub which was introduced into Australia in the early 1900s from North America as an ornamental. It established in Queensland and extended its distribution coastally from Calliope in Queensland to Kempsey in New South Wales. It is a densely branched shrub with pale yellow (male) or white (female) flowers and grows up to about 5 m high. An individual plant can produce up to one million seeds which are easily dispersed by wind. In 1951 it was officially declared noxious due to its ability to invade pastures and native *Melaleuca* wetlands. Initially chemical control and mechanical control were used, but these methods were expensive and time consuming, and so a biological control campaign began in 1963. Very little quantitative data exists for groundsel bush prior to and after the introduction of the agents, making it difficult to evaluate the success of the biological control programme.

To assess agent impacts, I conducted a survey throughout the distribution of groundsel bush to determine if the agents are still around and, if so, how heavily they are damaging the plants. During my survey I found all of the seven agents, although some were more abundant than others and the distribution of some species was patchy. Three permanent study sites were also set up to monitor populations over three years in order to understand the demography of groundsel bush. In the final year of the study an insecticide exclusion trial was conducted to test the effects of the agents on the growth, fecundity and survival of groundsel bush (coupled with a glasshouse experiment which showed the insecticide itself did not affect plant growth in the absence of herbivores). A significant increase in the growth rate of insect-free plants was found, demonstrating that the herbivores are having an impact. Finally, a number of statistical models were developed based on the demography data collected. These models also demonstrated substantial impacts of the agents on groundsel bush performance. The combination of these surveys, experiments and models demonstrates that the agents are having an effect at the individual plant level. The effect of the biological control agents on the groundsel bush populations will form the next part of my research.

It is also important to consider other hypotheses when evaluating biological control programmes. I used the climate modelling program CLIMEX to predict the potential distribution of groundsel bush, which showed that it has the potential to expand its distribution further south into New South Wales and Victoria. I also used this program to predict how favourable the climate had been for its growth over the past 100 years at locations within its known distribution. The results showed that many locations were more climatically suitable for groundsel bush prior to the introduction of biological control. Is the reduction in groundsel bush a result of climate or a combination of climatic stress and agent pressure?

Throughout the duration of this research, five study sites have been destroyed: by fire, council sprayers and urban development. It is therefore important not to discount such factors as reasons for groundsel bush decline, particularly the more permanent ones such as urban development. Since being declared noxious, areas which were once occupied by groundsel bush are now commonly housing estates, car parks and shopping centres. Is the human footprint on this planet therefore helping to eradicate weeds?

From this evaluation study of groundsel bush, it is clear that the agents are still around and their damage appears to be having some impact on the plants' vital rates. The most important question however is the agents' impact on plant populations. The next step in my research is to develop population models parameterized from 'real data' in order to predict what might be happening to the groundsel bush populations.

The groundsel bush biological control programme is one of many in Australia which have never been quantitatively assessed. Biological control evaluation is not always straightforward or easy; however, it should be undertaken for all programmes. Evaluation is necessary in order to enhance the knowledge and efficacy of current and future programmes and to justify continued expenditure on what is a valuable process in weed control.

[1]McClay, A.S. (1995) Beyond 'before-and-after': experimental design and evaluation in classical weed biocontrol. In: Delfosse, E.S. & Scott, R.R. (eds) Proceedings, Eighth International Symposium on Biological Control of Weeds. Melbourne, DSIR/CSIRO, pp. 213–219.

[2]McFadyen, R.E. (1998) Biological control of weeds. *Annual Review of Entomology* **43**, 369–393.

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Invasive Ladybird Spreading in South Africa

As he describes below, South African taxonomist Riaan Stals did not anticipate that an article he wrote for a 'house' newsletter (the excellent Plant Protection News *from ARC-PPRI [Agricultural Research Council-Plant Protection Research Institute]) would provoke quite so much public interest, but the interest is being put to good use.*

The harlequin lady beetle or ladybird, *Harmonia axyridis*, also known as the multicoloured Asian ladybird and by several other common names, currently enjoys the dubious honour of being the beetle receiving the most press. Bad press, that is. Once a firm favourite for the biocontrol of aphids and other soft-bodied arthropod pests in North America and western Europe, this creature has changed its spots to emerge as arguably the most invasive insect species of our decade.

The harlequin lady beetle is hitting the headlines both in scholarly writings and in the broadsheets and popular magazines. The entire February 2008 issue of the journal *BioControl* was set aside for this harlequinade, a special issue titled '*From biological control to invasion: the ladybird* Harmonia axyridis *as a model species*'. The arrival of the harlequin in the UK in 2004 – unaided by deliberate human action – was widely publicized and announced in startling press headlines, as noted in *BNI* in December 2004 [25(4), 81N–82N, 'Ladybird strikes discordant note']. The presence of the harlequin in South Africa was confirmed in 2006, but only in April 2008 did the media splash the news here, in rather sensationalized manner. Nearly every South African daily ran the story and pictures of the '*damn lady*' [*Pretoria News*, 26 April 2008], but the headline that takes the cake would be that on the front page of the *Cape Times* of 22 April 2008: '*Invasion of the killer ladybirds hits Cape Town*'.

A German visitor collected the first (singleton) South African harlequin in 2002, but this specimen was incarcerated in a European collection and only came to the attention of South African researchers towards the end of 2006. Goddy Prinsloo of the ARC-Small Grain Institute (Bethlehem, South Africa) discovered the first South African colony of the harlequin outside the hamlet of Riviersonderend in the Western Cape Province. He initially noticed these beetles in the spring of 2004, but only in the summer of 2006 were specimens sent to the South African National Collection of Insects in Pretoria, where they were conclusively identified as *H. axyridis*. Field observations led to the conclusion that the harlequin was established and reproducing at Riviersonderend. The die was cast.

Any Publicity is Good Publicity

In 2007, the arrival and establishment of *H. axyridis* in South Africa was formally announced in the *South African Journal of Science*[1], but that did, somehow, not attract all that much interest. A more popular article in *Plant Protection News*[2], the newsletter of the ARC-Plant Protection Research Institute, South Africa, triggered enormous media attention. Although not a gambling man, I got my contact details to be published and broadcasted, and a deluge of reports of the harlequin (and unavoidable false alarms) followed. This was citizen science at work, albeit in a much less sophisticated way than the UK's web-based Harlequin Ladybird Survey[3].

Within a week it was confirmed that the harlequin lady beetle had already spread widely through the more temperate reaches of southern, central and eastern South Africa. Reports have – at the time of writing – not abated, and through the cooperation of kind folk the rapid range expansion of the harlequin in South Africa is being observed. There is no reason to doubt that the invasion will continue throughout much of South Africa and beyond into countries to the north of South Africa.

In North America and western Europe, the 'harlequin phenomenon' put classical biological control in a spot, as these beetles had repeatedly been released as biocontrol agents there. Indeed, it is feared that the anti-biocontrol lobby may have a field day. In contrast, the harlequin was never intentionally released in the UK, but the English Channel is not so much of an obstacle to a large lady beetle. It is not known how *H. axyridis* reached South Africa. A media release[4] on 29 April 2008 announced that the first harlequins (all of them dead) to reach Australia were imported there on excavation equipment!

This Harlequin's No Jester

The burgeoning literature on *H. axyridis*, by origin an East Palaearctic species, adequately outlines its untoward features. Besides being a superior predator of aphids and other pestiferous soft-bodied arthropods, it willingly feeds on immatures of various non-pest arthropods, including beneficial kinds and including other lady beetle species, which are generally outcompeted by the harlequin. This can lead to ecosystem disorder and disruption of biocontrol systems. In South Africa, these effects are anticipated, but should in future be confirmed empirically. The harlequin is also known as a household pest, forming large overwintering aggregations against or inside buildings – this phenomenon has already been documented in South Africa. Furthermore, especially in late summer, the harlequin may move on to feed on pollen and fruit. Harlequin individuals present among harvested grapes are a serious threat to winemaking, and the term 'ladybug taint' has been coined for the resultant contamination of wine and juice. This is a real threat to the South African wine industry, as the harlequin has already been reported from the centre and periphery of the important wine-lands of the Western Cape Province.

Suppressing the Mirth

Research on the management of the harlequin in the Northern Hemisphere has, as yet, delivered few tangible measures to combat the problems it causes or potentially brings about. It is a quandary, presently, not really knowing what advice to give to citizens and industry concerned about the harlequin invasion.

Myself a mere beetle taxonomist, I am not quite the appropriate person to act on the whistle I have blown. Presently I am collecting and collating information on the inexorable spread of the harlequin in South Africa. Batches of specimens have been preserved for DNA microsatellite analyses by Arnaud Estoup of the Center for Biology and Management of Populations, INRA (Institut National de la Recherche Agronomique), France – this may reveal where the South African harlequins came from. Elleunorah Allsopp of ARC-Infruitec-Nietvoorbij, the Fruit, Vine & Wine Institute of the Agricultural Research Council, is formally proposing a monitoring scheme to the South African wine industry in July 2008. Goddy Prinsloo of the ARC-Small Grain Institute is betting some of his money on the positive, aphid-biocontrol aspects of the harlequin's presence. The symposium, '*Harmonia axyridis*: a model invasive insect', forthcoming in July 2008 at the International Congress of Entomology in Durban, South Africa, is oversubscribed – a real plan might just emerge from that.

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Web: http://search.sabinet.co.za/images/ejour/sajsci/sajsci_v103_n3_a10.pdf

[2]Stals, R. (2008) Alien invasive predator spreading in South Africa – this harlequin is no jester! *Plant Protection News* **75**, 1–2.
Web: www.arc.agric.za/uploads/images/4819_PPNews_no_75.pdf

[3]www.harlequin-survey.org/

[4]www.agric.wa.gov.au/aboutus/mr/mr290408.htm

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REBECA Final Report

The Final Report on the European Union (EU) Specific Support to Policy Action REBECA, 'Regulation of biological control in Europe' is complete and is now available on the Web.

European agriculture and horticulture experience major problems with pesticide resistance, management of pesticide residues in food products and lack of control measures in minor crops. Biological control offers environmentally safe and sustainable alternatives. Biological control agents (BCAs) preserve the natural antagonistic potential of agricultural ecosystems, enhance plant health and promote plant growth resulting in increasing yields and residue-free agricultural products.

The exploitation of BCAs based on microorganisms, plant-derived substances and insect pheromones, however, suffers from registration requirements that follow the approach developed for synthetic pesticides regulation (EU Directive 91/414). Lengthy registration procedures and relatively high costs prevent the further introduction of BCAs in EU agriculture. The EU registration of new microbials takes on average more than seven years for authorization to be reached (i.e. inclusion in Annex 1 of Directive 91/414). National authorization has to follow in each member state. The costs related to EU registration of a microbial (sometimes more than 2 million euros) often exceed the annual turnover from the product.

This situation endangers the availability of safe BCAs for European farmers in the future. Companies developing BCAs are usually small- and medium-sized enterprises, which become discouraged from developing BCA products for the European market. To overcome these problems and develop more balanced procedures for risk assessment and regulation of BCAs, the EU supported the Policy Support Action REBECA (2006–2007, www.rebeca-net.de). REBECA was a joint Action of several project partners. Coordination was in the hands of the authors of this report. Hermann Strasser (University of Innsbruck, Austria) was responsible for microorganisms, Lucius Tamm & Bernhard Speiser (FiBL, Switzerland) for botanicals and semiochemicals, Jeffery Bale (University of Birmingham, UK) for invertebrate BCAs, Heikki Hokkannen & Ingeborg Menzler-Hokkannen (University of Helsinki, Finland) for the socioeconomic impacts, and Anita Fjelsted (Danish Environmental Protection Agency) for measures to accelerate regulation. Rüdiger Hauschild (GAB Consulting GmbH, Germany) and Ulrich Kuhlmann & Emma Hunt (CABI Europe – Switzerland) provided inventories on current regulatory practice in the EU and other OECD (Organisation for Economic Co-operation and Development) states. The partners organized several workshops to define risks and elaborate proposals for improvement of the registration process, and two larger conferences to present and discuss results of the workshops. More than 200 experts from science, regulatory authorities and industry participated in the development of the REBECA proposals. The REBECA Action was funded by the European Commission (EC) under the Sixth Framework Programme.

The objective of the Action was to review the regulation of BCAs in Europe, develop alternative proposals for regulation and improve communication between stakeholders in regulation. REBECA brought together stakeholders from industry, science, regulatory authorities, policy and environment to share knowledge and experience in regulation and safety of BCAs and to identify those fields that need further research to assist regulation. A major objective of this Action was to form a network within Europe bringing together the expertise necessary to improve regulatory procedures for BCAs. Much information on relevant risks associated with the use of BCAs is available. The dissemination of relevant information among companies developing BCAs, EU and national regulatory authorities and other interested stakeholders was the task of the Action.

There are several reasons to treat BCAs differently from synthetic chemicals in the registration process. In contrast to chemical pesticides, BCAs have a history of safe use. Regulatory procedures for BCAs in the EU have not been introduced as a consequence of reports of damage. BCAs regularly have a more specific mode of action than synthetic chemicals, with reduced non-target effects. Pheromones, for example, even lack a killing mode of action. Humans and the environment are usually already exposed to the active ingredients of BCA products as they are part of our natural environments. In general, BCAs are biodegradable and have different dispersal capabilities to synthetic chemicals. On the other hand, BCAs might be able to propagate in the environment.

REBECA compared the regulation of BCAs in Europe with registration practice in other OECD countries. The comparative studies on the regulation of microbials, botanicals and insect pheromones in and outside the EU identified several EU-specific hurdles for BCAs. Reasons for the lengthy registration process for BCAs stem from the unique regulatory system in the EU involving now 27 member states (MS). Limited expertise in risk assessment of BCAs is scattered through different MS. In private enterprises specified departments dealing with registration problems are rare. In contrast, in the USA and Canada, for instance, the registration process is less complicated, carried out by usually one authority equipped with departments with experts in BCAs. Furthermore, the North American authorities usually provide more support to the applicant to manage a BCA registration. The data requirements for the risk assessment of BCAs are quite similar in the EU, USA and Canada. However, outside the EU, data requirements on human and environmental risks of BCAs are more often waived.

Based on the experiences outside the EU, REBECA proposed a more centralized registration of BCAs in the EU, within a department specifically trained in handling dossiers on BCAs. However, it was realized that this proposal might have little chance of being accepted by the EU and MS regulatory authorities.

In order to promote the registration of safe BCAs, REBECA proposed a reduction in fees. Another possible measure to accelerate registration after inclusion of BCA active ingredients in Annex 1 of Directive 91/414 is the registration of the BCA products according to ecozones. The EC has proposed dividing Europe into three zones and for authorization to be given in all member states of one zone should a product be registered in one country of that zone. Such an approach would be an appropriate measure for reducing the costs and workload associated with registration. However, the EU Parliament disagrees with this approach because of concerns about risks related to the use of synthetic chemicals. Since BCAs and chemicals fall under the same legislation, BCAs inevitably suffer from the increasing restrictions placed on the use of synthetic chemicals. REBECA therefore supports the EU Parliament proposal to separate the legislation for BCAs and synthetic chemicals (see Deliverable 29 on the website).

REBECA made several proposals on how registration of BCAs can be accelerated in the near future (Deliverable 27). Improved communication between regulators, industry and science will improve dissemination of knowledge and experience, which might aid the provision of waivers on data requirements. A reduction in fees can help market access of biological products for niche applications. Pre-submission meetings between regulators and applicants are a well accepted tool for improving communication between regulators and industry and for facilitating the registration process and limiting data requirements. This is practice already in several MS and has a good chance of becoming the general rule in the EU. Reduced fees and short timelines for low risk products are included in the proposal for a new regulation for plant protection products published in 2006 by the EC.

REBECA also developed specific proposals for different groups of BCAs. Prior to the development of proposals for risk assessment and risk management, REBECA defined and evaluated the potential risks related to the use of BCAs. REBECA developed guidance to identify low risk products and elaborated proposals for better adapted and reduced data requirements. Based on REBECA activities, products containing insect-pathogenic baculoviruses will be registered by a simplified procedure. REBECA also developed proposals for more balanced regulation of fungi and bacteria (Deliverable 10). Even though the EC has put efforts into the development of better adapted data requirements for microbial BCAs (Directives 2001/36/EC and 2005/25/EC), the current procedures can still be judged inappropriate. Some data requirements seem unnecessary and the risk assessment methodology based on the assessment of chemicals is not properly adapted and validated for microbials. However, an adequate risk assessment of those products will depend on the validation of better adapted methods.

There is a good chance that the registration process for insect pheromones will also be simplified in the near future. Strait-chain-lepidopteran-pheromones (SCLPs) are recognized as safe already. A number of semiochemicals are subject to re-evaluation under the fourth list of the review programme under Directive 91/414. REBECA anticipates that the review will result in Annex 1 inclusion of all SCLPs, whereby each SCLP could be listed separately, or SCLPs could be listed collectively as a group of homogenous substances.

Plants and particularly plant extracts have been used for plant protection for a long time. Extracts can range from crude to highly purified substances. Plant extracts or 'botanicals' are not defined in the EU legislation, and no separate data requirements exist in Directive 91/414. Reduced data requirements are described in the SANCO (Health and Consumer Protection) draft working document 10472. However, this document is not legally binding. Regulators and applicants have little experience with this document, since it was published quite recently. REBECA recommended that a comprehensive guidance document should be formally adopted for botanicals. This could be based on SANCO/10472, with some amendments. Its scope should be broadened to cover all extraction methods and all plants and plant parts. It is desirable to establish a system to identify substances/ extracts of low risk/concern at an early stage of the process. The document should contain a list of plants and/or combinations of plants and extraction methods which are recognized as of low risk/concern. This should be an open list which can be amended when new botanicals have been evaluated.

One reason for the tremendous success of beneficial invertebrates (insects, mites, nematodes) during the last decade was the lack of major regulatory hurdles for these products. No EU regulatory process exists for these kind of BCAs and in the past many MS refrained from restricting their use. However, this situation is changing. Currently most of the MS develop their own regulations. REBECA developed comprehensive proposals for a balanced risk assessment and registration procedure in order to harmonize requirements and avoid an exaggeration of the potential risks. An application form for the import, shipment, rearing and release of invertebrate BCAs in European countries was created which can serve as a template for all EU MS and other European countries. This application form was supplemented with a guidance document on methods for an environmental risk assessment. REBECA recommended assessing risks only of foreign invertebrate species and limiting regulation of indigenous species to information on their identity and distribution. REBECA made contact with EPPO (European and Mediterranean Plant Protection Organization) to jointly reactivate the panel for the listing of safe invertebrate BCAs for the EPPO region.

For further information and details please consult the website www.rebeca-net.de, which provides the final report to the EC and makes available all Deliverables categorized under:

1. General Proposals

2. Microbials

3. Botanicals

4. Semiochemicals

5. Macrobials/Beneficials

6. Studies of Current Practice

7. Minutes of Meetings

In addition, this website also provides a comprehensive collection of contact addresses of authorities and relevant EU Directives and makes available guidelines and safety information on all BCA product groups. Thus the website is a useful tool and information source for all stakeholders involved in regulation of BCAs and it will continue to be maintained after the REBECA Action has been completed.

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Reviewing US Augmentative Biological Control

A paper in the April 2008 issue of *Biological Control*[1] gives a systematic socioeconomic study of the commercial biological control industry in North America based on interviews with industry leaders, research scientists, retail distributors and customers conducted during 2004–06.

The study found that 22 North American insectaries produce just 38 natural enemy species. No new insectaries have been successfully established since 1996 while several have declared bankruptcy, and few new arthropod species have been brought into production. The authors note that commercial natural enemies constitute less than 10% of the biologically based pest control market, with an estimated gross annual value of US$25–30 million at the wholesale level. Producers described the market for commercial natural enemies as generally static, with declining demand for some species. The parlous state of the industry is also reflected in declining prices for some species since the mid 1990s and insectaries having to abandon production lines due to economic losses. Industry leaders interviewed reported serious difficulties in obtaining capital for investment, recruiting researchers to address applied scientific questions in augmentative biological control, and moving commercial natural enemies across US borders.

The authors conclude that realizing the potential of augmentative biological control as a pest management strategy in North America will require new initiatives to address these challenges.

[1]Warner, K.D. & Getz, C. (2008) A socio-economic analysis of the North American commercial natural enemy industry and implications for augmentative biological control. *Biological Control* **41**(1), 1–10.

IPM Systems

This section covers integrated pest management (IPM) including biological control, and techniques that are compatible with the use of biological control or minimize negative impact on natural enemies.

Battles over the Light Brown Apple Moth in California

Pheromones have found unusual detractors in the US state of California, with 'green' groups joining concerned citizens in calling for a ban on aerial pheromone spraying against the light brown apple moth (LBAM), *Epiphyas postvittana*.

This leaf-rolling tortricid moth is a native of Australia and has been introduced to other countries including New Zealand, New Caldonia, Hawaii, UK and Ireland. It was first detected in California – the first time it had been found in mainland USA – in late 2006 and its presence was confirmed in March 2007, but there are suspicions it has been present a good deal longer. By July 2007 LBAM had been found infesting over 200,000 ha of residential areas, nurseries, cropland and forests in at least nine of California's counties.

LBAM is a feared pest because of its broad host range which includes fruit trees, soft and cane fruits, vegetable crops, and forestry and ornamental species, so its economic impacts are potentially enormous. The USA has a zero-tolerance quarantine requirement for LBAM for produce imported from countries where it is present. Canada and Mexico were quick to impose restrictions on Californian produce when it was confirmed there. A US Department of Agriculture report estimated that LBAM could cause US$160–640 million in crop damage annually if California were to become generally infested, and in addition would hamper export opportunities and interstate commerce.

Pheromones Fall from Grace

A Technical Working Group (TWG) was assembled comprising experts from USA, Australia and New Zealand to advise the federal Animal and Plant Health Inspection Service (APHIS) and the California Department of Food and Agriculture (CDFA). Their recommendations, implemented since, included:

- Quarantine regulations to prevent human-mediated transfer of LBAM to uninfested areas; long-range dispersal is not flight-mediated but is largely the result of movement of infested nursery plants or green waste, equipment and containers.

- Widespread trapping to define currently infested areas.
- A long-term goal of eradicating LBAM through a programme based, at least in the short term, on pheromone technology.

If eradication is the goal, the sooner control measures are implemented after a pest's arrival, the more likely eradication is to be achieved. The LBAM programme needed immediately deployable and fast-acting measures to reduce higher-density populations, and suppress low-density populations at the edges of infested areas to contain the spread. At the same time, research was begun to develop additional control options to either complement or replace initial measures.

Deployment of pheromones was one component of the rapid response, biopesticides were another – and actually came into use first, before authorization was obtained to use pheromones against LBAM. Manual spraying of *Bacillus thuringiensis* (*Bt*) and another bacterial product, spinosad, continue to be used as an additional measure against heavy larval populations.

During 2007, pheromones were deployed by two methods. Initially, pheromone-coated twist-ties ('ropes') were manually attached to plants and trees, but this labour-intensive method is suitable only for small areas. While this continued to be the method of choice for small 'outlier' infestations, aerial spraying was introduced for larger infested areas where manual deployment was impractical. Of 15 areas subjected to ground-based pheromone deployment which began in July 2007, LBAM has been eradicated from five, while treatment continues in the other ten.

Night-time aerial spraying of pheromone began in September 2007 and, as reported widely in the local press, hundreds of residents reported respiratory and digestive health complaints, and spraying was temporarily suspended. The California Department of Pesticide Regulation (DPR) and Office of Environmental Health Hazard Assessment (OEHHA) assessed what had happened and found that although some of the reported symptoms were compatible with high exposure to the pheromone in use at the time (a CheckMate® formulation), the actual levels of exposure were too low to have caused them. Despite this, and despite CDFA including an information-sharing component with health bodies and professionals in their 2008 plan, public concern has not been allayed, nor have attempts to block spraying this year been halted.

In addition, organizations normally supportive of pheromone-based technology have not only declared themselves against the aerial spraying programme on safety grounds, but have suggested the programme is over-reliant on pheromones, and such a focus goes against the basic tenets of IPM. CCOF (California Certified Organic Farmers), one of the oldest and largest organic certification organizations in North America, has called for more diversified ground-based IPM approaches, and the Pesticide Action Network of North America (PANNA) wants a review of all available least-toxic methods and expedited R&D for more approaches. Moreover, PANNA not only questions the efficacy of the aerial spraying strategy, but asks whether the eradication goal is realistic.

More Support for Pheromones

The 2008 plan remains heavily reliant on the contentious aerial pheromone treatments, anticipated to begin in June or August (depending on area) and continue at 30- to 90-day intervals while the moths remain active. Meanwhile, different CheckMate formulations are being assessed for efficacy and safety, and alternative pheromone formulations are also being tested to find the best available technology.

Two new control options likely to become available in 2008 can be used in conjunction with the pheromone treatments:

- Egg-parasitic *Trichogramma* wasps will be released as biological control agents, either by growers on an individual basis, or on an area-wide basis in some locations.
- 'Attracticides', pheromone mixed with an insecticide and carrier, will be deployed in traps as an 'attract-and-kill' method.

Another option is insect growth regulators (IGRs), which play a major role in managing LBAM in New Zealand integrated fruit production and IPM systems, and their use against LBAM has been recommended in California. Tests of insecticide efficacy have been commissioned in Australia.

In the longer term, the potential of the sterile insect technique (SIT) and other (local and exotic) biological control agents are being investigated; these measures are expected to be two years or more in development.

SIT would involve mass release of sterile male moths, which produce no progeny on mating and thus reduce the LBAM population in the next generation. The approach is already used in California by the CDFA, where the pink bollworm (*Pectinophora gossypiella*) SIT programme has been running for 37 years, and involves daily releases of up to 28 million sterile moths.

In LBAM's native home in Australia, spiders are considered some of its most important natural enemies. Both spiders and indigenous leafroller parasitoids may play some role in slowing the establishment and spread of LBAM in California. Introducing natural enemies from LBAM's area of origin in a classical biological control programme is also being considered, although this may face opposition unless host-specific parasitoids can be found. The host range of several biological control agents introduced into New Zealand now includes native leaf rollers, and such introductions would probably not be approved there today. However, *Dolichogenidea tasmanica*, the dominant member of the parasitoid complex throughout southeastern Australia, is much more of a specialist parasitoid and its host range is currently being tested in relation to North American leafrollers.

The Real Threat: Assessing or Guessing

The latest twist in the LBAM story comes from a report by Daniel Harder (Executive Director, Arboretum, University of California, Santa Cruz) and Jeff Rosendale (grower and horticultural consultant) which argued that the threat to California has been overstated and that LBAM is a manageable problem. Their arguments were based on a three-week fact-finding study of New Zealand's major agricultural regions where they assessed IPM of LBAM, and strategies applicable for adoption in California.

Harder and Rosendale's argument that LBAM, which has been established in New Zealand for more than 100 years, is controlled there almost exclusively by natural predators, was challenged by CDFA and its TWG, who argued that they had omitted key points regarding the introduction of non-native natural enemies – notably that effective biocontrol was a recent phenomenon (until recently growers relied heavily on insecticides) and, importantly, some of the generalist species introduced for LBAM control are now having non-target effects, and might never be approved for release in California.

Whatever the truth about LBAM biocontrol in New Zealand, its management is important because of the USA's zero tolerance for LBAM. Pheromone sticky traps are used to monitor LBAM populations and, based on monitoring data, timed ground applications of IGRs are used in select agricultural settings to prevent shipments from being rejected for export to the USA. Harder and Rosendale suggested that this is a model of best IPM practices that could be readily adopted in California. The TWG rejected this notion on the grounds that Harder and Rosendale were scientifically unjustified in extrapolating from New Zealand's experience to California, and also argued that they had underestimated LBAM's potential impact by failing to take into account its potential further spread through California and the continental USA.

It is the spectre of economic impact on California that lies behind the drive to eradicate the pest. Ironically, whether eradication is necessary to protect California's agriculture will only be answered if it fails. However, APHIS and CDFA have already said that if they reach the point where they decide LBAM can no longer be eradicated, then management of the pest will move to a traditional IPM programme.

Sources and Further Reading

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www.cdfa.ca.gov/lbam

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www.panna.org/resources/lbam

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IPM Improves Cabbage Production in DPR Korea

The Democratic People's Republic of Korea (DPR Korea) faces enormous agricultural and food security problems: only 15–20% of land can be cultivated, the growing season between severe winters is short, and attempts to boost productivity have led to soil degradation, falling yields and over-reliance on pesticides.

Cabbage is an important crop for DPR Korea with each family consuming up to 400 kg per year. Cabbage has a high nutritive content (vitamins, trace elements, iron) and is a particularly good food source in winter as it can be made into the traditional mainstay of kimchi, a long-lasting pickle. The high demand means many urban areas are under continuous cabbage cultivation. This has led to problems including decreasing soil fertility, a build-up of soil-borne diseases, insect pest outbreaks, and negative impacts on biodiversity. As a consequence, quality of cabbages from these urban farms is notoriously poor.

A collaborative integrated pest management (IPM) project, funded by the Swiss Agency for Development and Cooperation (SDC) involving CABI (CABI Europe – Switzerland and CABI Southeast and East Asia – China), the Plant Protection Institute of the Academy of Agricultural Sciences (PPI-AAS), Pyongyang, DPR Korea, and Hubei Biopesticide Engineering Research Centre (HBERC), Wuhan, People's Republic of China (PR China), has developed a combination of biological, cultural and chemical control measures that has significantly improved cabbage production.

Surveys at the start of the project showed that pest problems were severe, particularly diamondback moth (*Plutella xylostella*) and small white butterfly (*Pieris rapa*): total crop losses were observed, and it was not uncommon to count more than 50 diamondback moth caterpillars on a single plant. Treatment with insecticides, notably the organophosphate monocrotophos (WHO classification 1b: highly hazardous) and the pyrethroid deltamethrin (class 2: moderately hazardous), was relatively ineffective because of (a) insecticide resistance, particularly in diamondback moth, and (b) negative impacts on natural enemy populations.

An IPM strategy was developed with the following core components:

• Transplanting clean seedlings to delay insect pest population build-up.

• Replacing chemical pesticides with biopesticide, *Bacillus thuringiensis* (*Bt*), for control of diamondback moth and small white butterfly (which would also enhance the impact of the natural enemy community).

• Mass-releasing the parasitic wasp *Diadegma semiclausum* to control diamondback moth.

• Using a pest-monitoring and action threshold system under which farmers spray insecticides only when pests reach a damage threshold level.

In DPR Korea, there is a cooperative farming system, with 1000–2000 people living and working together on a farm of some 500 ha (for vegetable production), effectively as a village community. The farms, led by a manager and a chief engineer, are partitioned into teams and sub-teams, each with leaders and engineers.

The IPM strategy was first tested on five cooperative farms. Encouraged by its success, farms were motivated to extend the new approach to their entire area of cabbage cultivation and neighbouring cooperative farms showed keen interest to follow the IPM approach. Currently, 170 ha of cabbage are successfully produced using the concept of IPM, producing an additional 1200 tonnes of cabbage annually. This corresponds to a 40% yield increase compared with conventional production. Although implementing IPM costs more than applying conventional practices on an area basis, this is more than offset by the increased yield.

For example, in early cabbage varieties, a mean yield of 32 t/ha is produced under IPM compared with 22 t/ha under conventional production. *Bt* costs about twice as much, per hectare, as chemical treatments (the latter costs some 15,000 Won/ha). However, the additional 10 t/ha cabbages produced under IPM represents an additional 70,000 Won/ha of income, giving a net financial benefit of IPM of 55,000 Won per hectare – and this equates to 11 months of a farm worker's salary.

Capacity building is key to successful IPM uptake. The success of the project, including both very positive farmer attitudes and governmental support, means the IPM strategy is ripe for scaling up. This calls for local biopesticide and biocontrol agent production capacity to be strengthened.

• A local pilot facility for the production of *Bt* biopesticide was constructed to support large-scale dissemination of the IPM strategy in cabbage. Key elements in the choice of production system were a capacity to produce high-quality product without high-energy inputs or sophisticated technical equipment that would be difficult to maintain. Following initial testing in 2007, with the help of Chinese specialists, the facility can run at a capacity of 8 tonnes per year, enough *Bt* to treat 2000 ha of IPM cabbage.

• Releases of the parasitic wasp *D. semiclausum* against diamondback moth were carried out in 2003 and 2004 using insects supplied from Switzerland; a total of 19,500 and 25,000 wasps, respectively, were released at five cooperative farms. Positive effects were observed in the years of release and it is hoped they will eventually establish permanently and provide sustainable and economic control, but this has not yet been achieved.

An important facet of the project involved training and dissemination of the technology at both institutional and farm levels.

• Training began with scientists at PPI-AAS, who learnt aspects such as the development of monitoring and damage threshold models, experimental design and analysis of IPM-related field studies as well as technical topics such as rearing diamondback moth parasitoids. They were also trained in use and maintenance of the *Bt* production equipment. The trained scientists acted as master trainers for the next phase.

• Extension officers from the Ministry of Agriculture and farm team leaders and farmers were then trained by the master trainers though participatory IPM approaches. Their training focused on general knowledge about cultural, biological and chemical control practices in IPM, as well as gaining hands-on experience in recognition of cabbage insect pests and the natural enemy complex controlling them. The impact of using a broad-spectrum chemical insecticide compared to *Bt* was also demonstrated via field-based participatory training.

• Each of the trainers can pass on their knowledge to some 200 farmers a year, and the project is training additional master trainers and trainers to scale up dissemination of the technology. Through this cascading approach to training and knowledge dissemination, it is anticipated that within 3–5 years, farmers will be able to manage all of DPR Korea's cabbage production through IPM.

The direct impact of this project was higher per-hectare production of a nutritionally valuable vegetable at a lesser cost, providing enough extra cabbage for 9000 people annually from the area under IPM. It also replaced hazardous pesticides with effective environment-friendly alternatives and thus improved the health of farm workers and the environment.

Cabbage is produced on a total area of over 30,000 ha in DPR Korea. If the 40% increased yields seen under this project were to be replicated on the country's entire cabbage production area, as much as an additional 300,000 tonnes of cabbage could be grown each year. This corresponds to the annual cabbage consumption of some two million people, which would make a substantial contribution to the Millennium Development Goal (MDG) of halving hunger by 2015 and towards food security in DPR Korea.

Source: SDC/CABI Europe – Switzerland (2007) Asia Brief. Cabbage for all in DPR Korea – Partnership Results. Swiss Agency for Development and Cooperation, East Asia Division, Berne, 8 pp.
Email: eastasia@deza.admin.ch
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Announcements

Are you producing a newsletter or website, holding a meeting, running an organization or rearing a natural enemy that you want biocontrol workers to know about? Send us the details and we will announce it here.

IOBC on ICE in Durban

The International Organization for Biological Control (IOBC) is hoping biocontrol scientists at ICE 2008, the XXIII International Congress of Entomology on 6–12 July, 2008 in Durban, South Africa (www.ice2008.org.za), will attend the four symposia it has organized:

- Can boundaries between biocontrol and GMOs [genetically modified organisms] be overcome?

Papers will address concerns about GM crops from the perspective of biological control, including their effects on non-target organisms and whether they have adverse impacts on biological control. Others will look at opportunities for biocontrol, and how GMOs could be used to enhance biological control. A final paper will assess the impact of commercial use of GM crops.

- Critical analyses of successes and failures of biological control in Africa

Papers will discuss biological control of *Chromolaena odorata,* aquatic weeds in Lake Victoria and *Sirex* woodwasp, and biological control as a component of IPM in cowpea. Another will consider the future of microbial control in Africa.

- Environmental benefits and risks of biological control

Papers will consider how to value, and balance, environmental risks and benefits, and select non-target hosts for specificity testing. 'Quick scan' and comprehensive evaluation methods for exotic natural enemies will also be examined. Two more papers will look at the Dutch and New Zealand experiences of evaluating large numbers of natural enemies and post-release evaluation, respectively.

- What are ecology's contributions to biological control and vice versa?

Under the spotlight here will be research on the competitive exclusion principle, foraging behaviour, natural enemy–prey interactions; intra-guild predation, chemical and behavioural ecology, and population dynamics models.

Information: www.unipa.it/iobc/downlaod/ newsletter 83.pdf, p.8.

Bacterial Plant Diseases Meeting

The Second International Symposium on Biological Control of Bacterial Plant Diseases will be held in Orlando, Florida, USA on 4–7 November 2008.

Following on from the inaugural symposium in Germany, the second symposium will continue the focus on biological control of these diseases. Therefore, as well as continued discussions of the status of biocontrol measures in most commercial crops, the organizing committee is inviting all plant pathologists to initiate a broad discussion on all aspects of the biological control of bacterial plant diseases. This should include promotion and development of environmentally safe control strategies, both current and as a potential future opportunity. Topics will include: Fire blight; Mechanisms of biocontrol agents; Biocontrol of horticultural crops; Genetics/genomics; and Safety and regulation of biocontrol agents.

The deadline for abstract submission is 1 September 2008.

Contact: Dr Jeffrey B. Jones, University of Florida, Plant Pathology Department, 1453 Fifield Hall,
PO Box 110680, Gainesville, FL 32611, USA.
Email: jbjones@ufl.edu
Web: http://grove.ufl.edu/~biocon/

International Bioherbicide Group Workshop

The IX International Bioherbicide Group Workshop will be held on 8–9 February 2009 in Orlando, Florida, USA, in conjunction with the Weed Science Society of America's (WSSA's) annual meeting, which begins on 10 February. A formal call for titles and pre-registration will be made in the near future.

Contact (email preferred): Joe Neal, Department of Horticultural Science, 262 Kilgore Hall, Box 7609, NCSU, Raleigh, NC 27695-7609, USA.
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Biological Control Focuses on Conservation

For those who have not already found it, the May 2008 issue of *Biological Control* (45:2) is a 'special' devoted to conservation biological control. Edited by Mattias Jonsson, Steve D. Wratten, Doug A. Landis and Geoff M. Gurr, there is a preface by David Pimentel and nine further papers explore different aspects of the topic.

TAME Invasives Portal

A web portal, 'TAME Invasives: A Solution for Your Life' is being developed at:
http://pesticide.ifas.ufl.edu

The portal features research-based information, multimedia products and online coursework that focuses on the management of four high priority invasive pest plants in south Florida including old world climbing fern (*Lygodium microphyllum)*, tropical soda apple (*Solanum viarum*), Brazilian peppertree (*Schinus terebinthifolius*), and melaleuca (*Melaleuca quinquenervia*).

Online courses have been developed to teach participants how to (1) manage these high priority invasive pest plants; (2) use herbicides in the most effective manner that is safe for people and the environment; and (3) understand the role of biological control as an essential IPM tool for the management of these invasive plant species. The primary audience for the courses includes licensed pesticide applicators, although members of the public tackling the invasives could also benefit.

Assessing GM Crop Risks to Non-Target Arthropods

A framework for conducting environmental risk assessments of insect-resistant genetically modified (GM) crops to non-target arthropods has been developed by a diverse group of stakeholders led by Jorge Romeis of Switzerland. It aims to provide a basis for improving harmonization of international risk assessment guidelines that will facilitate data acceptability and give greater scope for comparing data on ecological effects.

The framework takes a three-step approach: (1) Definition of threshold values which is the basis for advancing to higher tiers or for immediate decision action; (2) Selection of surrogate species for appropriate laboratory testing; (3) Development of standardized, validated test protocols for surrogate test species. The authors believe that this approach should minimize the likelihood of releasing insect-resistant GM crops that would later have undesirable effects on non-target insects.

Source: Romeis, J., Bartsch , D., Bigler, F., *et al.* (2008) Assessment of risk of insect-resistant transgenic crops to nontarget arthropods. *Nature Biotechnology* **26**, 203–208.

Conference Reports

Have you held or attended a meeting that you want other biocontrol workers to know about? Send us a report ans we will include it here.

First Antipodean Biocontrol Conference

Australia and New Zealand have a distinguished history in the development and implementation of all forms of biological control research. The First Australia and New Zealand Biocontrol Conference was held at the Menzies Hotel in Sydney, Australia on 10–14 February 2008. It was organized under the auspices of the Asia and the Pacific Regional Section of the International Organization for Biological Control (IOBC) and attracted participants from seven countries.

In itself, biological control sounds like a specialist area, but this is a diverse field of research encompassing as it does classical biological control of arthropods, weeds and diseases, invertebrate pests, integration of natural enemies with other control methods, biocides, the manipulation of habitats to conserve agents, and other fields of endeavour. All of these subjects were covered in the 60 oral and 30 poster papers presented. Meetings such as this usually concentrate on specialities within the discipline, and so delegates revelled in this rare opportunity to cross-talk and share insights across research specialities. A striking feature of the conference was the amount of research presented that sought to either explain or optimize the interaction of biological control with target and non-target species in complex habitats and ecosystems, even at the landscape level.

There were three keynote addresses. Prof. Mark Hoddle (University of California, Riverside) told the conference that the continuing challenges of off-target effects and resistance development in pesticides coupled with the growing uncertainties around climate change should provide impetus for further development of biological control. He claimed that the growing use of transgenic crops also provided an opportunity for more strategic and more effective IPM incorporating natural enemies. However, he warned that these opportunities will be lost if we cannot train and retain researchers with relevant skills. Prof. Hoddle also described the successful biological control of glassy-winged sharpshooter in Tahiti but warned that the relentless advance of the species across the South Pacific poses an imminent threat to primary industries in Australia and New Zealand.

Dr Andy Sheppard (CSIRO Entomology) stressed the critical importance of selecting the most appropriate classical biological control agents to maximize impact on the problem while minimizing the risks. He compared and contrasted the methods available for assessing candidates, ranging from the assessment in containment of a range of agents obtained in surveys in the native range of the pest to detailed long-term studies of the target and its natural enemies in the native range before deciding which agents to develop. Both approaches can yield success. He reviewed the success that CSIRO and others have achieved using the former approach especially at the CSIRO laboratory in Montpellier, France. The benefit-to-cost ratio of investment in this laboratory over 40 years is at least 27:1. He also advocated that researchers should develop an explicit strategic approach to the selection of agents, informed by studies of the population dynamics of the target in both the native range and the invaded range.

Dr Glen Saunders reviewed the history of biological control of rabbits in Australia and New Zealand, outlined current research aimed at the management of other vertebrate pests and presented his view on the role of biological control in vertebrate pest management. He pointed out that the science behind attempts at vertebrate control has been complex, and warned that we need to know more about the unheralded consequences of taking predators out of ecosystems. Dr Saunders' address was followed by four presentations about the prospects of biological control of rabbits, koi carp, cane toads and other vertebrates – a fascinating session for those used to presentations about insects and weeds.

The largest proportion of presentations and posters either described how biological control agents interact with contiguous ecosystems, or examined how these interactions might be modified or enhanced. There were papers on the prospects for the better integration of biological control into intensive production systems. Safety of classical biological control agents was the subject of one session, and a range of papers examined how modelling and the study of population dynamics can help us to select safe and effective control agents in the first instance, and later to assess impacts. There were papers on the biological control of diseases. Other papers dealt with methodologies ranging from the selection and safety-assessment of biological control, the development of novel biomolecules using genetic manipulation, commercial production and deployment of control agents in protected cropping, and the quantification of economic benefits of successful control.

The papers presented at the conference will not be published in traditional form, but abstracts and the details of participants can be found at www.anzbc2008.org, and the audio and powerpoint presentations will be published in CD form shortly. A paper to be published in the IOBC journal *BioControl* will be submitted for publication detailing the results of the workshop held for the entirety of the final day. This paper will be a needs analysis of biological control research and adoption in Australia and New Zealand and will be authored by many of the delegates present at the conference who are representative of the leading biological control practitioners and researchers in the region.

For further information contact Dr Leigh Pilkington Email: Leigh.Pilkington@dpi.nsw.gov.au

By: Richard Hill

Weed Management in Arid and Semi-Arid Climates

The Novel and Sustainable Weed Management in Arid and Semi-Arid Agro Ecosystems international conference, held in Rehovot, Israel on 7–12 October 2007, was the first meeting of the recently inaugurated European Weed Research Society (EWRS) Working Group: Weed Management in Arid and Semi-Arid Climate. About 100 participants from 23 countries attended the entire five-day conference with many more participating on a one- or two-day basis.

The conference consisted of oral presentations and poster sessions in a range of areas including biotechnology and molecular biology in weed science (four presentations), application methods and formulations (four), herbicide behaviour in soils (five), weed management in arid and semi-arid farming systems (six), biocontrol, organic farming and allelopathy (six), invasive weeds (four), parasitic weeds (nine) and herbicide-resistant weeds and crops (nine). A special poster session was dedicated to three elected posters out of a total of 23.

The first day of the conference, Sunday 7 October, was devoted to a statistical analysis course by Prof. J. C. Streibeg which took place in a computer room with 20 participants.

Each day opened with a keynote lecture. The first of these, presented by Jonathan Gressel, was on potential biotech solutions for intractable weed problems in our arid and semi-arid ecosystems. Prof. Gressel stated that: "transgenic herbicide resistant wheat, rice, sorghum, sunflower and beets would be solutions, but failsafe mechanisms must be instituted to prevent transgenes flow to the relatives. The parasitic weeds that plague us can be controlled by transgenic herbicide target site resistances to systemic herbicides. Micro-RNAi constructs are being tested, as well as transgenically enhanced biocontrol agents".

The second keynote lecture dealt with the status of physical and cultural weed control methods for field crops in Europe, and was presented by Bo Melander. Novel and sophisticated physical and cultural weed control devices, prototypes as well as commercial products, were displayed by Bo. The impressive progress in this field together with the problems of herbicide registration and regulations gave the impression that physical and cultural weed control devices will be the weed control backbone of the future.

The last conference keynote lecture was on the chemistry, biological activities, distribution in the plant kingdom and regulation and production of strigolactones – the germination stimulants of the weedy parasitic plants *Striga* and *Orobanche*. Koichi Yoneyama, a pioneer in the field of purification and characterization of strigolactones, presented this topic. *Striga* and *Orobanche* have enormous importance in the arid and semi-arid ecosystems given the prevalence of systems highly infested with these weedy parasites and the virtual absence of methods to control them. Prof. Yoneyama emphasized the dual mechanisms that the strigolactones possess, playing a role both in stimulating *Striga* and *Orobanche* seed germination and as branching factors for arboscular mycorrhizal (AM) fungi. Based on the fact that non-hosts of AM fungi such as *Arabidopsis*, spinach and white lupine also produce strigolactones, Prof. Yoneyama suggested that these compounds may have additional unknown important roles in plants. The detection of strigolactones in shoots and fruits of several plant species supports this hypothesis.

It is impossible to review the range of topics discussed in all the sessions but the vigorous and fruitful discussions at the end of each session underlined the necessity and demand from many areas in the world for weed control solutions that are unique to the arid and semi-arid ecosystems.

All participants went on a one-day excursion to technical and cultural sites. The route led us south of Rehovot to the northern part of the Negev Desert passing the cities of Beersheba and Dimona. The first stop was in the Arava Valley close to the Jordanian border where we saw a very impressive example of hi-tech horticulture, showing various ways of growing field vegetables and fruits both in the open and under cover in a very harsh climate. In particular, the techniques of irrigation using saline water from the nearby Dead Sea caught the interest of people from overseas. Then we continued along the west bank of the Dead Sea making a short stop for swimming (or rather floating) in the Dead Sea – a special experience for most attendees. Jerusalem was reached at the end of the day where we had a good dinner with a splendid view of the old city of Jerusalem.

The conference closed on Thursday evening with a farewell party at a restaurant close to Rehovot, which included folklore presented by Jewish immigrants from Yemen in the form of exotic dances and music.

By: Joseph Herschenhorn (Agricultural Research Organization, Israel) and Bo Melander (University of Aarhus, Denmark)