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General News

Heather Beetle: from Doom to Boom, Part Two

Fifteen years after it was introduced to New Zealand, the second outbreak of a beetle agent introduced to control heather (*Calluna vulgaris*) has been reported. Seven years after introduction, heather beetle (*Lochmaea suturalis*) numbers started to increase at one site (see: 'Heather beetle: from doom to boom', BNI 22(2), June 2001; www.pestscience.com/Bni22-2/Gennews.htm) but have subsequently collapsed. Once again though, beetle numbers have increased at two new sites and this project seems set to become a good demonstration of classical biological control as an effective management tool of an invasive alien weed in conservation areas.

Heather was introduced into the Tongariro National Park in central North Island as part of an unsuccessful and misguided attempt to set up a grouse moor in the early 20th century. The spread of heather into native red tussock (*Chionochloa rubra*) communities of this World Heritage Site has become a major conservation problem. Heather also invades other subalpine vegetation, and is now threatening the important Moawhango ecological zone, which is home to many rare New Zealand endemic plants. In 1991, CABI (at that time the International Institute of Biological Control, IIBC) was brought in to survey in Europe for possible biocontrol agents. The heather beetle looked like being the answer. Heather beetle 'outbreaks' occur typically at 5–10 year intervals in northern Europe, sometimes causing complete mortality of heather over many hectares. The beetle is regarded as a pest of heather moorland used for grouse shooting, and causes damage to valuable areas of heather in lowland nature reserves in both the UK and the Netherlands.

As a potential biocontrol agent for release in conservation areas, host specificity testing was rigorous and extensive. However, during five years' testing in the UK, *L. suturalis* was found to be completely specific to heather apart from one incidence of feeding on the New Zealand alpine species *Pentachondra pumila* in no-choice tests. Field tests were conducted in the UK on root-washed *P. pumila* imported from New Zealand before the beetle was declared safe for importation. At the end of 1992, shipments were dispatched with high hopes to New Zealand where Landcare Research was to complete screening.

During routine screening in 1994 the imported beetles were found to be infected with a microsporidian disease. Painstaking rearing and hygiene procedures finally led to the establishment of a disease-free colony, and the first beetles from this were released in 1996. During the first three years there was no sign of the beetles but in December 1999 a few adults and larvae were found at one release site and by the following spring (December 2000) beetle numbers there had grown to outbreak proportions: one patch of dying heather was found to contain thousands of beetles. Unfortunately by the spring of 2002 the beetle population had collapsed and since then we have been trying to figure out why this occurred.

After sampling for the presence of predators and pathogens[1] and checking climate records we concluded that weather conditions during overwintering and spring in 2002 were the most likely explanation for the beetle collapse. During the 2002 collapse we experienced the warmest winter since records began in 1968 followed by the coldest October (early spring) since 1982 including the lowest air temperature recorded since 1945! Subsequent data logger records suggest that winters at high altitude Central Plateau sites in New Zealand may be up to two months longer than those at Oakworth in the UK where the beetles were sourced from. Field and laboratory trials have also indicated that cold snaps (below –4°C) in spring may kill a large proportion of emerging beetles following overwintering. This work is ongoing in conjunction with colleagues at the University of Western Ontario, Canada.

Furthermore, after an initial investigation into whether or not our beetles may be adapting to long winters and extreme spring conditions we discovered beetles in New Zealand were nearly 10% smaller than their UK counterparts. Given that body fat content (used to survive winters) is proportionate to body size in heather beetles, this may be an important limiting factor in the beetles' overwintering survival. We are currently investigating if the size difference could have been caused by heather beetle collection, rearing and releasing methods having had a detrimental impact on genetic variability, and if we can rear bigger beetles to improve overwintering survival.

More recently, and again to our surprise, we uncovered a third hypothesis for why heather beetle has struggled to establish and grow in New Zealand. After collecting heather sprigs from eight sites in the UK and comparing these with sprigs from New Zealand we were amazed to find that nitrogen content was approximately 50% lower at high altitude Central Plateau sites in New Zealand compared with sites in the UK. This finding, coupled with research demonstrating that larger beetles can be reared on nitrogen enriched heather[2], has us wondering if poor nutrition may be an important part of this puzzle. We are currently running experiments to determine if nitrogen can be used to trigger outbreaks and will be sampling more vegetation to help us understand how widespread low nitrogen levels are at our sites.

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So, poor heather beetle establishment in New Zealand (until recently) may have been due to either long winters and variable spring conditions, small beetle body size, poor nutrition or a combination of these factors.

Recently outbreaks covering approx 4 ha have occurred during a period of relatively settled spring conditions (La Niña weather pattern) and at one site where nitrogen (30 kg/ha urea) was applied. We predict, given favourable conditions and exponential growth of heather beetle populations continue for three more years, the entire 50,000 ha heather infestation across Tongariro National Park and adjacent New Zealand army land could be badly damaged or killed.

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[2] Power, S.A., Ashmore, M.R., Cousins, D.A. & Sheppard, L.J. (1998) Effects of nitrogen addition on the stress sensitivity of *Calluna vulgaris*. *The New Phytologist* **138**(4), 663–673.

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Breakthrough in Biological Control of Cotton Mealybug in Pakistan

A project to combat the damage mealybug is causing Pakistan's cotton industry is showing successful initial results. Two biological agents are looking particularly promising at this stage.

In 2007 the Pakistani Government's Ministry of Food, Agriculture and Livestock approved an initial one-year project which has since been extended by a further three years. This project has a two-pronged approach: (1) conservation and augmentation of the existing natural enemy fauna, and (2) importation and release of exotic natural enemies.

The mealybug, a complex of species of *Phenacoccus*, was first recorded in Pakistan in 2005. It is now the most damaging pest of cotton in Pakistan. Its presence is detected by the appearance of white fluffy wax on sheltered areas of the plant – the insect produces the wax as a protective layer to shelter beneath when feeding. Large infestations lead to a build-up of the sugary excrement 'honeydew'; this sticky substance encourages the growth of sooty moulds which give the plant a dark appearance. The insect is highly polyphagous and has attacked about 160 species of plants in Pakistan, including other important crops such as tomato, aubergine, okra, chilli, wheat and tobacco.

Over the past three years the mealybug has caused massive economic loss to cotton crops and the Pakistani Government has cited it as a high priority threat to the nation's agriculture. Some 3.1 million bales of cotton have been ruined (a bale of cotton weighs 500 lbs, i.e. 227 kg) and farmers have been spending 1500 Pakistani rupees (just over US$20) per acre (approximately equivalent to 3700 rupees or $50 per hectare) each year on pesticides in an attempt to control the new pest.

Cotton is a very important crop in Pakistan. It is the fourth largest producer of cotton in the world and the third largest consumer. Cotton is one of the country's main exports, making up 60% of the total export revenue. Not only is cotton a valuable material for cloth, 55% of Pakistan's domestic cooking oil comes from cotton seed. However, Pakistani cotton yields per hectare compare poorly to other producers such as Australia, China, Egypt, Syria and Turkey. There is a huge variety of cotton pests and diseases in Pakistan, and these are the main causes of the lesser yields.

The CABI-led mealybug project involves three field reservoirs, each of five acres (2 ha), at Multan, Tando Jam and Lasbela. These have been established to develop mass rearing techniques for mealybug predators. In the field reservoirs, cotton and other host plants of the mealybug are grown with the aim of increasing mealybug numbers. Insecticide sprays are strictly prohibited. This technique for encouraging endemic biocontrol agents to become associated with the exotic pest has, as expected, produced results. Initial successes have included the production of thousands of predators over a fortnight interval, suggesting the possibility of eventually building capacity to produce predators in the millions. Studies on conservation of predators are also being conducted in the field reservoirs. Some promising predators have been identified whose populations are density dependent and fluctuate with the population of the mealybug, and play an effective role in suppressing mealybug populations on cotton and other host plants.

A parasitoid was recorded for the first time in August 2008 at Tando Jam. This large-bodied insect has been detected in field populations, and is most commonly found in third-instar (pre-adult) female mealybugs. From field populations it was difficult to tell whether mealybug mummies originating from younger instars had developed in female or male crawlers. Further studies on the biology, host stage preference and host stage suitability for development of the parasitoid have been initiated in the laboratory. Specimens of the parasitoid have been sent to the Natural History Museum in London, UK, for identification. It is suspected to be a species of the aphelinid genus *Aenasius*. Surveys are being carried out in Punjab to assess the incidence of the parasitoids on the mealybug.

Initial studies show that the parasitoid is causing more than 50% mortality of the pest on cotton and other host plants. It is reported to be spreading quickly. Cultures of the parasitoid have been established at the Tando Jam laboratory and will be distributed throughout the country for mass production and release in farmers' fields. Follow-up research will then be carried out.

A second predator, *Cryptolaemus montrouzieri,* is also showing promising results. Introduced by CABI – South Asia from California in December 2007, this insect is being mass produced at various sites throughout the country and releases have been taking place since March 2008. This coccinellid beetle is native to Australia and has been used to control pest mealybug species in many other countries.

Initial numbers recorded following its release were small but it is expected that over time *C. montrouzieri* will acclimatize to Pakistani conditions allowing it to build up its population and contribute substantially to controlling the pest.

The overall project will involve the establishment of three insectaries, one each in the provinces of Sindh, Balochistan and Punjab, for the primary purpose of mass production of endemic and exotic predators of mealybug and other cotton pests.

It is hoped that this two-pronged approach will reap economic benefits for the region.

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Revisiting Rust for Noogoora Burr Biocontrol

A weed that was one of the earliest targets for weed biological control in Australia is the focus of renewed interest, with investigations into the potential of new strains of a rust fungus for areas where it remains problematic.

Noogoora burr (*Xanthium occidentale*) is a riparian weed that forms monocultures across northern Australia and has the potential to spread much further. It is invading previously uninfested catchments and is perceived as a major threat by pastoralists and government agencies. Worldwide, Noogoora burr is an annual weed of 11 major agricultural crops in 28 countries, and has been listed as one of the ten most noxious weeds in the USA.

The weed outcompetes palatable plants, the seedlings are toxic to stock and the burrs reduce wool value. It is a weed of agricultural crops as well as pasture, and poses quarantine risks.

The two major phases in the Australian programme against Noogoora burr were in 1929–40 and 1953–75. Three agents were released: a seed-feeding fly in the 1930s, and two stem-borers in the 1960s, but none of these had significant impact. A fourth insect, a gall-forming moth (*Epiblemma strenuana*), which was actually released against parthenium (*Parthenium hysterophorus*) in 1982 and also attacks Noogoora burr, did cause some damage.

Since then, Noogoora burr infestations in eastern Queensland have been largely brought under control by a rust fungus, *Puccinia xanthii*, which was accidentally or illegally introduced into Australia in 1975. The same rust fungus has not been effective in controlling infestations in the far north of the Northern Territory and Western Australia.

To find more effective strains of *P. xanthii* for northern Australia, CSIRO established a partnership with NRETA (Northern Territory Department of Natural Resources, Environment and the Arts) and DAFWA (Department of Agriculture and Food, Western Australia), with financial support from the Australian Government through the Land & Water Australia; Defeating the Weed Menace R&D initiative.

The aim was to collect and test the host specificity of exotic rust strains that are better adapted to the tropical climate, and gather baseline data of Noogoora burr populations in northern Australia. Exploration for additional rust strains was undertaken in Mexico, Venezuela and the Dominican Republic in areas with climates that match those of northern Australia. The rust was found in Dominican Republic and Mexico and permission was obtained to import several strains from these countries into the CSIRO Black Mountain Containment Facility in Canberra for further testing.

At this point it was found that none of the newly imported strains would infect Australian Noogoora burr, which developed typical resistance reactions when inoculated with them. Australian rust strains, on the other hand, produced severe disease symptoms.

Further investigations in the areas where collections had been made revealed that the Noogoora burr plants from which the strains had been collected were genetically different to their Australian counterparts. These differences could explain why the tropical American rust strains could not infect Australian Noogoora burr.

The plan now is to find out where Australian Noogoora burr originated from and look there for more pathogenic rust strains. If this cannot be achieved, an alternative step could be to establish an outdoor 'garden' of Australian Noogoora burr in tropical America to try and attract rust strains.

The team has developed a molecular method to distinguish between exotic and Australian rust strains. In addition, collaborators from NRETA and DAFWA have monitored Noogoora burr along three rivers in the Northern Territory and northern Western Australia. This will help assess the efficacy of any additional strains of *P. xanthii* that might eventually be released in Australia.

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Is Weed Biocontrol Limited by Biocontrol Agent Parasitism?

In these times of tough requirements for importing biological control agents and equally tough financial constraints, it would desirable to predict whether or not a promising natural enemy will go on to reduce the target pest if it is released, before significant time and money are invested in studying it, perhaps at the expense of other potential agents.

Weed scientists at New Zealand's Landcare Research, who have a knack of spotting interesting and significant questions, have been looking at how far parasitism of introduced natural enemies may be impeding their success as weed biological control agents. Such knowledge could be useful for prioritizing natural enemies in the future. Moreover, if a biocontrol agent is susceptible to parasitism, it could have impacts beyond weed biological control. By acting as an additional host, a biocontrol agent might allow a parasitoid to become more abundant, which might make it better placed to exploit other hosts more heavily – and these could be native or beneficial insects.

Quentin Paynter and team have recently begun a major nationwide survey and literature review to investigate the role of parasitism in weed biocontrol. So far they have collected more than 10,000 individuals of 24 invertebrate species (where possible all life stages) from more than 50 locations in New Zealand and have been looking at what parasitoids they harbour.

The survey has another year to run, but preliminary results are interesting. The evidence collected so far suggests that just over one-third of invertebrate weed biocontrol agents in New Zealand are being parasitized to some degree. The key question is how significant this is. Experience suggests that biocontrol of insect pests is rarely successful if the agents take out less than 40% of target hosts and is usually successful if they can hit more than 60%. Applying this to the results for parasitoids of weed biocontrol agents, the team identified as 'causes for concern' cinnabar moth (*Tyria jacobaeae*), old man's beard leaf miner (*Phytomyza vitalbae*), mist flower gall fly (*Procecidochares alani*) and Mexican devil weed gall fly (*Procecidochares utilis*), because parasitism levels of more than 60% have been measured for all of them. But this does not seem to have compromised biocontrol of the target weeds in these specific cases, as ragwort (*Senecio jacobaea*) and mist flower (*Ageratina riparia*) are mostly under good control owing to other biocontrol agents, while anecdotal evidence suggests that Mexican devil weed gall fly and a fungus, *Phaeoramularia eupatoriiodorati*, are significantly suppressing Mexican devil weed (*Ageratina adenophora*).

The team have found no evidence that the duration of exposure affects whether or not biocontrol agents get attacked by parasitoids. Some very recent introductions, such as the boneseed leafroller (*Tortrix* s.l. sp. *chrysanthemoides*), have been attacked very quickly, while some agents released in the 1930s and 1940s, like the St John's wort beetles (*Chrysolina* spp.), remain unexploited by parasitoids.

How useful is this knowledge with regard to biocontrol agents under consideration today? Paynter points out some limitations: there is still limited knowledge of the New Zealand parasitoid fauna, and new parasitoids are being introduced, deliberately or accidentally, all the time, which both affect the ability to make useful predictions, and mean scenarios could change over time. However, he argues, with the more rigorous host-range testing of today and the stringent process controlling introduction of new organisms, the risk of parasitoids being deliberately released without considering the impacts on beneficial insects, such as weed biocontrol agents, is likely to be less than in previous times.

There are some indirect sources of information, which Paynter points out: sufficient information can sometimes be gathered when surveying target plants for natural enemies at the outset of projects. He cites the example of finding that generalist leafrollers living on boneseed (*Chrysanthemoides monilifera* ssp. *monilifera*) in New Zealand are attacked by generalist parasitoids, which allowed them to predict that the boneseed leafroller was also likely to be attacked. Nonetheless, it was decided to introduce the exotic boneseed leafroller anyway, because they also knew that outbreaks of it occur in its South African homeland despite heavy parasitism by nine species. He also says that an educated guess, based on what is known about similar biocontrol agents, can sometimes be justified. For example, it was known that the Mexican devil weed gall fly is parasitized in New Zealand, so it was likely that the very similar mist flower gall fly would be utilized by the same wasp species (*Megastigmus* sp.). Nonetheless, it was decided to proceed with the introduction because the Mexican devil weed gall fly is common and damaging in New Zealand, despite parasitism by *Megastigmus*, and reports from Hawai'i indicated that the mist flower gall fly was useful against mist flower there despite being heavily parasitized by several parasitoid species.

It is the limited role of native parasitoids that Paynter describes as possibly the most important finding so far with respect to predicting parasitism. The team found that only three introduced biocontrol agent species are attacked by native parasitoids, and all of these had been released against target weeds which have closely related New Zealand native plant species, which in turn have native natural enemies which attack the plant in a similar way. Examples he cites are cinnabar moth on ragwort being analogous to the native magpie moth (*Nyctemera annulata*) on native *Senecio* species (and ragwort); likewise, old man's beard leaf miner on old man's beard (*Clematis vitalba*) is analogous to a native leaf miner (*Phytomyza clematadi*) on native *Clematis* species (and occasionally old man's beard). On the other hand, ragwort flea beetle (*Longitarsus jacobaeae*) has no equivalent species on native *Senecio* species. Thus, for target plants that are closely related to native plants, the risk of parasitism and indirect non-target effects may be significantly reduced if selected agents have no native counterparts. For example, the chances of the old man's beard sawfly (*Monophadnus spinolae*) being attacked by parasitoids should be low since there are no native phytophagous sawflies in New Zealand. (Unfortunately, as the sawfly has apparently failed to establish in New Zealand, this cannot be checked, although Paynter would bet that parasitism is *not* the reason for the failure.)

The results of the study so far indicate that while parasitism of weed biocontrol agents is reasonably common, it has probably only contributed to the failure of one programme out of 14 to date: the old man's beard project (although that is far from abandoned as an additional agent, the old man's beard beetle, *Xylocleptes bispinus*, is currently being tested in the UK, and further efforts to establish the sawfly may be made).

In conclusion, Paynter says, it is heartening to know that lessons being learnt from this retrospective study should help even better choices to be made when selecting agents in the future.

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Search for Plant Growth-Suppressing Rhizobacteria (PGSR) to Restrain *Cyperus rotundus*

No other weed is as ubiquitous and as serious to agriculture as the sedge *Cyperus rotundus* or purple nutsedge, and because of this it has been called 'the world's worst weed'[1]. *Cyperus rotundus* is tough to control through conventional means and most of the existing management practices are not reliable in every field situation. Chemical control, by far the most exploited strategy, cannot give sustained results as the plant possesses an extensive system of underground rhizomes and tubers coupled with a resistance to most herbicides.

Though *C. rotundus* is purported to have originated in India, contrary to biocontrol theory it is not under natural suppression even in its home country, meaning its natural enemies, due to reasons unknown, cannot keep pace with the weed's rapid growth and spread. However, biological control, both inundative and augmentative, has shown promising results in several instances in India. For example, the indigenous, lepidopteran stem borer *Bactra venosana* has been shown to have potential as an augmentative biocontrol agent. Among plant pathogens, the rust *Puccinia canaliculata* (reported as *P. romagnoliana* in India), which occurs on an epiphytotic scale every year, has also been shown to have biocontrol promise. Other rust species, i.e. *P. cyperi* and *P. cyperi-tegetiformis*, recorded in the Neotropics, and the *Uredo* spp. reported from the Old World should be subjects of exploration within India, or considered for importation and evaluation.

At the Project Directorate of Biological Control (PDBC) in Bangalore, a specific sub-project within the Indian Council of Agricultural Research (ICAR) funded network project on 'Application of Microorganisms in Agriculture and Allied Sectors' (AMAAS) is being undertaken to develop a mycoherbicide-based strategy for the weed. Apart from fungal pathogens, in the course of our research we have also stumbled upon a few soil-borne bacteria that possess inhibitory traits towards *C. rotundus*.

Bacteria, in spite of their immense potential, have largely been overlooked as potential agents in weed biological control. Lately, there has been a steady increase in interest in engineering microbial interactions in the rhizosphere for biological control of weeds. The so-called deleterious rhizobacteria or 'DRB'[2] or plant growth-suppressing rhizobacteria (PGSR), as we christen them for the first time, appear to have weed biocontrol potential. Their potential for biocontrol was first described on downy brome (*Bromus tectorum*) and later on several other weedy plants[3].

So far we have identified five PGSR isolates out of the many that were found in the rhizosphere soil samples collected from several locations in Karnataka, Kerala, Maharashtra and Punjab states. All the five isolates suppressed the Hebbal (Bangalore) ecotype of *C. rotundus.*

An antibiotic sensitivity test showed various levels of resistance in the rhizobacterial isolates. Only one candidate strain (PGSR3) was found to have hydrogen cyanide- (HCN-) producing ability; this chemical has been demonstrated to be a growth retardant by earlier workers. At this stage, however, no definite conclusion can be drawn on the relationship between HCN production and the growth-suppressing activity of the candidate organisms. The factors that limit or prevent the production of HCN need to be understood through future research.

All the five rhizobacterial isolates significantly reduced *C. rotundus* seedling growth, and continuous observations indicated that all these candidate bacteria could weaken the plants. Symptoms such as wilting, necrotic reactions, distortion of emerging leaves and stunting of plants were observed. The inoculated bacteria reduced both fresh and dry weights of plants; PGSR5 reduced fresh and dry weights by 82% and 79%, respectively.

To identify these isolates based on 16S rDNA sequence data, genomic DNA was isolated and a ~1.4kb rDNA fragment was amplified using high-fidelity PCR (polymerase chain reaction). The PCR product was sequenced bi-directionally using forward, reverse and internal primers. The sequence data indicated that the isolates were species of *Acinetobacter*, *Bacillus* and *Stenotrophomonas*.

We are currently researching possible complementary role for these PGSR in a mycoherbicide-based biocontrol strategy for *C. rotundus*.

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WHO Report: Public Health Significance of Urban Pests

A major report from the World Health Organization (WHO) on the public health significance of urban pests[1] in Europe and North America argues that pest-borne diseases can no longer be considered relics of the past. The report, based on a review of the current status of urban pests and health in these two continents, points out that major changes in ecology, climate and human behaviour since the mid-20th century have favoured their proliferation, and that a dramatic rise in urban sprawl has led to city suburbs becoming the natural habitat of ticks, rodents and other pests. WHO invited international experts in various pest-related fields to identify the public health risk posed by various pests (allergic asthma, cockroaches, house dust mites, bedbugs, fleas, pharaoh ants and fire ants, flies, birds, human body lice, ticks, mosquitoes, commensal rodents, and non-commensal rodents and lagomorphs) and to suggest appropriate prevention and control measures. The book presents these reviews and formulates policy options for all levels of decision-making on the future management of pests and pest-related diseases. Of key importance is the report's executive summary which summarizes its main conclusions and presents thirteen points for action; these are expanded on in a summary document prepared by CIEH[2] (UK Chartered Institute of Environmental Health).

The report highlights the importance of IPM, and many chapters devote space to biological control, but how far biological control is considered a useful or promising approach varies depending on the pest.

- Of the groups for which biological control is discussed, house dust mites and fleas are considered to offer few opportunities.
- Research into biological control of cockroaches is well reviewed and is concluded to show potential for some species and circumstances; the most promising agents are identified as parasitoids, notably the cockroach wasp *Aprostocetus hagenowii* against *Periplaneta* spp., and the encyrtid wasp *Comperia merceti* against the brownbanded cockroach (*Supella longipalpa*). Transitory predatory evaniid wasps are thought less useful especially in an indoor setting, while application problems are considered to make fungi and nematodes problematic.
- Ticks are discussed as potential biocontrol targets, with *Metarhizium anisopliae* described as one of the best candidates. But the need for a good deal more research is highlighted, notably in application, and for non-target effects to be considered.
- Research on biological control of fire ants in the southern USA using phorid flies and a microsporidium is summarized, together with successes in establishing these agents in the field. Results so far suggest that impact at the population level will take some years to achieve, and the approach is judged to be of limited use against ants in urban settings at the present time.
- The chapter on mosquitoes (dealt with separately from other pest Diptera) covers biolarvicides (*Bacillus thuringiensis* ssp. *israelensis* and *B. sphaericus*) but these are described as 'biochemicals' and not biocontrol agents. And although the chapter notes that "40 biocontrol agents" including "bacteria, fungi, protozoa, nematodes, viruses, fish, insects, snails and plants" were investigated under a WHO programme, as biological control agents it features only predatory fish and 'in the pipeline' microbial products and copepods.
- A somewhat startling argument in the chapter on flies (nuisance Diptera) suggests that most biocontrol strategies for this group are not appropriate for urban settings because they target the larvae while the problems are caused by adult flies; it thus considers only entomopathogenic fungi that infect the adults.

The report ends with two general chapters. The first, on risks and hazards associated with pesticides (primarily to residents during professional pest control activities), provides an overview of pesticide regulation in Europe and North America, and discusses toxicology, pesticide application and exposure, and risk assessment. The second provides an introduction to IPM. This describes the foundation of IPM thus: "control [the] pests' access to food, water and shelter and you will control the pest." It explains IPM as a hierarchy of control practices: "public education, sanitation, pest exclusion and other biological and mechanical control measures, while limiting pesticide application."

One striking point about the report is that it becomes apparent that while an IPM approach is encouraged for urban pests, IPM means different things in the pest control and agriculture/environment sectors, and this make the approaches not always compatible.

The executive summary of the report describes how planners and developers often seek to integrate construction projects (housing developments, single buildings, recreational areas) both visually and ecologically with their natural surroundings but without considering the risk of increased pest infestation, which the various review chapters have identified. In its first action point, it says the risk should be reduced through regulations that take into account pest infestation and disease transmission. Maybe so, but this means a change in attitude. As the CIEH summary explains: "Perhaps surprisingly ... modern living and certain practices considered exemplary by government or ethical by 'good citizens' can encourage pests and pest-borne diseases into the urban environment." Thus the current trend for ecologically based planning and land management may exacerbate pest and therefore pest-related disease problems. The CIEH summary points to the rise in tick-borne diseases as an example: "As cities expand and more houses are built on their wooded outskirts, people will be more exposed to tick-borne diseases, such as Lyme disease and tick-borne encephalitis." Equally the trend for 'green' gardening may increase pests: "Encouraging hedgehogs and other small mammals into gardens can be part of a chemical-free garden pest control strategy but may also bring infected ticks nearer to homes [which] may then be transferred on to pets and domestic animals." Thus IPM in the agricultural/environmental sense may not be compatible with IPM in the pest control sense: a log pile may provide a refuge for spiders and a place for solitary bees to nest – but it may also harbour rats, and those rats may harbour human diseases.

Many, but not all, of the problems can be dealt with given sufficient knowledge and an appropriate regulatory framework; the importance of raising awareness at all levels, from the general public up to government, is highlighted in both the full WHO report and the CIEH summary. Nonetheless, because paramount concerns for agriculture, the environment and public health can differ (e.g. productivity/profit, biodiversity and human safety), compromises will be necessary.

[1] Bonnefoy, X., Kampen, H. and Sweeney, K. (2008) *Public health significance of urban pests.* World Health Organization, Regional Office for Europe, 582 pp. ISBN 978 92 890 7188 8. Price: CHF120/US$120. In developing countries: CHF84/US$84.
Orders: WHO Press, World Health Organization, 1211 Geneva 27, Switzerland.
Email: bookorders@who.int / publications@who.int
Web: www.euro.who.int/InformationSources/Publications

[2] CIEH (2008) *Urban pests and their public health significance: a CIEH summary.* [available in Dutch, English, French, German, Polish, Russian, Spanish]
Web: www.cieh.org OR www.urbanpestsbook.com/

Cane Toad Bigger than the Rabbit?

Newspapers seem unable to resist an opportunity to print a photograph of the poor ugly cane toad. It was such a picture that drew this contributor's attention to an article in the UK newspaper, *The Times,* on 29 August 2008, 'Chilly weather can stop the deadly cane toad cold'. The article described a recently published study showing that cane toad movement is very limited below 15°C. While it possibly comes as no great surprise that a tropical species is not pre-adapted for cool weather, the article drew my ire because it announced that the cane toad is "Australia's most notorious and resilient pest." Has *The Times*'s reporter not heard of the rabbit?

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.

Bug-free Life for Ontario's Strawberries

The tarnished plant bug, *Lygus lineolaris*, is one of the most important pests of strawberries in the Canadian province of Ontario and until now intensive use of insecticides has been the only means of control. *Lygus* goes through two full generations and a partial generation per year in southern Ontario and has adverse impacts on strawberry production throughout the growing season: first-generation nymphs cause severe economic damage to June-bearing cultivars, while second-generation nymphs are the major limiting factor on later day-neutral cultivars.

The high risk of *Lygus* populations developing resistance to insecticides, concerns about the impact of insecticides on beneficial insects, pollinators and human health, and increasing competition with imported berries from the USA, Mexico, China and eastern Europe have driven a search for new control strategies for these plant bugs based on no, or only limited use of, conventional pesticides. In addition, while the above concerns apply to many crops, frequent insecticide use brings additional problems in a continuously harvested crop such as strawberries because of pre-harvest interval and residue issues.

Agriculture and Agri-Food Canada (AAFC) and Health Canada's Pest Management Regulatory Agency (PMRA) established the Pesticide Risk Reduction Program together with industry and the Canadian provinces in 2003 with the aim of reducing the risks to the environment and consumers from pesticides used in agriculture.

Following the example of organic strawberry growing in California, USA, an IPM strategy has been developed by scientists from CABI Europe – Switzerland in collaboration with Canadian partners in OMAFRA (Ontario Ministry of Agriculture, Food and Rural Affairs), AAFC and the University of Guelph, funded by the Pesticide Risk Reduction Program. The new strategy may help to reduce or eliminate the application of pesticides in Ontario strawberries in the near future. Implementation of this strategy aims to minimize costs to producers as well as reduce the need for broad-spectrum insecticides.

The IPM strategy combines trap cropping, classical biological control and a reduced-risk approach using chemical control:

- Trap crops such as alfalfa planted along the edges of, or within, strawberry fields have the potential to limit plant bug damage by offering the pest a food source they prefer to the strawberry crop itself: *Lygus* adults migrating from adjacent areas are concentrated in the trap crop and numbers of adults migrating into strawberry are reduced. Alfalfa had earlier been identified as the most effective trap crop for Lygus bugs in California.
- Insecticides are applied to the trap crop after adult migration, reducing the number of *Lygus* females before they start laying eggs. This way the number of developing nymphs, which cause the main damage, is reduced and the need for insecticide applications in the strawberry crop itself is avoided. On organic farms, where insecticide use is prohibited, the alfalfa strips need to be partially cut and removed as soon as the *Lygus* adults have laid most of their eggs.
- When small *Lygus* nymphs are present, a classical biological control agent, the European nymphal parasitoid *Peristenus digoneutis*, is released to further reduce the *Lygus* populations in the strawberry growing area.

The European *P. digoneutis* had previously been introduced to the northeastern USA where it has been shown to reduce plant bug field populations in alfalfa. Since its first release it has dispersed naturally into Canada, where it is now present in plant bug populations in southern Quebec, southern Ontario and Nova Scotia. The inundative releases under this project, from insects mass reared at AAFC in London, Ontario, were intended to support the spread of the parasitoid throughout the province and to allow its impacts to be realised much sooner in Ontario's strawberry fields.

Before the new approach is applied to large-scale strawberry operations, it is being first tested on smaller conventional and organic farms. The interest of farmers was engaged during farmer participatory workshops, and several farms volunteered to participate in the project. These farmers were trained by CABI, through farmer participatory methods, in the basic concepts of *Lygus* IPM in strawberries and to provide them with the technical skills needed to implement the strategy.

The implementation of the IPM strategy was started in 2007 and has continued in 2008. In both years, several hundred adult *P. digoneutis* were released directly to the base of plants at five locations within the trap crop (to allow them to encounter *Lygus* nymphs as they climb up the plant) when small nymphs were first recorded in spring. Further releases were made later in the season when early-instar nymphs of the second *Lygus* generation were detected. Monitoring for *Lygus* and parasitism was then conducted throughout the field season in the crop, trap crop, and surrounding weedy areas. At the same time, damage in the strawberry crop was monitored to assess the impact of the IPM strategy.

In 2007 plant bug populations were generally low, but at all release sites a promising increase in parasitism was observed soon after the first releases in 2007. However, after a single field season it is too early to state whether *P. digoneutis* has already reduced *Lygus* populations in Ontario and whether the IPM approach has been successful.

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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.

SIP Future Meetings in USA and Turkey

Following the successful Society of Invertebrate Pathology (SIP) meeting in Warwick, UK, this August, the venues have been confirmed for the next two meetings: the 2009 meeting will be back in the USA, in Park City, Utah, and the following year, 2010, SIP returns to Europe when the annual meeting will be held in Trabzon, Turkey.

Further information: Society for Invertebrate Pathology, PO Box 11, Marceline, MO 64658 USA.
Tel: USA -888 486 1505 / Elsewhere- +1 660 376 3586
Email: sip@sipweb.org
Web: www.sipweb.org

Watch out for a report on this year's meeting in the December 2008 issue of BNI.

Indian Biocontrol Website

A new biocontrol website, 'Biocontrol strategies for eco-friendly pest management' has been launched by the Department of Biotechnology (Ministry of Science and Technology, Government of India). The site is a treasure trove of information for anyone working in that country. It lists biocontrol agents (microbials and macrobials, predators and parasitoids) in use in India with brief notes on their biology and application. Also covered briefly is the use of botanicals, novel biopesticides (avermectins) and semiochemicals. A resource section provides details of important manufacturers/suppliers in India and the agents/ biopesticides they produce. There is also a listing of companies by state, while under 'Referral lab' is a list of the laboratories so-designated by the Department. Most impressively, the innocuously named 'Achievements' is in reality a large database of past projects, outlining the aims and achievements of each. Past and current projects of the Department are also listed. 'Links' sections are not always useful, but this site provides an excellent list of websites for 45 key institutions, mostly in India.

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Web: www.dbtbiopesticides.nic.in/

New Biopesticides Journal

The inaugural issue of the *Journal of Biopesticides* was published in June 2008. This twice-yearly journal is devoted to publication of research work on plant protection with biological pesticides. The Journal aims to be interdisciplinary in approach, bringing together scientists and researchers on pests, diseases, weeds, rodents and molluscan management, thus paving the way for information exchange and interaction between industry, researchers, academia, students, extension workers and farmers.

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Whitefly Sustainable Management Manual

A new discovery learning manual on sustainable management of whitefly pests and whitefly-borne viruses has been published[1] as a tool for technology dissemination for researchers and extension staff. The three main sections cover (1) Background information about whiteflies, whitefly-borne diseases and crops affected; (2) Participatory exercises, which guide the user towards informed decision-making by helping him/her to better understand the ecology of the pest and choose the most cost-effective control method; and (3) Three case studies from Africa and South America.

The manual comes in hardback together with a pdf-version on CD and six complementary hand-outs on topics including pesticides and rational pesticide use, facilitation skills, farmer field schools (FFS) and impact evaluations.

The new manual complements an earlier publication: Anderson P.K. & Morales, F.J. (eds) *Whitefly and whitefly-borne viruses in the tropics: building a knowledge base for global action.*

[1] Lopez, V, Vos, J., Polar, P. & Krauss, U. (compilers) with Morales, F., Gibson, R. & Legg, J. (collaborators) (2008) *Discovery learning about sustainable management of whitefly pests and whitefly-borne viruses.* CABI – Caribbean and Latin America, Curepe, Trinidad & Tobago.

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A Weeds CRC by Any Other Name...

Australia's Collaborative Research Centre for Weed Management, the renowned 'Weeds CRC' closed at the end of June 2008.

After a strong campaign by its supporters, from grass roots through scientists to politicians, which emphasized the importance of weeds research to Australia's agriculture, environment and economy, the Australian Labor Government announced that Au$15 million over four years has been set aside for a new national weeds research centre to continue the work of the axed CRC.

When the Weeds CRC closed, so did the website www.weeds.crc.org.au owing to a ruling by the Australian Domain Name Administrator. But until a new 'Weeds' centre is up and running, the resources the Weeds CRC built up over the years are still accessible through a (very slightly) different url. Although no updates will be made to the site after 30 September 2008, the site will remain online until approximately June 2010.

The new url: www.weedscrc.org.au

New Books

In this issue we review some key biocontrol titles published in the last year

New Biological Control Text from the Van Driesche Stable[1]

For over ten years, Van Driesche and Bellows[2] was one of the outstanding introductory texts for biological control. Many biological control instructors considered this a required or recommended class text. While the book provided a broad-based treatment of the subject, it was ripe for a revision in order to capture recent developments in the field. Thus, Roy van Driesche teamed up with Mark Hoddle and Ted Center to produce this new book which comes as an excellent replacement for the earlier text. The book covers many of the original topics but the authors have also made a distinct effort to balance representation of arthropod and weed biological control, by providing greater coverage of the latter. More importantly, the authors have captured the key recent developments in biological control, for instance issues to do with safety.

The book is divided into 11 parts with 29 chapters. Part 1 comprises a short introductory chapter which frames the different approaches to biological control in economic terms. It emphasizes the 'public goods' nature of classical biological control and the importance of cost effectiveness in relation to the other approaches. Chapter 2 provides a definition for biological control and introduces the main approaches to its application. Of note is the distinction of 'new-association biological control,' a well recognized principle, but one that has in many instances been included within classical biological control. Part 2 discusses the different types of natural enemies from a context of diversity and ecology. This part combines information that was placed in two disparate sections in the original text. The combination provides a more effective presentation of related information. Chapters 3–6 focus on parasitoids, predators, weed biological control agents and arthropod pathogens respectively.

During the last two decades increasing attention and rightly so, has been given to the problems posed by invasive species. It is therefore appropriate that among the new material introduced into this book is Part 3, which discuses the invasion crisis and ways to suppress invasive species. Using several case histories, the authors discuss the enormity of the problem and introduce some of the key ecological issues. Chapter 8 provides an overview on suppression methods along the continuum from prevention to control, and places the role of biological control in context.

Parts 4–7 comprising Chapters 9–20 focus on the science and application of introduction of natural enemies. Part 4 comprises four chapters the first of which introduces interaction webs as the conceptual framework for classical biological control. Chapter 10 builds a theoretical framework for understanding population regulation and was guest authored by Joseph Elkinton. Chapters 11 and 12 focus on classical biological control and weed biological control respectively.

The three chapters in Part 5 discuss tools used for classical biological control beginning with foreign exploration (Chapter 13), followed by two new chapters. Chapter 14 looks at climate matching both as a tool to identify the best areas to look for natural enemies and also as a tool to assess the potential for spread of species. The last decade has seen a tremendous growth in the use of molecular techniques in various fields including biological control. It is therefore fitting that a guest chapter (Chapter 15) written by Richard Stouthammer which captures the key facets of molecular biology as they relate to biological control has been included. Issues surrounding the safety of biological control have probably had the most significant impact on development of biological control, especially for arthropods, during the last two decades. This is one of the significant areas which has been espoused in the three chapters of Part 6. Chapter 16 looks at non-target impacts, Chapter 17, approaches to predicting host range and, Chapter 18, avoiding indirect non-target impacts. Part 7 wraps up this major section comprising four parts on introduction of natural enemies with two chapters (19–20), which cover field colonization and natural enemy evaluation respectively.

Conservation of natural enemies in crops is covered in Part 8 in two chapters. Chapter 21 examines the impact of pesticides in cropping systems including how they affect natural enemies and explores approaches to mitigating the negative effects. This chapter also discuss the potential offered by transgenic *Bt* crops. Chapter 22 discusses how to enhance crops as natural enemy environments. Perhaps my only misgiving with the book is that it does not include a chapter on integrated pest management which might have fitted in this part. Issues and concepts surrounding development of microbial pesticides and their use in practical biological control are discussed in Chapters 23 and 24 which make up Part 9 of the book. Part 10 discusses augmentative biological control in greenhouses (Chapter 25) and in outdoor crops (Chapter 26). The last part of the book is divided into three chapters. Chapter 27 looks at the controversial topic of biological control of vertebrate pests and Chapter 28, new types of targets such as weeds and arthropod pests of natural areas. The last chapter is dedicated to exploring potential ways in which developments may occur in the different types of biological control approaches.

As biological control has continued to grow as a discipline, so has the difficulty of capturing all the relevant components in a simple introductory text. The authors have done a remarkable job to provide a comprehensive introductory text whose chapters are sharp and to the point, but with an ample range of examples. The authors have also included many recent references which provide a good start for any student wishing to explore concepts further. This book will provide a very useful one-stop shop for students wishing to study biological control. Furthermore, Roy van Driesche has made available on his website the training resources that he has developed and which complement this text. This will be useful for biological control instructors. Finally, in comparison to the previous book, it is great that this book comes with a more attractive price tag of US$69.95 (UK£34.99) from Wiley-Blackwell.

[1] Van Driesche, R., Hoddle, M. and Center, T. (2008) *Control of pests and weeds by natural enemies: An introduction to biological control*. 1st edition. Wiley-Blackwell, Malden, MA, USA, Oxford, UK, and Carlton, Victoria, Australia, 484 pp. Pbk.
Price: US$69.95/UK£34.99/€47.30.
ISBN: 978 1 4051 4571 8

[2] Van Driesche, R.G. & Bellows, T.S. (1996) *Biological control*. Chapman and Hall.

Insect Pathology Techniques Manual: Now Adapted for Field Use

This mammoth undertaking complements the earlier *Manual of techniques in insect pathology* (1997), which is essentially a laboratory guide and covers only entomopathogens sensu stricto. This field 'guide', or rather tome, includes all the pathogen groups of all invertebrate pests, broadening the concept of the first edition and especially highlighting the recent advances in the practical control of slugs and mites.

The book is divided into ten sections: Theory and practice of application (although this applies only to microbial insecticides); Statistical considerations; Application equipment (including a novel chapter on auto-dissemination); Overview of pathogen groups; Naturally occurring pathogens; Exotic pathogens (essentially classical biological control, which has seldom been exploited in invertebrate pathology); Evaluation of entomopathogens in specific systems; Transgenic plants; Resistance; and Non-target organisms. These latter three sections seem somewhat peripheral to the main thrust of the Manual which concentrates on the application and evaluation of pathogens for the control of invertebrate pests.

The main section, comprising 23 chapters and over 400 pages, covers all the major, as well as some minor, crop systems. Also included are specialist chapters on the pathogens and the biocontrol programmes against specific pest groups: livestock and stored product pests, grasshoppers and locusts, molluscs, and mosquitoes, for example. However, some chapters do fail to address the full range of projects and the varying techniques employed against the target pests: a case in point being that on grasshoppers and locusts which makes little reference to the massive LUBILOSA project against the desert locust.

Nevertheless, the editors are to be congratulated on compiling such a wealth of knowledge on the subject which should serve as a highly practical, step-by-step guide not only to students newly entering the field but also to seasoned practitioners. For many, the inclusion of a statistical section should be of great value, especially those involved with or confused by experimental design in their biocontrol projects. Similarly, the highly informative diagrams relating to application technology, in theory and in practice, should help avoid many of the pitfalls in getting the agent or product to the target pest in the field situation. This has often been the stumbling block when trying to replicate successful laboratory- or greenhouse-based experiments in the field.

The Manual has succeeded in its aims "to provide background and instruction on a broad spectrum of techniques and their use in the evaluation of entomopathogens in the field" and, therefore, it will be the standard reference source for all those involved in the management of invertebrate pests for many years to come.

Lacey, L.A. & Kaya, H.K. (eds) (2007) *Field manual of techniques in invertebrate pathology*. 2nd edition. Springer, Dordrecht, the Netherlands, 868 pp. PBk. Price: US$109. ISBN 978 1 4020 5923 2

Global Overview of Biological Control

As the title suggests, the editors went for a global perspective in the 44 chapters by leading experts in the field of biological control. Nevertheless, there is an overwhelming Canadian-centric bias with 45 out of the 99 authors owing allegiance to the 'maple flag'. This reflects the composition of the editorial board who, in their defence, do not claim that the coverage of this vast subject is comprehensive. As an example (which could be considered ironic in view of the publisher, as well as the reviewer!), CABI – with more than 80 years of experience in the field – is represented only by a part-authored chapter.

The editors describe the chapters on classical, inundative and conservation biocontrol programmes as "adventures in biocontrol", and this appears to have been taken up enthusiastically by the majority of the authors since many have written in the first person of their highly individual, often idiosyncratic experiences. This can be entertaining as the trials and tribulations of biocontrol scientists in chasing the funding – successfully or not – for their pet projects, as well as defining the (mis)concepts of the discipline, are catalogued in detail. This is especially evident in the chapters on control of invasive alien weeds in Canada, which dwell on the many problems that face biocontrol practitioners, not least the critical (often unanswerable) questions or issues posed by policy makers or ecologists: "Ecologically there is no free lunch, as there will be changes, even if only those arising from replacement of the weed" (P. Harris); "With each introduction comes a chance of indirect effects on non-target plants or influences on other components of the community, such as providing new food items for predators" (J. Myers). Such debate continues to frustrate classical biocontrol programmes. Similarly, there is a 'homely' review of the frustrations in trying to generate sponsorship for a project directed against the highly allergenic common ragweed in Europe (L. Kiss): an object lesson, perhaps, in the vision and dogged persistence of the scientists and the blindness of administrators! The theme continues with more successful efforts, especially to indoctrinate the general public into the benefits of biological control: "At a time when the misunderstanding of science and the scientific process is rampant, anything that demystifies the process is a benefit to us all" (R. Weidenmann *et al.*).

Other highly successful, but little-known biocontrol programmes – ranging from diseases of cocoa to pests of cotton, and through to IPM in vineyards – are gathered together in this volume which, thus, does go some way to justifying its claim to be a global perspective of the subject. The later chapters cover the relatively neglected field of conservation biological control – abbreviated to CBC, unfortunately, since this acronym is shared by classical biological control: a case against employing simplistic acronyms, perhaps! Some interesting case studies are presented here; although this is marred, somewhat, by the constant references to the inherent safety of this approach compared to the potential dangers of classical biological control (CBC?), citing the cane toad 'programme' as an example – poor science in more ways than one! Included here is a fascinating account of take-all decline of wheat, and the cryptic biocontrol agents involved, which leads to a thought-provoking discussion of the often controversial subject – "What is biological control?" (R. Cook): an issue that is also addressed by the editors in the introductory chapter.

The final chapter returns to the maple-centric theme, describing the successful efforts to establish a 'biocontrol culture' in Canada; not surprising, really, since the book was part-financed by this Network, as well as by a Canadian government agency.

The book is well illustrated with, on the whole, high-quality black-and-white text pictures and illustrations. But why also include them in colour in composite format (ten plates) as a frontispiece? Perhaps the price could have been reduced by sticking to one format only, thus making it available to a wider audience. Nevertheless, this is a minor aberration in what is an excellent contribution to this increasingly mainstream discipline in which there is something of interest for 'everyman', and which should inspire both aspiring as well as practising biocontrol scientists (and, hopefully, administrators and policymakers).

Vincent, C., Goettel, M.S. & Lazarovits, G. (eds)
Biological control – a global perspective (2007).
CAB International, Wallingford, UK. 440 pp. Hbk.
Price: UK£90/US$180/€145
ISBN: 978 1 84593 265 7