General News

Island-Hopping Mealybugs

There are now two mealybug pests threatening the Caribbean and surrounding regions [see *BNI* **19(3)**, 72N (September 1998)]: *Maconellicoccus hirsutus* (the hibiscus or pink hibiscus mealybug – HMB or PHMB) and the more-recently arrived *Paracoccus marginatus* (papaya mealybug). Here we give an update on biocontrol programmes against these two pests.

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Rapid Response to Mealybug Invader

The ability to identify pest mealybugs and readiness to react are key elements of a proactive biological control programme for containing the spread of *Maconellicoccus hirsutus*. The efficacy of this approach was shown when *M. hirsutus* reached the Central and North American mainlands in 1999 for the first time. Biological control agents were deployed within weeks of confirmation of the pest's presence in the USA and Belize.

Maconellicoccus hirsutus is native to Southeast Asia. It was first reported in the Caribbean from Grenada in 1994 and has since spread to most islands of the Caribbean [*BNI* **18(3)**, 68N-69N (September 1997)]. The most recent island invasion reported is that of Martinique in March 1999. It reached Guyana on mainland South America in 1997, and it was acknowledged that inevitably it would eventually reach Central and North America too. Plans, based on programmes implemented in Caribbean island countries, were therefore made for its reception. It reached the North American continent first, and was confirmed from southern California in August 1999. Shortly afterwards it was found in northern Mexico and then in Belize, Central America in September 1999. *Maconellicoccus hirsutus* has been effectively controlled in most countries using two natural enemies, the wasp *Anagyrus kamali* from China and the ladybird *Cryptolaemus montrouzieri*. Another parasitoid, *Gyranusoidea indica* from Egypt, has been released in several countries, and its performance is being evaluated.

In Imperial County in southern California, USDA-APHIS-PPQ (US Department of Agriculture – Animal and Plant Health Inspection Service – Plant Protection and Quarantine) was able to release *Anagyrus kamali* within three weeks of the pest first being reported, and *M. hirsutus* within the USA is still confined to an 11 square mile (ca. 28 km²) area of this county. In California, field studies are being conducted to determine the impact of the introduced agents, and further releases will be made when evening temperatures rise above a threshold of 45°F (7.2°C) in spring 2000. A local insectary operation is being established, but until it is functional, agents for release will continue to be available from the rearing facility in St Thomas, US Virgin Islands.

In Belize, the Pink Hibiscus Mealybug (PHMB) Control Programme introduced *C. montrouzieri* from a commercial source in the USA in October. Releases of *A. kamali* began the same month, through a cooperative effort between the Belize Ministry of Agriculture and Fisheries, CABI Bioscience and IICA (Inter-American Institute for Cooperation). USDA-APHIS-PPQ also assisted with introduction of parasitoids, supplying strains of *A. kamali* from China and Hawaii, and *G. indica* from Egypt. It also provided technical assistance for in-country rearing of *A. kamali* and field studies, and conducted a number of training courses. By March 2000, nearly 27,000 *A. kamali*, 5800 *G. indica* and 20,000 *C. montrouzieri* had been released. An insectary facility has been established in Belmopan and field insectary sites have also been established to facilitate redistribution of field-collected parasite material.

The results of field studies conducted in Belize City by the Belize PHMB Control Programme and USDA indicated that *M. hirsutus* field densities at study sites decreased 93.1% in less than four months as a result of the natural enemy introductions. These results mirror findings from elsewhere in the region. In St Kitts & Nevis, where natural enemies were first released in 1996, population densities were reduced by 91.6% over a seven-month period, and a 94% reduction was maintained through to 1998. In St Thomas and St Croix (US Virgin Islands), there were reductions of 86.7% and 95.2%, respectively, in the seven months to February 1998, and a population reduction of 88% in the six months to November 1998 was recorded in Puerto Rico following natural enemy releases. *Maconellicoccus hirsutus* was first recorded on the north-eastern end of Puerto Rico at the end of April 1998, but has not yet spread across half of the island. It is probable that biological control is playing a part in slowing its spread, as 80% of newly reported *M. hirsutus* infestations are already attacked by the exotic natural enemies. By suppressing populations of the invading mealybug, the natural enemies are preventing an explosive advance towards the western end of the island. Both *A. kamali* and *G. indica* have been released by USDA in all the above countries; *A. kamali* is the dominant species.

Training, technology transfer and clear planning procedures are crucial to the success of *M. hirsutus* control programmes, and early identification of the infestation is important, before it spreads. The rapid deployment of natural enemies in affected countries has been made possible through the high degree of cooperation between stakeholder organizations and governments. For example, Belize is the only country in Central America to have found *M. hirsutus* so far, and this was through an active annual surveillance programme. The Belize government has invested since 1996 in training its personnel in the identification, field recognition and management of *M. hirsutus*. It also ensured that a task force (emergency group) was formed specific to *M. hirsutus*. Due to the formation of this group, implementation of an emergency action plan was immediate and comprehensive. The pest was detected on Friday 24 September 1999, and was identified the same day. By the following Monday, just 3 days later, an emergency action plan was presented to the Ministry. This included public awareness, internal quarantine, surveillance, eradication (cut and burn) and biological control (insectary provision and field releases of exotic agents). The first natural enemies (*C. montrouzieri*) were released on 13 October, and releases of *A. kamali* began 5 days later. In-country expertise was enhanced by a one-day workshop on technology transfer, which was held in Belize in November 1999 by USDA-APHIS-PPQ. A 6-day mealybug identification workshop in March 2000 was run with funding/collaboration from OIRSA (Organismo Internacional Regional de Sanidad Agropecuaria), the Belize Ministry of Agriculture and Fisheries, USDA-APHIS-PPQ and CABI Bioscience. A second 3-day technology transfer workshop for the biological control of *M. hirsutus* will be held in June 2000 in Belize.

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Parasitoids Island-Hop Too

Gyranusoidea indica, the Egyptian parasitoid first introduced into the Caribbean in St Kitts with assistance from USDA-APHIS (US Department of Agriculture – Animal and Plant Health Inspection Service), was recently discovered in Trinidad, identified by Dr John Noyes of the Natural History Museum, London (UK). *Gyranusoidea indica* has been deliberately released in St Kitts & Nevis, the US Virgin Islands, Puerto Rico, Grenada and perhaps in some islands of the Netherlands Antilles for control of *Maconellicoccus hirsutus* (the hibiscus or pink hibiscus mealybug – HMB or PHMB), but has not been deliberately introduced into Trinidad. In view of this, one can only speculate about how it came into the country. However, it seems feasible that it may have been accidentally introduced on *M. hirsutus*-infested plant material. Such fortuitous introductions are not unknown. For instance in Curaçao, *Anagyrus kamali* appears to have been introduced together with the pest. *Gyranusoidea indica* has been recovered from material collected in central and north-east Trinidad, but it appears likely that it may be more widespread. The distribution of the parasitoid will be assessed in forthcoming surveys by the Ministry of Agriculture, Land and Marine Resources, Trinidad & Tobago.

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Second Mealybug Invader

Paracoccus marginatus, the papaya mealybug, is a polyphagous species native to Mexico and some countries in Central America. It was first reported from the West Indies from St Martin (French West Antilles) in May 1996 and has since then been reported from other Caribbean countries (Antigua, Cuba, Dominican Republic, Guadeloupe, Haiti, Monserrat, Puerto Rico, St Kitts & Nevis, British Virgin Islands, US Virgin Islands and St Barthélémy) and the USA (Florida). *Paracoccus marginatus* will attack *Hibiscus* and a wide range of other plants, but prefers papaya; *Maconellicoccus hirsutus* (hibiscus or pink hibiscus mealybug – HMB or PHMB) will attack a wide variety of hosts but prefers *Hibiscus*. The damage *P. marginatus* causes is similar to that of *M. hirsutus*, but although the species are superficially similar, in the field they differ in body colour when squashed on paper – *P. marginatus* is yellow whereas *M. hirsutus* is pink. The species can be distinguished relatively easily once examined as microscope slide mounts (*M. hirsutus* has nine antennal segments, while *P. marginatus* has only eight) [*BNI* **19(3)**, 72N-73N (September 1998)].

A joint cooperative programme has been developed between the Inter-American Institute for Cooperation (IICA) and USDA-APHIS-PPQ (US Department of Agriculture – Animal and Plant Health Inspection Service – Plant Protection and Quarantine) in order to implement a biological control programme against *P. marginatus* in the Caribbean. A technical meeting and workshop is tentatively scheduled for September 2000 in St Kitts & Nevis sponsored by IICA and USDA-APHIS-PPQ. The status of this pest in the Caribbean will be discussed and strategies developed to survey for its presence in other Caribbean countries. In addition, strategies will be developed to survey for existing natural enemies attacking *P. marginatus* in known infested countries and for the release of exotic parasites from Mexico. Up to now, four genera of parasites of *P. marginatus* have been collected from Mexico that have potential for releasing in the Caribbean: *Anagyrus* spp., *Apoanagyrus* spp., *Acerophagus* spp. and *Pseudaphycus* spp. The first three genera have representative species already in culture in St Thomas, US Virgin Islands and await release and field evaluation. Presently, targeted releases are being planned for the US Virgin Islands, Puerto Rico, Dominican Republic and St Kitts & Nevis.

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Paracoccus marginatus *in Cuba*

Paracoccus marginatus was described as a new species from specimens collected on cassava in Mexico and papaya in Belize, but it has since become evident it is highly polyphagous. It is common in Central America where it causes significant damage to cassava. In Cuba, it was found for the first time in cassava and papaya in January 1999 in Oriente Province in the east of the island during a survey conducted under the National Program for the detection of *Maconellicoccus hirsutus* (hibiscus or pink hibiscus mealybug – HMB or PHMB).

The mealybug was also found on a wide variety of other plants: mango, pomegranate, cherry (*Eugenia uniflora*), orange, pineapple, tomato, aubergine/eggplant, sweet pepper (*Capsicum annuum*), beans (*Vigna* sp., *Dolichos lablab, Hebestigma cubense, Cajanus cajan* and *Phaseolus* sp.); cotton, *Acalypha* sp., *Annona muricata*, *Manilkara zapotilla, Solanum torvum, Solanum nigrum, Erythrina* sp., *Bidens* sp., *Ligustrum* sp., *Pluchea odorata, Hibiscus* spp., *Cordia* sp., *Jatropa* sp., *Guasima tormentosa, Cordia alba, Dahlia pinnata* and cocoa.

Abundant populations were observed attacking the above-ground parts of the plants, and these produced symptoms of deformation and early fall of fruit, yellowing, and leaf curl. The symptoms were particularly evident in plants in the genus *Hibiscus* and were similar to those produced by *M. hirsutus.*

Although no economic damage has been observed on major crops so far, strict surveillance of this pest will continue in Cuba because of its recent introduction and highly polyphagous nature.

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Citrus Blackfly Biocontrol for Trinidad

The citrus blackfly, *Aleurocanthus woglumi,* (CBF) is an important pest of citrus in many parts of the world. A native of Asia, it was first reported in the Caribbean from Jamaica in 1913 and subsequently spread to many other countries in the Caribbean as well as mainland North, Central and South America. In recent years, damaging populations of CBF have been reported from Dominica and the pest has extended its geographical range, with new country records being reported for St Kitts & Nevis and St Lucia. In Trinidad, CBF was first collected in 1997 in the Port of Spain area. Over the past two years, it has spread rapidly, initially on citrus and other plants in backyard gardens, but more recently into areas of commercial citrus production. This rapid spread is attributable to a lack of effective, host-specific natural enemies.

CBF has the potential to cause severe losses in fruit production. Even infestations of short duration can reduce production by as much as 50%, and losses in citrus have been estimated to range from 25% to almost complete crop failure. Citrus is an important commercial crop in Trinidad & Tobago. Total area under cultivation is estimated at 5000 ha, with 1200 ha under Caroni (1975) Ltd and the remaining 3800 ha held by small farmers. Citrus contributes nearly 4% of the total GDP from agricultural produce, valued at TT$23.4 million [approx. US$3.74 million]. The advent of the CBF is therefore a source for serious concern.

In all countries where CBF has been accidentally introduced, biological control using parasitic wasps has proven to be the most economical, long-term and sustainable method for its control. Two natural enemies that have been responsible for the control of CBF at most locations are *Amitus hesperidum* and *Encarsia perplexa* (= *E. opulenta*). The prospects for successfully controlling CBF in Trinidad using these natural enemies are therefore very promising. Towards this end, the Ministry of Agriculture, Land and Marine Resources (MALMR), Trinidad & Tobago, is funding a project aimed at the implementation of biological control. On behalf of the MALMR, CABI Bioscience is undertaking the introduction of *A. hesperidum* and *E. perplexa*. Natural enemies are being procured from Florida with the assistance of Dr Ru Nguyen, Division of Plant Industry, Department of Agriculture and Consumer Affairs.

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Locust Control: Europe Learns from Africa

Everyone knows that Africa suffers periodically from plagues of locusts, but it is not common knowledge that Europe has locust problems too. Now experience gained during the nine-year LUBILOSA programme (LUtte BIologique contre les LOcustes et les SAuteriaux) to develop Green Muscle™ in Africa is to be used to develop a mycoinsecticide for Europe, and this will be the key element in reducing the environmental impact of the locust control operations in Europe and beyond.

Locusts and grasshoppers are key pests in several parts of Europe and the neighbouring regions. The Moroccan locust, *Dociostaurus maroccanus*, has been recorded as an important pest of pasture and crops in Spain for several centuries. Total area affected in the provinces of Extremadura, Ciudad Real and Zaragoza exceeds 500,000 ha. Outbreaks of *D. maroccanus* also occur in other Mediterranean areas such as southern Italy, Crete, Sardinia, Morocco, Algeria and Turkey, as well as parts of eastern Europe and the former Soviet Union. Indeed, states such as Kazakhstan, Uzbekistan and Turkmenistan are currently suffering major invasions of locusts covering literally millions of hectares. The Italian grasshopper, *Calliptamus italicus*, assumes pest status in France, Spain and Italy, and many hundreds of thousands of hectares are sprayed each year in Russia for control of both this species and the white-striped grasshopper, *Chorthippus albomarginatus*. Future changes in rainfall patterns due to global climate change together with changes in land use may well exacerbate the problem further.

Chemical insecticides have to-date provided the only means for ensuring wide-scale control of locust and grasshopper outbreaks. This is exemplified by the situation in Spain where, in an average year, many thousands of hectares are treated with the broad-spectrum organophosphates malathion and fenitrothion, and this often in areas of major conservation value. The widespread use of such chemicals and their associated detrimental effects on the environment, combined with the hazard they represent to users and livestock, remains a major drawback to continued reliance on their use. Particular concerns arise since many of the outbreak areas occur in unique steppe ecosystems of substantial importance for biodiversity (e.g. the Cabaneros National Park in Spain and Gargano National Park in Italy). Interestingly, the locust problem in the Gargano National Park is a result of EU set-aside policies, which have led to substantial areas of cultivated land being returned to uncultivated pasture. This has created greater opportunities for locust populations to breed. Both traditional and new chemicals currently in widespread use for locust and grasshopper control are classified as harmful to key non-target invertebrates, highly toxic to key crustaceans, or harmful to indicator vertebrate fauna such as lizards and birds. There is clearly a need for alternative forms of control to chemical insecticides.

'Protecting Biodiversity through the Development of Environmentally Sustainable Locust and Grasshopper Control' (ESLOCO) is a new project funded by the European Union through EU Framework V – Quality of Life and Management of Living Resources. Its aim is to reduce the environmental impact of locust and grasshopper control operations through the development of a new environmentally sustainable strategy, based on the use of a mycoinsecticide. The mycoinsecticide, Green Muscle™, which is based on a natural entomopathogenic fungus, *Metarhizium anisopliae* var. *acridum*, has been developed and tested in Africa through the LUBILOSA programme where its safety and efficacy are proven. However, the capacity to produce and use this new technology effectively in Europe does not exist. The ESLOCO project will create this capacity, so providing immediate benefits for biodiversity and, additionally, creating new opportunities for exploiting microbial agents for control of other pests. The project is led by CABI Bioscience in partnership with Imperial College (London), the University of Cordoba (Spain), the University of Bari (Italy) and two commercial companies, NPP (France) and Aragonesas Agro (Spain).

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Metarhizium *Biopesticides Registered in Australia*

BioCane™, Australia's second *Metarhizium*-based biopesticide was launched on 2 May 2000 in Bundaberg during the Australian Association of Sugarcane Technologists conference. The active ingredient is viable conidia of *M. anisopliae* var. *anisopliae* isolate FI-1045 (from Richard Milner's CSIRO Insect Pathogen Culture Collection; see review article, this issue) effective against the greyback canegrub, *Dermolepida albohirtum*, Australia's most serious insect pest of sugarcane. It was fully registered by the Australian National Registration Authority on 24 March 2000 and is expected to go on sale for the forthcoming sugarcane planting season starting in July 2000.

The product consists of rice granules, 1-2 mm in diameter, on which the *Metarhizium* fungus has been grown. It is applied to the plant crop using existing granule applicators developed for applying granules of chlorpyrifos. The material contains at least 2×10^9 viable conidia/g and the recommended rate is 33 kg/ha. At this rate, it is expected to cost less than the standard chemical. Extensive testing over the last few years by the Bureau of Sugar Experimental Stations, in collaboration with CSIRO and the manufacturer, BioCare Pty Ltd, funded by the Sugar Research and Development Corporation [see *BNI* **19(1)**, 5N (March 1998)] has shown that at the recommended rate the fungus provides over 50% grub control in the season of application. The conidia have been shown to persist for at least three years following application to sugarcane and the original application is augmented by natural sporulation in infected grubs, thus providing medium- to long-term control.

BioCane™ is expected to gain rapid acceptance in the rich Burdekin sugar-growing region of Queensland where recent field trials have given consistently good results and there are serious problems with alternative methods of control. A total of about 16 tonnes of product have been applied, mainly in commercial field trials, over the past three seasons. The main target pest is the greyback canegrub, a univoltine scarab, the larvae of which feed on the roots of sugarcane severely reducing the yield of sugar. Further research is currently looking into other strains of *Metarhizium* effective against related genera of canegrubs.

Meanwhile, another strain of *Metarhizium*, FI-985 (CSIRO Insect Pathogen Culture Collection), is being commercialized by SGB Australia Pty Ltd, under the name Green Guard™ and has recently been granted a 'minor use permit' by the National Registration Authority to enable it to be used operationally on organic properties by the Australian Plague Locust Commission (APLC). It is currently being used in this way for the first time to assist the control of a major locust outbreak in South Australia. At the time of writing (14 April) it has been applied to 15 km^2 and the final area treated is expected to be considerably greater. It is being applied at the rate of 1×10^{12} conidia in 500 ml oil per hectare.

Richard Milner, the CSIRO project leader, says that mycoinsecticides offer substantial advantages over chemical pesticides in terms of reduced hazard to users and the environment. He points out that they have known for some time that *Metarhizium* is highly effective against locusts and wingless grasshoppers, but their recent focus has been to develop consistency in the product and to lower the production costs, in turn making Green Guard™ not only more effective, but affordable.

Jim Cullen, the CSIRO Entomology chief, says that the adoption of GreenGuard™ is excellent news for beef and veal producers, particularly organic certified growers exporting to the highly sensitive Japanese market, which is worth around Au$1.3 billion or 45% of the total value of Australia's beef and veal exports. Three species of locust (plague, migratory and spur-throated) inflict widespread and severe damage to pastures, cereal crops and forage crops. Preventative control undertaken by the APLC is effective in preventing large-scale crop damage, which can amount to many millions of dollars without effective control. In the last serious outbreak of the Australian plague locust in 1984, crop losses prevented by locust control were estimated by the APLC to exceed $100 million. Cullen points out that until now only chemical pesticides were available for plague locust control, and that these pesticides can make their way through the food chain into beef products. He reminds us that previously Japan has rejected containers of Australian beef with even very low levels of residual pesticides.

Graeme Hamilton, Director of the APLC is particularly pleased that the results from the field trials have shown successful control of the insects and have enabled the team to fine-tune the effective field doses. This has resulted in a lower dose and reduced the volume of spray per hectare, substantially reducing the overall cost. He notes that CSIRO's commercial collaborator SGB Pty Ltd (part of the IAMA group of companies) has completed a new production facility, and that material produced by them has been shown to be very effective in the field.

A recently signed exclusive deal between SGB Pty Ltd and CSIRO Entomology will fund further R&D on Green Guard™ and other research on products for use against termites and in horticulture. Insect-specific fungal diseases are important in natural control of insects. *Metarhizium* is a naturally occurring fungus which is common all over the world and affects only insects. Tests in Australia and overseas have shown it to be is harmless to humans, plants and animals.

Information:
http://www.ento.csiro.au/research/biotech/biot07.htm
http://www.ento.csiro.au/publicity/pressrel/1999/15dec99.html
http://www.affa.gov.au/aplc/

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Rubber Stamp for IT Pioneer

When CABI's *Crop Protection Compendium* was awarded the Pirelli INTERNETional Environment Award in Rome this April, the CD-ROM product was commended for "its extraordinary value in supplying science-based information for the protection of worldwide food resources, with a special emphasis on sustainable development in Third World countries". This accolade signals the successful pioneering of an idea that began more than ten years ago with the recognition of the significance of information provision for agricultural development.

Back in 1989, an international workshop on information needs for crop protection, run by CAB International (CABI), FAO (the Food and Agriculture Organization of the UN) and CTA (the Technical Centre for Agricultural and Rural Co-operation) recognised that scarcity of information was a serious constraint to progress throughout the developing world, and particularly in agriculture. They foresaw that information technology would allow more efficient delivery, and came up with an imaginative idea of how this could be achieved so that the benefits would be felt particularly in developing countries, where the dearth of information was greatest. Over the next ten years CABI, first in collaboration with ACIAR (the Australian Centre for International Agricultural Research), and subsequently with the backing of a Development Consortium of some 40 private and public organizations worldwide, and in consultation with potential users, developed the relational database system in a multimedia application that became the *Crop Protection Compendium*.

The *Compendium* is a unique, authoritative, comprehensive resource that brings together a wide range of information on pests, diseases and weeds and their natural enemies of worldwide or regional importance, together with information on their crop hosts and the countries where they occur. This factual core of information is complemented by utilities that allow users to interpret data. While the sheer quantity and quality of information gave the *Compendium* excellence, it was the linkages between different kinds of information that made it a pioneer and, ultimately, so successful. Long before 'hyperlinks' had become a slick way to navigate through cyberspace, the development team for the *Compendium* had invented the 'soft link', which allowed users to flip between different parts of the database in just the same way but 'on the fly', and so created a powerful knowledge base. This has a multitude of uses: for analysing patterns and trends, aiding research and decision-making, and preparing briefs, proposals, presentations and training material.

The Global Module of the *Crop Protection Compendium* was launched in mid 1999, and the 2000 edition will cover 1550 pests, diseases, weeds and natural enemies in detail (and include outline data for 10,000 more). There is also data for more than 170 crops and 150 countries. It provides text, pictures, maps, databases, economic data, statistics, bibliographic data, diagnostic keys, taxonomic information and other components of a portable library and decision-support system, presented so as to facilitate retrieval and interaction.

Currently available on CD-ROM, work is underway to migrate it to the Internet in the latter part of 2000. The CD version is already in use in more than 60 countries. The *Compendium* is updated regularly and development of new ideas continues. Currently the team is enhancing the product in two other priority areas: plant quarantine and economic impact of pests. The annual subscription costs US$300 in a developing country, and $1200 in an academic or research institution in the developed world.

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CABI Bioscience News on the Web

The CABI Bioscience website at:
http://www.cabi.org/bioscience/index.htm
has undergone a make-over. It now provides up-to-date information on its projects around the world, together with press releases and monthly news items. Recent stories at the time of writing (April) highlighted:

Beetles Hit at Any Age

Parasitoids are fussy beasts usually, and not least over the stage of the host that they will attack. However, a new species of the braconid genus *Perilitus* has been discovered in Zambia that parasitizes both larval and adult stages of the sesbania leaf beetle, *Mesoplatys ochroptera*. The leaf beetle has recently become a serious pest of *Sesbania sesban*, the nitrogen-fixing tree that is being widely adopted by farmers in short-rotation planted fallows for soil fertility improvement in southern Africa. The new *Perilitus* species and its unusual life history were discovered during a study of the beetle's natural enemies in Zambia by Marc Kenis (CABI Bioscience) and Gudeta Sileshi (ICRAF/ICIPE – International Centre for Research in Agroforestry/International Centre for Insect Physiology and Ecology) under a DFID (UK Department for International Development) project.

Stuck for a Fungal Name?

No need to be! The database of names of fungi maintained by CABI Bioscience has gone 'live' at:
http://194.131.255.3/cabipages/
The database, which has been contributed to by many mycologists from around the world, started life as just a list of names, but is now including more and more taxonomy. Information on families and higher ranks will follow in the next few months. For a small but gradually increasing subset, there is real taxonomic information that allows users to ascertain whether the name they are checking is the preferred one or a synonym, and for a smaller subset there are complete taxonomies for genera, families, orders or classes.

New Wave to Hit Water Hyacinth

The Danish International Development Agency (DANIDA) has committed US$2 million for the research and development phase of an international programme to develop a mycoherbicide for water hyacinth (*Eichhornia crassipes*) control. Led by CABI Bioscience with collaborators from the UK, Kenya, Benin, Egypt, Zimbabwe and South Africa, the programme was launched at a workshop in Cairo in March 2000 and will focus initially on Africa. Although insect agents have had an effective impact in some cases, for example in the tropical and eutrophic conditions of Lake Victoria [see *BNI* **21(1)**, 1N-8N (March 2000)], water hyacinth remains an intransigent problem in other regions and climates. The programme aims to complement insect agents with a fungal ally, and will work with national programmes to isolate and identify suitable fungal pathogens. The mycoherbicide programme is also contemplating shortening the timescale of biological control of water hyacinth. Even on Lake Victoria, control by the insects took 2.5-3 years to achieve. A mycoherbicide could potentially begin to exert control in a matter of weeks.

Key to the successful development of the mycoherbicide will be rigorous testing of isolates for virulence and potential to control water hyacinth, human and environmental safety, and suitability for mass production and storage. The efficacy of different formulations will be assessed in the field. Opportunities for commercialization and registration procedures in water hyacinth-affected countries will also be addressed.

Developing Capabilities to Develop Biopesticides

Many developing countries face a pressing need to develop safe commercial-scale alternatives to chemical pesticides. Biopesticide development has been identified as one avenue worthy of following, but this requires specialist expertise and facilities. The International Biopesticide Consortium for Development has been established to deliver to developing countries the training and technology that biopesticide development requires. The members of the consortium include CABI Bioscience, IITA (the International Institute for International Agriculture, Cotonou, Benin), NRI (National Resources Institute, Chatham, UK), BBA (Federal Biological Research Centre for Agriculture and Forestry, Darmstadt, Germany) and PACE Consulting (San Diego, CA, USA). It aims to make appropriate training and facilities available to national sustainable agriculture programmes and small-scale enterprises to help them develop, produce, commercialize and use biopesticides effectively. By providing technical support and access to a range of expertise through the whole product development process, the consortium aims to equip countries with the tools they need to tackle food production problems in a cost-effective and environmentally friendly way.

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IPM Systems

This new section replaces the 'Biorational' section, but will essentially cover the same topics – integrated pest management (IPM) including biological control, and techniques that are compatible with the use of biological control or have little impact on natural enemies.

Commercialization of Neem in East Africa

The neem tree, *Azadirachta indica*, called 'mwarubaini' in East Africa, has long been known for its medicinal and pesticide properties. The potential use of the various tree components as natural pesticides has been intensively researched worldwide in the last twenty years. Neem-based pesticides are environmentally friendly and able to control a wide range of pests without leaving dangerous residues. Pesticides formulated on neem are being widely used in India. Elsewhere, particularly in Australia, Germany, the USA and some countries in Central and South America, researchers are also working intensively on formulating neem-based pesticides. As a result, many neem-related products for pest management are available on the market in some countries.

In Africa, neem is a valuable shade and fuelwood tree. Knowledge of neem's efficacy as a traditional medicinal plant is widespread in East Africa. Indeed, it is claimed to cure 40 different diseases, hence its local name, mwarubaini (arubaini is Kiswahili for 40). In contrast, its potential for use as a natural pesticide is little known in the region. Home-made pesticides, using the leaves and seeds, have been considered an attractive option, especially for resource-poor farmers. However, the acceptance of this approach has been low. Major problems hindering adoption of neem by growers include poor dissemination of neem-related knowledge, and the fact that in those regions where neem could be used successfully, such as vegetable growing areas, there are either not enough neem trees or none at all. Other constraints to its use are labour intensity and storage problems.

For the use of neem-based pesticides to be successfully promoted among small-scale farmers in Africa, it is essential that formulations become available on the local market at competitive prices. This could be achieved if the products can be locally processed using seeds collected by farmers. To assess the possibilities for this, two feasibility studies were undertaken by the GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) IPM Horticulture Project (IPMH) in 1994-95 in Kenya. Based on climatic classifications, these studies estimated that over 25% of the land in Kenya is suitable for growing mwarubaini. The tree is currently found in Kilifi, Lamu, Mombasa and Taita Taveta districts in Coast Province as well as the semi-arid areas of north-eastern Kenya. It was therefore judged as worthwhile to establish a small industry to process the mwarubaini seeds and to formulate suitable products for sale on the local market.

In mid-1996, ICIPE (the International Centre for Insect Physiology and Ecology) received a research and development grant from GTZ to undertake the development of a small-scale industry of mwarubaini-based insecticides. The aim of this project was to produce simple, standardized, mwarubaini-based pesticides, which could be purchased on the local market at competitive prices. The processing, formulation and standardization of the mwarubaini-based pesticides as well as efficacy tests were carried out simultaneously. The work was carried out by the GTZ-IPM Horticulture Project in collaboration with ICIPE and SAROC Ltd, a local pesticide manufacturer.

To date, four formulations of extracts from mwarubaini seeds have been issued a preliminary certificate of registration by the Pest Control Products Board of Kenya and are available for commercial use. These products have proved to be effective against important pests of horticultural crops such as the black aphid on French beans, cabbage aphids, diamondback moth, leafminers, caterpillars and root-knot nematodes. In addition, they have given good control of aphids, whiteflies and bollworms in tobacco. Furthermore, a remarkable development of natural enemies has been observed after long-term applications of mwarubaini-based insecticides, which have led to reduced applications of pesticides. In addition, the project created an alternative income generation through seed collection, especially in areas of marginal agricultural activities.

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By: Brigitte Nyambo

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Indian Cotton IPM is Material Success

Encouraged by consistent success in field trials in earlier years [see *BNI*, **20(2)**, 56N-57N (June 1999)], the Indian National Centre for Integrated Pest Management (NCIPM) chose the village of Barad in the Nanded district of Maharashtra as the setting for a 200 ha village-scale validation trial for its cotton IPM module. More than nine million ha of land in India is planted each year with cotton, but although this represents some 5% of cultivated land, 52% of pesticides applied to crops in India are used on cotton. The NCIPM has been developing IPM modules for dryland cotton for some years to provide farmers with alternatives to such high pesticide use. The Centre has a mandate to develop and promote IPM technologies for major crops in India, to sustain higher yields with minimum ecological implications.

The IPM module combines need-based use of crop protection measures with appropriate crop management practices, which have been refined over the course of several years' smaller scale field trials. Certified acid-delinted seed was treated pre-planting with imidacloprid at 7 g/kg seed. Planting was synchronized, rather than staggered over a month, just after the onset of the monsoon rains. Only one hybrid (NHH-44) and one variety (RENUKA) were used, and these were planted at spacings of 90 × 60 and 60 × 30 cm, respectively. Maize and cowpea were grown as a border intercrop to augment coccinellid and other beneficial insect populations. *Setaria* was planted between every 9th and 10th row of cotton to provide perches for predatory birds and so lure them into the crop. Crop protection measures included releases of biocontrol agents, and application of *Helicoverpa armigera* NPV (HaNPV) and botanicals; applications were based on the economic threshold levels (ETLs) of the pests, and their populations were monitored by scouting and monitoring using pheromone traps. A typical farmer made two releases of the egg parasitoid *Trichogramma chilonis*, 15 days apart, following the appearance of *H. armigera* moths in the traps, and 2-3 applications of farmer-produced 5% neem seed kernel extract which also controlled other bollworms. If *Helicoverpa* populations continued to rise, one application of HaNPV would be made.

The worth of the imidacloprid treatment was proved when emerging seedlings in the non-IPM treatment were subjected to heavy millipede attack in the heavy monsoon rains, and the crop had to be replanted. Field sanitation and acid-delintation in the IPM treatment contributed to the suppression of most seedling diseases to low levels. Foliar disease was restricted to early growth stages (when the adopted crop architecture led to an unfavourable microclimate). A grey mildew disease caused by *Ramularia areola* became severe, but no fungicide was necessary at the dehiscence stage. However, heavy rain led to severe boll rot, which was attributed to a number of pathogens.

The pest insect population, which was monitored in IPM and non-IPM fields, included jassids (*Amrasca bigutulla*), aphids (*Aphis gossypii*), thrips (*Thrips tabaci*), whitefly (*Bemisia tabaci*) and several species of bollworm (spotted bollworm, *Earias insulana*; pink bollworm, *Pectinophora gossypiella*; American bollworm, *Helicoverpa armigera*). The populations of sucking pests were low in IPM fields compared to non-IPM fields, and were controlled by the imidacloprid treatment for up to 50 days after planting. But much larger populations of insects (coccinellids and chrysopids) and birds (mynas, finches and blackjays) were recorded in the IPM fields, and these also contributed to suppression of these pests and the bollworms. In the IPM fields, jassid populations were less than two-thirds, and aphid populations less than one-third those in non-IPM fields. *Helicoverpa armigera* populations in IPM fields were half those in non-IPM fields and similar differences were found for *E. insulana* and *P. gossypiella*. In addition, parasitism by *T. chilonis* was found to be highest in fields with least chemical interventions.

The IPM module gave substantial reductions in insecticide use and gave higher net returns and yields compared with the conventional non-IPM farmers' practices used the previous year in the village. IPM inputs cost Rs 1545 (excluding labour) compared to Rs 3225 for conventional inputs. The average seed cotton yield with the IPM module was 962.5 kg/ha, more than four times the previous year's average yield of 220 kg. The cost benefit ratio of IPM over conventional farmers' practices exceeded 1:15. However, the most important achievement of the project is argued to be an extraordinary reduction in pesticide use, from 9.28 to less than 0.03 kg/ha. Villagers not only saw better yields and higher net returns, but began to see the improvements an IPM approach brought to the environment as birds began to nest in the cotton ecosysytem.

This is just one of many IPM modules being developed by the NCIPM showing encouraging results in the last year. In Uttar Pradesh, for example, an IPM module for basmati rice was evaluated in trials covering an 8.5-ha area. Mean yields of 4.771 t/ha were recorded, compared to 3.628 t in plots under chemical control treatment and 3.628 t in farmers' practice plots. Here, leaf folder and stem borer were the commonest pests, while sheath blight and blast were the worst diseases. Substantial improvements were made to the website for IPM in this crop, and socioeconomic surveys added to knowledge about basmati rice growers' problems and concerns. Progress is also being made with IPM modules for mustard, chickpea and pigeon pea. The Centre's key work in forecasting systems continued for *Helicoverpa* and potato aphid (*Myzus persicae*). They also assessed the threat to Indian crops from exotic pests and diseases, and a study was made of nematodes and their management in rice and wheat. Training is a key function of the centre, and it ran field days, Farmer Field Schools, a Master Trainers Training Programme, training in cotton IPM for industry personnel, and an IPM workshop under NATP (the National Agricultural Technology Group).

Information:

NCIPM (1999) Annual Report 1998-99. New Delhi, India; National Centre for Integrated Pest Management, 80 pp.
NCIPM (1999) *NCIPM Newsletter* **5(1)**, 4 pp.

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Delivering Biocontrol: Identifying Bottlenecks

An elegant biocontrol solution to a crop pest or disease may look good on paper and make an impressive conference presentation, but IPM is a practical and knowledge-intensive subject. If farmers don't adopt the technology, it's a might-have-been, and not a success.

Over the past twenty years, IPM has become a preferred and widely implemented methodology in crop production, but whereas in the 1970-80s IPM was based on research-driven technology with farmers the uninvolved beneficiaries, today, as IPM spreads, farmers are developing their own local solutions and look increasingly to researchers for technologies to test and incorporate. This demand is likely to increase as farmer-participatory IPM methods spread, but can it be met? The development of practical and economical biocontrol technologies has progressed more slowly than anticipated. The multinational crop protection industry has not found them economical to develop and smaller more local enterprises have received virtually no incentives. Biocontrol technology development is generally assumed to have presented a number of common obstacles for small enterprises, although how far these difficulties are real, or widespread, has not been fully investigated. These include:

- Developing products to meet high performance standards.
- Achieving good product quality with inherent safety and efficacy implications.
- Achieving adequate market penetration and product distribution.
- Competing effectively with agrochemicals.
- Operating within an unfavourable regulatory environment.

Stakeholders are beginning to address how far such obstacles really limit delivery of biocontrol technologies in developing countries and, if they do, how the constraints and barriers can be removed. As part of this process, UNEP and CABI have initiated a series of case studies* to consider critical issues in the delivery of biocontrol technology to IPM farmers. These are preliminary and small-scale studies, and their findings should be considered in this light. However, they do attempt to bring a multidisciplinary and delivery-focussed approach that addresses technical, economic, education and farmer related perspectives. The first three case studies cover:

- The use of the egg parasitoids *Trichogramma* spp. for control of lepidopterous pests of sugarcane, rice, cotton and vegetables in Tamil Nadu and Karnataka in southern India.
- The delivery of biopesticides based on the fungi *Beauveria bassiana* and *Metarhizium anisopliae* for control of insect pests in coffee, vegetables and sugarcane in Nicaragua.
- The use of *Trichoderma* spp., fungal antagonists of a number of soilborne pathogens that attack field crops in Vietnam.

Food for Thought

The case studies summarize current government policy, industry structure, research and production, extension, distribution, training and farmers' views. Conclusions are drawn and recommendations made for each country covered, and more general conclusions and recommendations are drawn up from all three studies. Despite differences between countries and the specific biocontrol agents under consideration, some common constraints to the delivery of biocontrol technologies emerged.

Regulatory Framework

The need for a specific biocontrol regulatory framework, or exemption, or special status with regard to existing chemical pesticide regulations was recognised. Generally, biopesticide registration is similar to that required for chemical pesticides, and this can obstruct progress particularly for smaller would-be producers. In Vietnam, biopesticides are subject to conventional pesticide legislation.

In India, macrobiological control agents do not have to be registered, but biopesticides now have to be registered under the Pesticides Act under some circumstances: if farmers or cooperatives are producing biopesticides for their own use, there is no need for registration; if biopesticides are produced for commercial use by large (national or international) companies they have to follow registration requirements. In Tamil Nadu State in India, one NGO (VOICE Trust) has recently begun village-level production of *Trichogramma*, but faces uncertain, and at best fluctuating, demand through the year. Although initially donor-aided, VOICE Trust now needs to become commercially viable, so wants to diversify into other biological control agents and biopesticides. It argues that the recent legislation regarding biopesticide registration makes it difficult for a small commercial producer to meet registration requirements. This, it says, may prevent it from expanding into biopesticide (particularly microbial biopesticide) production, which would both increase product availability to smallholders and make the fledgling biocontrol business more secure through product diversification.

In Nicaragua, although the government supports IPM and biological control, there is no fast track registration procedure for biopesticides. Registration is expensive as well as lengthy. Small organizations can sell unregistered products to their members, but are unable to supply outside demand. Prospects for market growth are thus very limited and the biopesticide sector seems doomed to remain fragmented unless more appropriate biopesticide registration is facilitated. One farmers' association, the Miraflor Union of Agricultural Cooperatives (UCA-Miraflor), aims to register its product and use sales-derived income for improving production systems.

Production Capacity

Biological control agent production capacity often limits uptake of the technology. This is particularly striking in Nicaragua, where demand for biological control agents now far outstrips supply. There, biocontrol is still largely a development issue funded by international donors with sustainable agriculture and poverty alleviation goals. There is no commercial production, and biological control research and production are confined to universities, NGOs and farmers' groups. The Entomopathogenic Fungi Unit of the National Agricultural University (UNA) produces *Beauveria bassiana* (for coffee berry borer and for diamondback moth in cabbage) and *Metarhizium anisopliae* (for rice bug, sweet pepper weevil and sugarcane and pasture bugs) semi-commercially, using a solid substrate system based on rice. Products are not stored but are produced on demand. NPVs are also produced for lepidopterous pests in maize, vegetables and soyabeans. A number of NGOs also produce fungal biocontrol agents on a smaller scale. For example, the UCA-Miraflor supplies *B. bassiana* to its own members, but production is impeded by lack of laboratory facilities; the unit operates without electricity, and spore extraction, which involves lengthy sieving, is the key production bottleneck. Current demand for biological control (fungal and viral) products in Nicaragua comes mainly from smallholder farmers. This capacity has been generated largely through IPM training, which has built up a national network of enthusiastic and skilled extension staff and farmer groups engaged in experimentation. The growing organic coffee market is likely further to stretch biological control agent supply. The UCA-Miraflor sees the demand for *B. bassiana* from the organic coffee sector as an opportunity to expand their market beyond their own cabbage growers.

In India, national and state governments have been strong supporters of IPM and biological solutions to pest control for many years. In 1977, the All-India Coordinated Research Project (AICRP) on Biological Control was initiated to conduct systematic studies on natural enemies of crop pests and to utilize both exotic and indigenous natural enemies. The first private insectary, Biocontrol Research Laboratory, was established at Bangalore in 1981. A rapid proliferation of companies ensued, and there are now some 80 country-wide, producing predators (including ladybirds, lacewings, anthocorids and predatory mites), a variety of parasitoid species (notably *Trichogramma* spp. and strains), entomopathogens (including *Bacillus thuringiensis* formulations, viral products and fungal pathogens), plant disease antagonists (*Trichoderma* and *Pseudomonas* spp. and strains) and weed-feeding insects (for water hyacinth control). These commercial concerns also supply other inputs such as pheromone traps for lepidopteran monitoring and mating disruption, and plant products such as neem-based formulations. The companies supply end-users directly or through government agencies. Apart from these private concerns, states have their own mass production units, including sugar co-operative mills which supply natural enemies to farmers. In short, a vast array of biocontrol products is available in India, yet inadequate production is still identified as one of the major bottlenecks to IPM adoption.

In Tamil Nadu, the Central Plant Protection Station began to promote IPM in 1981. The importance attached to this mandate was reflected in its change of name in 1991 to the Central Integrated Pest Management Centre (CIPMC), one of 26 such government-supported centres in India. The centres produce augmentative biological control agents and biopesticides, which are used mostly in demonstration plots in farmers' fields set up to train extension officers and farmers in augmentative biological control techniques as components of IPM. Most commercially available *Trichogramma* is currently produced by private companies, and most is sold on to farmers through state extension services (subsidized at about 10-25% of the commercial cost). Mass production methods are well established and well tested. Although adoption in sugarcane is high and *Trichogramma* supply to this sector is reliable, poor product availability was identified as a significant obstacle to biological control adoption in other crops (predominantly cotton and rice and also vegetables). It was the opinion of almost all stakeholders (including researchers, NGOs, extension agents and commercial producers) that *Trichogramma* needs to be produced locally at village level if the two key constraints of product availability and quality assurance are to be overcome. This view is not new, having been first put forward in 1990 by staff of the CIPMC in Bangalore, Karnataka. However, the Indian Government has recently taken steps to deal with the perceived production bottleneck, announcing funding for the Departments of Agriculture of state governments to develop infrastructure to allow their biological control centres to increase the supply and hence use of augmentative biological control agents and biopesticides.

Vietnam has virtually no national biopesticide production capacity, so nearly all products are imported and their availability is limited. A number of institutions work on *Trichoderma* and although they are being looked to for larger scale production, researchers identify constraints to achieving this at all levels. Scale-up of production remains an issue and the institutes have no experience in the more commercial aspects of biopesticide development.

Product Quality and Shelf Life

Problems with product quality were found in all three studies (high levels of contamination, variable concentration of active ingredient, variation in viability, questionable shelf-life, etc.). In India, there is a striking difference between the situation in sugarcane, where *Trichogramma* has been used for internode borer (*Chilo sacchariphagus*) control for the last forty years, and other crops where the technology is newer. Although mass production technology is reliable, there is little quality control. The commercial producers sell mainly to the extension services, but a significant though minor part of the market is to the sugarcane industry. Biological control is encouraged and promoted by the sugar mills, and adoption rates amongst sugarcane growers are high. Uptake is much lower in other crops, and farmers report poor product quality as well as lack of availability. Equally, some production companies argue that with no direct customer contact they have no control over the supply process. They say that product quality suffers as a result, especially for a product with as short a shelf-life as *Trichogramma*. (*Trichogramma* does present particular problems. In contrast, NPVs can be stored in India at room temperatures for up to three months, and under refrigeration for up to a year. For NPVs, the major constraint is continuous large-scale production *in vivo* on specific insect hosts.) There does appear to be a failure by some companies to maintain quality standards, although in a competitive market it is expected that companies that do not supply good-quality products will fail as customers 'vote with their feet'. Recognising that a possible lack of self-regulation by some companies is causing a second major bottleneck to IPM adoption, the Indian government is considering enforcing strict quality parameters to protect the interest of end-users.

In Nicaragua, there is no national quality control body to oversee production standards. Quality control and monitoring are under-resourced and the relevant authorities lack necessary experience. Shelf-life is also a significant constraint, particularly for NPVs which need to be kept frozen until just before use. Most farmers do not have refrigeration facilities on their farms, let alone access to refrigerated transport, so although demand is high, the future of NPVs will be compromised unless formulation and storage characteristics of virus components can be improved.

In Vietnam, the regulatory authorities carry out quality control checks on chemical pesticides, but no such procedures are currently carried out for biopesticides. Farmers who purchase biopesticides (mainly imported *Bt* products) form their own opinions, based on experience, of the most reliable products and sources. Researchers included efficacy and shelf-life in the constraints they identified to developing large-scale production of microbial biopesticides.

Distribution Systems

Distribution systems for augmentative biological control agents and biopesticides are often limiting factors in product use. In India, the biocontrol industry acknowledges that it has a problem distributing direct to smallholder farmers, particularly given the short shelf-life of *Trichogramma*, and it also recognises that the state departments of agriculture have done a good job of promoting the use of biological control within IPM. Latterly, NGOs are also beginning to help. In Nicaragua, by contrast, there is no structured distribution system to reach the thousands of smallholders, and access to products is a key problem, with the exception of the UCA-Miraflor, whose members can either collect from the local town, or arrange a delivery within 1-2 days. NGOs and other IPM training projects have set up skeleton networks to supply biopesticides to some of their participating farmers; however, the cost of public transport and the time delay involved can be serious impediments to many smallholder farmers, especially coffee growers in isolated mountain areas.

Farmer Knowledge

Farmers often lack knowledge of biocontrol technologies, and in particular an understanding of the highly varied ecosystems within which such technologies have to perform. The case studies highlight the difference that training can make. In Vietnam, the government is a strong supporter of IPM and set up a successful National IPM Programme in 1992. Activities have included Training of Trainers, Farmer Field Schools and Participatory Action Research. Since 1998 the programme has been formally supporting local IPM movements to build a community IPM network that can provide a framework for nationwide IPM implementation. Farmers are currently evaluating *Trichoderma* under the IPM programme's participatory action research programme on disease management. However, the study identified a clear divide between IPM-trained farmers who are enthusiastic about biopesticide products, and non-trained farmers who are unfamiliar with biopesticide products. Amongst the latter group, there were concerns about the efficacy and speed of performance of biopesticides, and these reservations were largely based on a lack of understanding of how biopesticides work.

In Nicaragua and in the Indian sugarcane sector, where IPM training and a history of biological control, respectively, mean that farmers have a good understanding of the technology, there is great enthusiasm for biological control, the products are applied effectively, and the results are good. In other crops in India, by contrast, the technology is newer and farmers and extension staff are still learning how best to use biological control, aided by the strong commitment of the Indian government to IPM training. The Project Directorate of Biological Control (PDBC), Bangalore (established in 1993 by up-grading the AICRP on Biological Control) has since its inception provided training to scientists, entrepreneurs, agricultural officers of state and central agricultural departments and managers of private companies for the production, utilization and supply of quality natural enemies, and consultancy services are also provided. Since 1999, the Indian Council of Agricultural Research (ICAR)has established a Team of Excellence on Biological Control (funded by the World Bank) at PDBC, where two-month crop-based and six-month subject-based training is provided. With such a large farmer population to reach, their task is vast.

In Tamil Nadu, farmers report that problems with poor availability and poor quality of *Trichogramma* are compounded by a lack of understanding of augmentative biological control. The VOICE Trust suggests that the successful adoption of biological control needs a high level of farmer training and has developed special training curricula in biological control for farmers' field school graduates who are taught in small groups. In particular they suggest that farmers need to learn about augmentative biocontrol agents as living entities, their basic food and habitat requirements, and how to cater for these needs by providing alternative food sources/hosts. Explaining the importance of intercrops is seen as an essential component of IPM training, particularly in cotton and vegetables, to make the technique more sustainable. Unless knowledge and understanding is effectively conveyed to farmers, released agents may die on or soon after release, or migrate from the system.

Take-Away Messages

So which of the assumed problems outlined at the beginning of this article were found to be limiting adoption of biocontrol technologies in practice, and which weren't? There was certainly some variation in product performance. Some farmers were very happy with the biological control agents they bought, but others were not and some of these believed that local-level production could improve this. Although training had a major impact on the efficacy with which products were used, there seems to be a widespread lack of any quality control regulations for biological control agents on both local and national levels. Lack of quality control is affecting the long-term adoption of biological control in at least some cases. On the other hand, detailed, lengthy and costly procedures for registering biopesticides were identified as constraints to their development, particularly for small-scale producers, and simpler 'fast track' systems were commonly suggested.

Market penetration and product distribution were found to be key constraints in all three countries. Even where an effective distribution network had been established (e.g. in parts of India), drawbacks were identified by farmers. Interestingly, farmers there want to replace the commercial production and extension-led distribution system with a village-level production system. Nicaraguan biopesticide producers are discussing the pros and cons of either cottage-industry local production centres or large-scale industrial production, or whether a combination of both is desirable. However, and as highlighted in Nicaragua and Vietnam, limited production capability is at least as important a constraint to uptake of biological control and the growth of the sector.

The ability of biological control products to compete successfully with agrochemicals depends on a wide range of issues, including those dealt with above. In India, for *Trichogramma* at least, factors that may constrain uptake in the non-sugarcane sector include poor product quality and availability, and lack of farmer training in augmentative biological control. In Vietnam, there was a clear divide between IPM-trained and untrained farmers in their preference for biopesticides or conventional pesticides, but the biopesticide products were also considered to be too expensive and of variable quality. The development of a national biopesticide production capability is being hindered by lack of funding and local expertise. In Nicaragua, inadequate supply and poor distribution were the overwhelming problems in a farming sector that was keen to adopt IPM following effective training. However, complex regulatory procedures were identified as hindering the resolution of production and supply problems.

So, within the context of these studies, the obstacles identified at the outset were shown to be limiting the adoption of biocontrol technology to some extent, and two more key constraints were identified: production capacity and farmer training. In the general conclusion to the case studies, it is suggested that the following avenues might be explored to find a means of removing barriers to delivery of biocontrol technologies in developing countries:

- The impact and value of incentives on the availability and uptake of biocontrol products.
- How appropriate shelf-life and quality can be achieved, maintained and monitored.
- How necessary support, experience and information can be provided to national regulatory authorities.
- The economics of scale of biocontrol technology.
- Improving and maintaining farmer learning methods.
- Defining the role of farmer participation in the development and evaluation of new biocontrol products, and identifying the mechanism by which this can be achieved.

A workshop is planned for later this year to consider in depth how best to remove the barriers. Other studies by other stakeholders will doubtless come up with other findings. For example, further studies are under discussion to look at issues in India in greater depth. However, it is hoped that these preliminary studies will begin to contribute to a better understanding of the constraints to delivering biocontrol for IPM farmers, and to an eventual resolution of them.

Raj, D.; Hill, G. (2000) Delivery of biocontrol technologies to IPM farmers: India. UNEP/CABI Critical Issues Case Studies. Dent, D.R.; Gopalan, H.N.B. (*eds*) Nairobi, Kenya; UNEP, ix + 19 pp.

Jenkins, N.E.; Vos, J.G.M. (2000) Delivery of biocontrol technologies to IPM farmers: Vietnam. UNEP/CABI Critical Issues Case Studies. Dent, D.R.; Gopalan, H.N.B. (*eds*) Nairobi, Kenya; UNEP, ix + 29 pp.

Williamson, S.; Ali, B. (2000) Delivery of biocontrol technologies to IPM farmers: Nicaragua. UNEP/CABI Critical Issues Case Studies. Dent, D.R.; Gopalan, H.N.B. (*eds*) Nairobi, Kenya; UNEP, ix + 35 pp.

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Training News

In this section we welcome all your experiences in working directly with the end-users of arthropod and microbial biocontrol agents or in educational activities on natural enemies aimed at students, farmers, extension staff or policymakers.

Community Linkage for Whitegrub Management

The Chiapas highlands in Mexico are characterized by their indigenous communities of Mayan ancestry, and increasingly, the decline and poverty of their farming systems. Indigenous farmers traditionally grew a mixture of maize varieties in association with beans and they worked full-time on their farm, spending time observing and experimenting. In the last two to three decades, the economic situation and lifestyle of these communities have altered and many now are forced to look for off-farm employment to survive. They have shifted to farm practices which they see as less time consuming and more efficient, such as herbicide and insecticide application, burning of crop residues and monoculture of hybrid maize varieties, while abandoning many traditional cultural crop management methods.

The resulting trend is of soil impoverishment, loss of traditional cultivars, increases in pest incidence and a steady reduction in maize yields. Whitegrubs, in particular, have been encouraged by the changes in soil use and farming practice and are now held to be one of the main production constraints in maize, responsible for grain losses of up to 500 kg/ha. Many farmers carry out two manual weedings and up to three broad-spectrum herbicide applications, leaving the soil devoid of other vegetation. This practice leaves little but maize roots for whitegrubs to feed on, as well as provoking soil erosion. Lodging of maize plants is common in fields which have been burnt, ploughed and cleared of weedy species.

Researchers in the Department of Alternative Production Systems at the College of the Southern Border (ECOSUR) in the Chiapas highlands were aware that scant attention has been paid in Mexico to promoting linkages with smallholder farmers. As well as farmers being the supposed beneficiaries of IPM strategies, their knowledge could provide valuable information for IPM development. ECOSUR staff decided that if viable alternatives to current maize production in the Chiapas highlands were to be developed and implemented, it was necessary to work directly with farmers in a process of discussion and joint analysis. This process would require new methods and strategies for more effective interaction between farmers and researchers, in order to solve problems and support innovative rural development. In 1996, families from the *tzeltal* indigenous community in Amatenango del Valle requested ECOSUR's collaboration to solve their whitegrub problems and the village of El Madronal was selected for studies in farmers' fields and community activities. Most women in Amatenango make a living from pottery while their menfolk farm part-time, however, the women were very interested in improving maize production and the children take part in farmwork too.

The ECOSUR team began their work in the community by field walks and meetings with farmers using traditional maize–bean systems and modernized maize monoculture. The farmers discussed their recent changes in farming practice and the pressing need to reduce labour time, for instance, by burning maize stalks rather than digging them under, and abandoning the practice of earthing up young plants (which helps to develop a strong root system). The project was presented to farmers in a meeting after the initial field-walks, along with possible activities. Farmers and researchers agreed on methods for collaboration, with the latter promising to report back on research progress via participatory workshops. Season-long studies were carried out on nine irrigated and two rainfed farms to determine levels of damage caused by whitegrubs and to try and identify possible control options with the participating farmers. Simultaneously, bioecological information about the pest was collected and the local whitegrub complex identified. The history of use of each field was collected along with detailed management practices recorded throughout 1996, to draw up seasonal calendars. The researchers also sampled floral and insect diversity and whitegrub larval density on each farm.

In the Chiapas highlands there is a large guild of beetles which lives in the soil but only some from the melolonthid family feed on the roots of crops and cause typical whitegrub damage. Farmers know quite a lot about the whitegrub larval stage since it causes direct damage, but it became obvious from the field discussions that they were not aware of the lifecycle of the insect and its non-larval stages. Their usual control method is to apply insecticides, such as carbofuran and phoxim, with grave consequences for their health and the environment and for natural control since the number of beneficial insects is decreased. Current insecticide use is of limited effectiveness as larvae may be deeper than the chemical can reach, heavy rains tend to wash it out and farmers rarely apply at the critical periods to prevent larval growth. The team carried out a pests and diseases survey, with sampling and observation every three weeks with the active participation of the majority of the farm women who accompanied them in their fields. By observing and talking with these women in the field, the team collected ethnobotanical information about properties of weedy species (medicinal, edible, poisonous, harmful or beneficial to the crop, etc.). In August 1996 the first workshop for farm women was run, using field sessions in rainfed maize to teach them how to recognise whitegrub damage and how to distinguish this from other problems (other pests, excess moisture, wind, weeds, or soil-related). The women also presented their opinions of production problems in maize.

These activities served as a platform for discussing potential control options for whitegrubs with the community in early 1997, after which farmers decided on several options they would like to try out. Proposed alternatives were: interplanting maize with climbing beans, *Canavalia* legume cover, dolichos bean and alfalfa; single weeding combined with earthing up; selecting resistant seed (select from cobs from plants which did not lodge from whitegrub damage to the roots); and increasing planting density. Farmers chose to try the following options: in irrigated maize, they opted for maize with common bean; single weeding; earthing up; and in rainfed maize for maize with common bean; maize with *Canavalia*; and a community campaign to collect whitegrub adults. From the experiments in rainfed maize, association with legumes did not show any clear effect on whitegrub larval density or damage but the farmers thought it was a useful practice if one, rather than two, rows of beans were sown between maize rows because it reduces weed emergence and hence the need for herbicide application. In irrigated maize the practices of single weeding, earthing up and legume association were considered potential alternatives, depending on seasonal and field-specific variation and individual farmers' resources. Farmers were not so enthusiastic about *Canavalia* use because they could not see any immediate benefits of interplanting.

The control method which brought most impact was adult beetle collection in the rainfed maize zone. A total of 83 primary school pupils in the village were first taught how to recognise whitegrub pest damage and how to distinguish the pest species in adult form from related beneficial beetles which are decomposers. The collections took place over four weeks in April and May 1997 and every week the children collected beetles and explained to the ECOSUR team how and where they had captured the beetles. The girls mainly collected those attracted to lights while the boys explored to find beetles gathering in certain host tree species, which they shook to release the insects. The researchers took the weekly collections back to the laboratory for identification and to confirm the host tree feeding as observed by the boys. In total the pupils collected 40,995 adults over 27 ha, belonging to six *Phyllophaga* and *Anomala* species. The collections were organized as a competition and each child who took part received a school bag with a whitegrub control slogan and containing candies, and the most avid collectors were given notebooks and pencils. To confirm the effectiveness of adult beetle suppression, the team carried out larval density sampling four months after the collections in El Madronal and compared these with another community where no collection took place. Whitegrub densities averaged 1.5 larvae/m² in El Madronal while the control village averaged 17.24 and 13 larvae/m² for two of the most voracious species. These species were those which had been commonest in the children's collections. The results indicate that adult collection can noticeably reduce subsequent larval densities and thus contribute to improved maize yield. Mass capturing of adult whitegrubs has now been shown to be a cheap, efficient, simple and safe management method in rainfed maize zones but which relies on collective organization by the community.

The process of taking ownership of new technologies is slow but the ECOSUR team's experience in 1998 showed that methods with most impact for farmers were being followed up. They are now preparing a simple key for farmers to distinguish good from bad melolonthid and other beetles. The team continues to study other methods for whitegrub integrated management including applications of botanical extracts against small larvae; trap cropping of useful plants with attractive roots for larvae such as mustard and radish; natural enemy studies and entomopathogens; and weed management strategies. This academic linkage project has enabled ECOSUR to build relations with the farmers and potters of El Madronal and now the 'control' community too, where they have also run workshops and where they plan to continue with joint research for safe and effective pest management based on local resources and which can be integrated into farmers' existing farming practices.

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Internet Round-up

By: Tony Little, Technical Support Group to the Global IPM Facility, CABI Bioscience.

This quarter we are looking at mealybugs. There is a fair bit on the net, and much of it focuses on the hibiscus, or pink hibiscus, mealybug, *Maconellicoccus hirsutus* [see General News, this issue]. News bulletins over the past three or four years on the biological control of this pest can be found at a number of sites. For example: 'Search is on for natural enemies of mealybugs', a paper from the '*Good Fruit Grower*' at:

http://www.goodfruit.com/archive/Sept_96/feature5.html

'Wasps to keep pink mealybug in check', from the *Environmental News Network* at:

http://www.enn.com/enn-news-archive/1997/06/062597/06259706.asp

'Presence of the Pink Hibiscus Mealybug is confirmed in Belize' from the Government of Belize Press Office at:

http://www.belize.gov.bz/pressoffice/press_releases/29-09-1999-236.shtml

The USDA-APHIS Plant Protection and Quarantine site has produced a nice little fact sheet on the Pink Hibiscus mealybug at:

http://www.aphis.usda.gov/oa/mealybug.html

which is worth a look, and is linked to the 1997 status report on its biological control. A bit out of date now, but tells the story of biological control project in the Caribbean. CABI Bioscience also give details of their activities in this area at:

http://www.cabi.org/BIOSCIENCE/invertebrate.htm#mealybug

The University of California Statewide Integrated Pest Management Project has produced some brief, pithy pest management guidelines, including one for citrus mealybug at:

http://www.ipm.ucdavis.edu/PMG/r107300511.html

The 'Texas Fruit' home page can be found at:

http://aggie-horticulture.tamu.edu/citrus/citrus.htm

and has a section on pest management and pages dedicated to the citrus mealybug at:

http://aggie-horticulture.tamu.edu/citrus/l2311.htm

Not a great deal of information here, but quite a pretty site, and a useful place to visit if, like me, you are a bit of novice in the world of citrus pest management.

The Virtual Orchard at:

http://www.virtualorchard.net/

is a dedicated World Wide Web site for sustainable apple production, and has a little bit on the grape mealybug, biology and control. The Virtual Orchard is part of the Mid-Atlantic Regional Fruit Loop:

http://www.caf.wvu.edu/kearneysville/fruitloop.html

If I'm honest there is not a great deal of mealybug information here, but this is such a good site for apple IPM, that I felt compelled to include it somewhere!

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Announcements

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

Catch that Flyer!

The Entomology Events Calendar at:
http://www.sciref.org/links/EntEvent/index.htm
was first posted in January 2000, and is hosted by Scientific Reference Resources (SRR), a non-profit organization that currently publishes *Arthropod Endocrinology News*, the *Directory of Arthropod Endocrinologists*, and *New Entomological Taxa* at:
http://www.sciref.org/

The Events Calendar is updated almost daily and its goal is to provide a comprehensive, Internet-based list of events devoted to general or applied entomology, including apiculture, pest control, mosquito or vector control, and crop protection. Commercial meetings, society and association meetings, conferences, congresses, workshops, courses, expositions, insect film festivals and seminar series are all listed. At the time of writing (March) some 700 events are listed for 2000, and calendars for future years are in preparation. Six indexes help the entomologist with wanderlust locate meetings of interest in the chronological list. These are based on sponsoring society/association and the type of event, and on the topic of the meeting: specific taxonomic groups (such as Coleoptera), apicultural events, mosquito and vector control events, and pest control, IPM, crop protection and plant protection events.

To submit information, send it either by email to: entmeet@sciref.org
or by post to: Scientific Reference Resources, PO Box 73674,
Davis,
CA 95616, USA

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Chinese Water Hyacinth Meeting

The second IOBC (International Organization for Biological Control) Global Working Group meeting for the biological and integrated control of water hyacinth will be held in Beijing, China on 9-12 October 2000. The purpose of the workshop is to share and help disseminate information on biological and integrated control of the weed, identify research areas that may lead to improved control and establish closer links between project researchers and programme managers around the world. Sponsored by the IOBC Global Working Group, the meeting is being organized by the Biological Control Institute (BCI), Chinese Academy of Agricultural Sciences (CAAS).

The registration fee of US$280 should be paid by 31 August (details below). Those wishing to attend should provide their name, nationality, date and place of birth, passport number and occupation to Ding Jianqing (address below) as early as possible to obtain a visa application form, and then apply for a visa at their local Chinese embassy/consulate/visa office.

Titles and abstracts (abstracts not exceeding 250 words), preferably in MS Word for Windows 95 or 98 format, should be sent in English no later than 31 July 2000 via Internet (preferably) or air mail to Ding Jianqing.

Registration payment to: IOBC WH Workshop, Biological Control Institute, Chinese Academy of Agricultural Sciences,
30 Baishiqiao Rd.,
Beijing 100081,
P.R. China
Bank Acount No. 71402953,
Bank of China, address: 410 Fuchengmen Neidajie, Beijing 100034, P.R. China.

Contact: Mr Ding Jianqing, Biological Control Institute, Chinese Academy of Agricultural Sciences,
30 Baishiqiao Rd.,
Beijing 100081,
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Fax: +86 10 68919567
Email: djq@public.east.cn.net

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Chromolaena Workshop Update

The second circular is now available for the Fifth International Workshop on Biological Control and Management of *Chromolaena odorata*, which is being held in Durban, South Africa, from 23-25 October 2000, with a field-trip from 26-28 October. The purpose of this workshop is to facilitate the dissemination of information on the management and control of chromolaena, to identify areas in which new research is needed, and to foster global co-operation on managing and controlling this plant. Please note the cut-off date of 15 July 2000 for submission of abstracts and titles, registration fees, post-workshop fieldtrip bookings and deposit to the organizers, and of accommodation bookings to the hotel.

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ARC-PPRI, Private Bag X6006,
Hilton,
3245, South Africa
Email: ntlws@natal1.agric.za
Fax: +27 33 355 9423
Or see the *Chromolaena* biocontrol website:
http://www.cpitt.uq.edu.au/chromolaena/siamhome.html

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Eradication of Island Invasives

A call for papers has been made for a conference on Eradication of Island Invasives: Practical Actions and Results Achieved. This is an international conference of the Invasive Species Specialist Group (ISSG) of IUCN and will be held at the University of Auckland, Auckland, New Zealand on 19-23 February 2001.

Papers and discussion sessions will be strictly limited to the subject of: 'Eradication of invasive species from islands; methods used and the results achieved.' The term 'eradicating' may include work to remove invasive species where complete eradication is some, or many, years away but the methods used to date are achieving positive results or providing a significant learning experience. The term 'island' may include true islands, natural habitat islands (e.g. ponds), remnant and artificial habitat islands (e.g. reserves), or new invasions of natural ecosystems where eradication was deemed feasible. Preference will be given to papers that provide detail of the techniques used or of the ecosystem response to the work. Significant learning experiences may include methods which failed. The titles of presentations are requested by 15 June 2000. The deadline for the receipt of abstracts is 1 October 2000, although late offers may be considered.

Contact: Dick Veitch,
48 Manse Road,
Papakura,
New Zealand
Email: dveitch@kiwilink.co.nz
Fax: +64 9 298 5775
Also see the ISSG website: http://www.issg.org

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Two Birds with One Stone?

The 13th Australian Weeds Conference (AWC) is being held in Perth, Western Australia on 9-12 September 2002. It is anticipated that some delegates will have a broad role in agricultural and/or environmental protection, and will be concerned also with vertebrate pests and their control. It is proposed to hold a workshop or symposium on vertebrate pests in conjunction with the weeds meeting (6-7 or 13-14 September are tentative dates). Suggestions for and/or expressions of interest in taking part in a vertebrate pests meeting can be sent to: Roger Armstrong, Department of Conservation and Land Management,
Western Australia
Email: rogera@calm.wa.gov.au

For details of the 13th AWC contact the conference organizer.
Email: convlink@iinet.net.au

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LUBILOSA Spin-off

The LUBILOSA programme (LUtte BIologique contre les LOcustes et les SAuteriaux) has spent the last nine years developing Green Muscle™ for control of locusts in Africa. The success of the programme rested heavily on the development of appropriate production and application technology, and the experience gained and lessons learned along the way are a significant output of the programme.

The raw material for a fungal spray or mycopesticide is dry fungal spores, for which mass production methods have to be developed. The next hurdle is how to extract the spores efficiently and cleanly from the solid fermentation product. Spores can be extracted by a laborious (and dusty) sieving process, using first coarse (300-500 µm) and then very fine mesh (say 100 µm) sieves. But even so, the final product can contain a high proportion (up to 40% by volume) of larger particles (10-100 µm) that cause problems by settling out in tanks and, if very large particles are present, they can cause blockages in filters and nozzles.

The MycoHarvester is both easier to use and produces extracts conforming to a very high particle size specification on a laboratory scale. For extractions of *Metarhizium anisopliae*, more than 80% of particles are less than 10 µm, and none exceed 100 µm. The device is designed to harvest fungal spores from a solid substrate (e.g. conidiated grains such as rice), and is suitable for small-scale, non-continuous preparation of mycopesticide samples or similar products. Conidia are concentrated in a form that is easy to desiccate and package. Experience collected during the LUBILOSA programme indicated that this was a key process in the development of commercially acceptable mycoinsecticides.

The MycoHarvester MH1 is now available for purchase. Price (not including postage and packing) for single units: UK£3890/US$6300. CABI member countries reduced price: £2590/$4200. Discounts for multiple orders.

Contact: Roy Bateman,
CABI Bioscience,
Silwood Park, Ascot,
Berks.
SL5 7TA, UK
Email: r.bateman@cabi.org
Fax: +44 1491 829123
Website: http://www.cabi.org/BIOSCIENCE/biopesticides.htm

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Records of European Whitefly Enemies

Under the auspices of EWSN (the European Whitefly Studies Network), a list is being compiled of predators and parasitoids of whitefly species within Europe by a group of experts including A. Polaszek and J. Noyes (UK), O. Alomar (Spain), J.

Fransen (Netherlands) and D. Gerling (Israel), and in cooperation with C. Rapisarda (Italy), who is compiling a host list of whiteflies in Europe. A literature survey has been undertaken, but to make the final list as complete as possible, the compilers would be pleased to hear from anyone familiar with records on natural enemies of whiteflies that are *not* within the mainstream literature. Suggestions on how to employ and utilize the forthcoming list are also welcome.

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Tel Aviv University, Israel
Email: dangr@post.tau.ac.il

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Conference Reports

Mexican Biological Control Congress

The 22nd Congress of the Mexican Biological Control Society (MBCS) was held from 28-29 October 1999 at the Postgraduate College in Texcoco, Mexico, under the theme 'Biological Control, the Key Tool for Pest Control in the New Millennium'. Prior to the Congress a 3-day lecture course was held together with practical workshops on hymenopteran identification; mass production of entomopathogenic fungi; and design of entomophagous arthropod rearing systems. In addition to the usual posters and presentations, manufacturers of biological products displayed their wares and a biocontrol quiz for students was organized. Themes for papers included Biotechnology and Genetics; Biosystematics and Taxonomy; Weed and Pathogen Control; Veterinary Biocontrol; Mass Rearing and Quality Control; Biology, Ecology and Behaviour; Education and Technology Transfer; Evaluation and Impact; and Integrated Management.

Most of the Congress sessions were technical but one session focussed on 'Farmers' Views and Experience in the Use of Biocontrol Agents', coordinated by Raquel Alatorre of the IFIT Postgraduate College and the Neotropical Section of the International Organization for Biological Control (IOBC). The Society has done preliminary consultation with farmers to get feedback on biocontrol agent (BCA) products but recognises the need to develop methods for BCA release and application strategies which are as rigorous as those for laboratory production. Despite a large number of small private sector enterprises in Mexico, dominated by researchers, there are no national guidelines for release and evaluation strategies. The Society is keen to develop these as this is the point where widespread use of BCAs will succeed or fail. Farmers from nearby states with whom MBCS members collaborate were invited to this session to share their opinions with researchers. Mr Jesus Rizo represented a smallholders' association growing maize, sorghum and chickpeas. Through collaboration with local research and extension staff, Mr Rizo had tried a *Metarhizium* biopesticide for soil pests, notably white grubs, and tried biofertilizers. University staff provided these products at subsidized cost to encourage their use. Mr Rizo had been conscious for some time of the risks to human health and the environment of excessive use of pesticides, as well as experiencing pest resistance to common insecticides. His motivation for involvement also came from the increasing cost of agrochemicals as well as being naturally curious. Local beekeepers whose hives had been affected by pesticides were those who first alerted him to the dangers. He described how his personal interest in natural control was sparked by a technician who took him out one night to watch white grub adults emerging from the soil and he was so impressed by the huge quantities that he agreed to try out these new methods. However, he admitted that the challenge remains to motivate other farmers to try out biological control. Other BCA programmes promote gradual integration of biocontrol, encouraging local producers' committees to set percentage adoption targets for biological and chemical methods.

Several large-scale growers of vegetables (strawberries, tomatoes and asparagus) spoke about their experiences with BCAs. One had calculated detailed input/output budgets for his fields to get fellow association members interested, as the only way to attract them is to show the economic savings. These growers felt that demonstration plots are the best way to interest others and then generate demand for BCAs by convincing association committees. There is a lot of misunderstanding about BCAs; for instance, many farmers think that mycopesticides will not work unless there is a lot of rain. Quality control and customer service is also key. Another factor in low adoption levels is the linking of credit available to association members with agrochemical and seed suppliers. Some farmers who had used BCAs were forced to stop using these products in order not to jeopardize their production credit. Everyone agreed that biocontrol needs to promote itself as aggressively as the agrochemical industry and several farmers suggested that traditional commercial suppliers of farm inputs should be persuaded to start distributing alternative products. Due to increasing export restrictions on residue levels, there is growing interest in non-chemical alternatives among many large-scale farmers. Technicians felt the most useful support the MBCS should offer is quality control standards and more promotion of IPM, rather than letting farmers think that biocontrol alone will solve all their pest problems. There should also be experience sharing between farmers who collaborate on trials and with new farmers.

The session concluded with the following recommendations:

- Practical demonstration and visualization of results is the best method to convince farmers.
- Subsidies are an important factor in increasing interest and uptake.
- Biocontrol is a key tool in IPM but not the only one.
- There is a need to look at the role of native natural enemies and their possible displacement under augmentative biocontrol.
- MBCS should support the rapid legislation of quality control.

A special symposium was held on 'Models of Participatory Research and Technology Transfer with Emphasis on Biological Control'. Leobardo Jimenez from the Postgraduate College's Centre for Rural Development and Bernardino Mata from the Rural Sociology Department at the University of Chapingo discussed the sociopolitical context for farmer-centred extension and the failure of much of Mexican agricultural research and extension to meet the needs of the smallholder and indigenous sector. Ann Braun from CIAT (International Center for Tropical Agriculture) outlined the principles and experience of the Local Agricultural Research Committees (CIALs) in Colombia and other Latin countries and Falguni Guharay from the CATIE (Centro Agronómico Tropical de Investigación y Educación) IPM programme in Nicaragua discussed the institutional processes in farmer-led research. Stephanie Williamson from CABI Bioscience discussed challenges for farmer participation in coffee research and extension. Christiane Junghans and Ramon Jarquin talked about the ECOSUR (the College of the Southern Border) academic links programme with rural communities and the challenges in changing farmer and researchers' attitudes and making academic research more relevant to production needs. The programme is now running pilot participatory research activities in indigenous methods for whitegrub management in maize [See 'Training News', this issue]; use of botanical preparations for control of varroasis disease in beehives; control of maize stemborers with baculovirus; and coffee berry borer IPM. Juan Barrera presented a proposal from ECOSUR for pilot development of farmer participatory IPM training in coffee and maize in Mexico which aims to combine the learning of agroecological principles as practised in Farmer Field Schools with action research for specific problem solving, as promoted by CIALs.

The Congress Proceedings, mainly in Spanish, draw together papers, keynote speeches, poster and symposium abstracts.

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By: Stephanie Williamson, CABI Bioscience

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Galaxy of Talent Tackles Cocoa Disease

Cocoa is a handsome crop and even its worst diseases have attractive names: 'Witches' Broom' and 'Frosty Pod'. But although a chocoholic could be forgiven for thinking these are seasonal chocolate novelties, to the cocoa farmers of Brazil they spell ruin, unless the cocoa sector can come up with some solutions quickly.

Bahia State in Brazil is the principal cocoa-growing region of the Americas. An agaric fungal disease was first noticed there in 1989, and since then witches' broom (*Crinipellis perniciosa*) has contributed to a halving of cocoa production. But some ten years after the disease was identified, and after a plethora of consultants, there is still no clear integrated approach to its management. For example: chemical, biological and cultural (pruning) methods have been tried, but there appears to be little idea of how these may interact with one another, or even the most appropriate timing of interventions. The problem currently affects over three million people of the Bahia Region, covering 600,000 ha of arable land, and could potentially have a devastating environmental impact if the traditional Cabruca cultivation system of growing cocoa under the original forest canopy should disappear.

It was against this sense of crisis for future cocoa production in Bahia that a witches' broom meeting was organized in Ilheus, Brazil on 21-24 February 2000, funded and organized by M&M Mars. The meeting was attended by over 50 participants from 19 organizations, including researchers and farmers and representatives of government, industry, NGOs and development agencies. It aimed to review research and familiarize all participants with work in progress on efforts to solve the witches' broom problem. M&M Mars was very much a driving force behind the meeting, and made a very professional effort to overcome some of the previous lack of communication between research organizations. The meeting looked for ways to initiate cooperative research, develop a collaborative approach and set in motion action plans to build on the activities being conducted by CEPLAC (Commisão do Executiva do Plano da Lavoura Cacaueira) in Brazil and other institutes worldwide, working toward a model of sustainability. This model of collaboration and planning, although initially applied to the witches' broom problem in Bahia, could be used to tackle other global cocoa disease problems.

CEPLAC hosted the first day at its site near Itabuna. Each participant was given the opportunity to air their hopes for the meeting. From this energetic discussion, four major themes evolved: Agroecology, Biocontrol, Genetics and Breeding, and Communication/Collaboration and teams were formed to focus attention and strengthen research in these areas. Each team developed an action plan, prioritizing at least four activities for the next six months and identifying for each activity: 'What needs to be done,' 'Why?', 'Who is the owner?', 'Who is doing the work?', 'Who needs to be kept informed?', 'People resources,' 'Money resources,' and 'Timing'. The process of sharing information and making plans laid the foundation of trust and familiarity within the teams that will help them carry forward their work. The Biocontrol group ended their session with a demonstration of new sprayer technology by CABI Bioscience. Equipment was left at Almirante Center (M&M Mars) and CEPLAC for further testing and analysis. Major activities identified by for each team were:

Agroecology

- Evaluate farmers' tolerant plant material.
- Develop techniques to multiply good material.
- Create a decision support model for researchers and farmers.
- Develop and evolve a new paradigm for agricultural change.
- Find and evaluate plants for sustainable agroforestry systems.
- Help establish a pilot for a micro-economic lending programme.

Genetics and Breeding

- Apply DNA fingerprinting techniques to 300 accessions at Almirante Center.
- Apply DNA fingerprinting techniques to 1000 accessions at CEPLAC.
- Identify and map witches' broom resistance genes for Scavina 6 and 12 and produce a complementary DNA library for the Expressed Sequence Tags (EST) project.

Biocontrol

- Ecology: predict behaviour of *Trichoderma* in the field.
- Field application studies to optimize *Trichoderma* delivery systems.
- Search and screen field materials to find new biocontrol agents.

Communication/Collaboration

- Distribute comprehensive email list of participants.
- Set up WWW (web) based repository of searchable data, information and knowledge related to witches' broom disease (which could be expanded to other cocoa diseases).
- Set the WWW based cocoa research bulletin board to support collaboration within and between the teams.
- Provide links to other cocoa and scientific sites of interest.

A gap analysis highlighted items for further consideration by the teams: how to involve all stakeholders (particularly small farmers), how to optimize extension activities and technology transfer, and how to acquire needed resources quickly. Each team will consider additional activities to fill those gaps.

Field trips were also made to small farmer-run biocontrol plots around the Una Biological Reserve area. CEPLAC have developed a sprayable product, 'Tricovab', based on the recently described mycoparasitic fungus *Trichoderma stromaticum*, and the application of this was demonstrated. The farmers have embraced the technology, although it is too early to determine if it is having significant impact. There was also a tour of the Una Ecopark, a private forest reserve bordering the Una Biological Reserve, to see how a well-preserved Atlantic Forest can offer lucrative economic alternatives for the region. The Una Ecopark was created by the Institute for Socio-Environmental Studies of Southern Bahia (IESB), in partnership with Conservation International of Brazil The organizations are also doing research on regional biodiversity and offering agroforestry extension assistance to farmers and communities to help save key forest fragments. The Cabruca cocoa system is seen as a key factor in the conservation and preservation of the ecoparks and acts as corridors between them.

Perhaps the greatest achievement of the meeting was the formation of collaborative teams. Two years ago most of the researchers in attendance were not even on each other's 'radar screens', and by the end of 1999 they were fragmented, at best. Now they are forming into research teams with action plans covering the next six months. The stages that the teams will go through as they evolve from an initial state of individual contribution to that of effective team collaboration and on to high performance state were discussed – they have the potential to develop into an exciting WWW-based collaborative venture. A set of team building activities may be included in the agenda for the next general meeting in September.

There are other promising developments. New players such as USDA (US Department of Agriculture) geneticists and plant breeders have entered the scene and they will help to assess South and Central American germplasm collections for resistance to diseases. Work on cocoa endophytes, although at an early stage, also looks a promising avenue and is being investigated as a long-term strategy for control of cocoa diseases.

It was argued that it may only be a matter of time before witches' broom reaches other cocoa-growing countries, in the Old World, for example, but it was also pointed out that witches' broom will probably be followed by other diseases such as frosty pod, and that could make witches' broom seem a mere hiccup.

Carol Knight (American Cocoa Research Institute – ACRI), representing the cocoa and chocolate industry, acknowledged the cooperation and resources provided by USDA, CABI Bioscience, Conservation International, IESB, CEPLAC, UESC (State University of Santa Cruz), OCP (Organic Commodity Project), and USAID (US Agency for International Development), as well as the leadership provided by M&M Mars and Almirante Center on behalf of the industry. She suggested that the teams created during the meeting could work in concert with ACRI's International Sustainable Cocoa Program.

In his final remarks, Raul Valle, Director of CEPLAC heralded the meeting as a positive step forward in undertaking co-operative research to find a solution for witches' broom. He also noted that a pending Memorandum of Understanding between USDA and CEPLAC would cover collaborative research in genetics and biocontrol. He expressed the hope that concrete actions and results would follow as a result of this meeting.

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This technical aspects of this report are based on a conference report by Vince Arecchi.
See the CocoaResearcher website: http://www.cocoaresearcher.com

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New Books

An Antipodean Perspective on Host-Specificity Testing

This slim A4 booklet* presents nine papers and a synthesis from a one-day workshop organized by the Co-operative Research Centre for Tropical Pest Management entitled 'Introduction of exotic biocontrol agents – recommendations on host specificity testing procedures in Australasia' which was held in Brisbane on 3 October 1998. The papers are by a range of Australian and New Zealand scientists involved in biological control of weeds and arthropods, and provide a useful perspective of the different approaches currently being used or developed to assess host specificity of insect biological control agents.

This is a timely publication, given the current concerns regarding possible non-target effects of introduced biological organisms. In this debate, I think it is useful to distinguish between the science-based assessment of the potential host range of a biological control agent as opposed to the decision-making process itself. This has become obvious in the recent discussion of some of the non-target effects reported in the popular as well as the scientific literature. For example, the host range studies on *Rhinocyllus conicus* clearly showed that a range of thistles would be likely to be attacked if this weevil were released in North America, and hence the fact that it has now been able to do so should not come as a surprise. When *R. conicus* was first introduced into North America in the 1950s, the decision-making process did not consider the fact that it might feed on other thistles as a matter of sufficient concern to prevent its introduction (watch out for André Gassmann's useful review to be published by CABI in the proceedings of the IOBC Conference in Montpellier, October 1999 [see *BNI* **21(1)**, 14N-16N (March 2000) for a conference report], and the post-hoc review in preparation by André Gassmann and Svata Louda). It can be argued that the science was correctly carried out, but the decision-making process was contemporary, and that society's values change over time.

The subject matter of the volume reviewed here and the workshop it reports refers to the scientific process of evaluating the potential host range of biological control agents and does not consider the decision-making process. The editors have conveniently summarized the contents of the papers in the preface as follows:

"The first seven chapters focus on the various methodologies commonly used in the host specificity testing of candidate agents for biological control of weeds. Richard Hill explains the political and scientific usefulness for the commonly utilized no-choice trial. He takes the concept further than just the no-choice starvation test, but also considers extended fecundity and developmental trials of herbivorous insects and mites under no-choice conditions. Both Michael Day and Bill Palmer add to the understanding of the breadth and application of no-choice trials. Michael Day considers how results over multiple generation on non-target hosts can be interpreted, while Bill Palmer reviews the biological control literature and finds no evidence that using cut foliage for no-choice trials rather than whole plants can drastically alter the outcomes, at least for foliage feeding insects. Tim Heard summarizes a technique for host range testing insects that utilize discreet resources and which have mechanisms, such as the use of an oviposition-deterring pheromone, that tend to prevent them from over-exploiting resources. Penelope Edwards defines what constitutes a choice test, considers the usefulness of such tests, and make recommendations about their role, particularly as pertains to ascertaining oviposition and/or feeding preferences between plant species. David Briese reviews the literature surrounding open field host range tests, their rationale, and interpretation. His recommendation for a two-phase methodology appears to overcome a number of the current concerns about field tests. Andy Sheppard provides a thorough review of the biological control literature and reveals that, to date, no significant sequence of assay type has been predominant. He has produced an insect biology-based decision flowchart to suggest how the selection of the initial host range assay type could be most appropriately made.

"The next two papers discuss methods used in host specificity testing of parasitoids for biological control of arthropod pests. Barbara Barratt and co-authors provide an overview of requirements for host specificity testing of parasitoids. The regulatory requirements as well as the complexities of assay design for parasitoids are considered, and some modern technological aids to host range assessment are introduced. Michael Keller discusses the importance of having an understanding of the processes involved in host selection and clearly illustrates the relevant concepts with mainly parasitoid examples.

"Finally, Toni Withers discusses prospects for developing an integrated approach to host specificity testing to improve the accuracy of predicting field host range. How the order of host specificity testing assay type can be altered so that applications for released biological agents fit within a 'best practice risk assessment' framework is discussed."

One thing that comes out very clearly from these reviews is the diversity of detail in the approaches used by scientists to assess the host specificity of the arthropods they study. I found this a very useful summary and reminder of some of the assumptions, difficulties, and potential pitfalls relating to the different approaches. It is clear that to test biological control agents for insect pests to the same level of predictability as for weed biological control agents will be challenging, time consuming and expensive.

Who needs to read this volume? Scientists involved in the study of host specificity of biological control organisms are the obvious audience. Scientists concerned with the potential impact of biological control organisms on non-target organisms should read it, and scientists who are tasked with the evaluation of applications for permission to introduce biological control organisms should certainly be familiar with the contents. It is not a how-to guide, but would be a very useful information source in developing such a guide. It is a snapshot of how biological control scientists in Australia and New Zealand were thinking in late 1998.

The binding on my copy is not very robust, and since in some sections the margins of the pages come close to the spine, I am not sure that it will last very well.

*Withers, T.M.; Browne, L.B.; Stanley, J. (1999) Host specificity testing in Australasia: towards improved assays for biological control. Indooroopilly, Queensland; Department of Natural Resources, 98 pp. Pbk.
Price: Au$30.00 + p&p; discounts for multiple purchases; credit card payments accepted.
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A Handy Quarantine Reference

World trade in biological material for agriculture or forestry purposes (e.g. seed, new cultivars) is now at an all-time high; as with other world trade, this is largely a consequence of the impact of the General Agreement on Trade and Tariffs (GATT). A whole spectrum of national and international agricultural organizations is now demanding information on containment facilities and detection procedures that significantly reduce the risks of pests (insects and mites) or pathogens ending up in the wrong place. There is additional interest from the environmental sector and the general public concerned about the accidental introduction of non-indigenous species that may have adverse effects on ecosystems. Quarantine facilities are also of relevance to biological control workers meeting new demands for the screening of exotic biological control agents.

This book* attempts to meet all of these demands and by any measure is a brilliant effort. Kahn and Mathur have assembled a good cross section of authors who, together, provide a truly international and holistic view on the subject. Chapters are grouped under four main headings: background regulatory and biological concepts with two nice reviews by Kahn; safeguards and facilities mostly for seeds with some interesting reviews of facilities and safeguards at the international agricultural research centres; facilities and safeguards with emphasis on vegetative propagating materials with a good cross-section of reviews from the USA, Western Europe, Kenya, Malaysia and China; and lastly, facilities and safeguards for the deliberate importation of plant pests and pathogens which contains chapters covering plant pathogens, nematodes and general principles of design.

The stated objectives of the book are to "provide information about how quarantine and research services perceive the risk associated with exotic plants and other organisms, and how this risk may be managed through containment facilities and safeguards." To achieve this, the authors collate much widely scattered published and grey literature into a single-source reference about principles, concepts and guidelines relating to the design and function of containment facilities for high and low risk activities. The authors do not attempt to set particular international scientific 'standards' but instead, provide examples of how various international research centres, governments and others have dealt with issues related to the import and export of plants, plant products and other organisms.

The magnitude of the problems to be grasped is nicely illustrated in the chapters covering the quarantine facilities at CIAT (International Center for Tropical Agriculture) and IITA (International Institute of Tropical Agriculture). The exchange of plant germplasm is an activity of major importance in the genetic improvement of cultivated species. The Genetic Resources Unit (GRU) of CIAT has been involved with the movement of some 65,000 bean seed samples to 83 countries and at least 27,000 tropical forage germplasm samples to 71 countries (chapter 5). Clearly there are real phytosanitary risks associated with the international movement of germplasm of this scale; in the case of CIAT, safe movement is managed by their GRU.

A knowledge of the life cycles of organisms to be contained is one of the most important factors necessary for the proper design of containment facilities and for implementing safeguards. Kahn (chapter 3) provides a good background discussion on this and on other biological concepts including pathway analysis; the latter is an evaluation of a pest's biology to assess the various ways that it could arrive in a new area. Kahn reminds us that quarantine activities are designed to reduce the risks of entry via manmade, and not natural, pathways.

In the chapters covering specific quarantine facilities, authors have included floor plans, diagrams, etc., and suggested biological and environmental standards, equipment needs, phytosanitation procedures, staffing and the results of pest and pathogen tests.

This book will be of interest to all those involved with the regulation of movement of biological material and is likely to become a standard reference text.

*Kahn, R.P.; Mathur, S.B. (*eds*) (1999) Containment facilities and safeguards for exotic plant pathogens and pests. St Paul, MN, USA; American Phytopathological Society, 213 pp. Hbk. ISBN 0 89054 197 3. Price: US$69.00

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Nontarget Effects of Biological Control

Until about twenty years ago little consideration was given to the impact of biological control agents (principally exotic species introduced for control of introduced pests) on non-target organisms, except for efforts to avoid damage to crop plants by agents applied for weed control. Methodology for host range screening of weed control agents was developed primarily for this purpose, but agents for control of arthropods and other invertebrate pests were not screened. In fact, it was often stated that the existence of alternative hosts was an advantage in maintaining natural enemy populations when the target pest was scarce or absent. Decisions relating to the introduction, release and distribution of biological control agents were then taken chiefly by agricultural departments and other institutions, working on behalf of farmers.

The situation changed dramatically with the rise of concern for the environment and the preservation of biodiversity. Biological control practitioners who had proclaimed the advantages of relatively target specific control over the use of broad-spectrum chemicals suddenly found themselves accused of causing extinctions and other irreversible environmental damage. At first those questioning the practice of biological control focused chiefly on introduced agents, quoting supposed examples of non-target effects on native species, many of them based on hearsay or speculation. Documented examples are required so as to move from accusation to rational debate founded on facts and from there towards policies that will avoid or minimize non-target effects. To this end a symposium was held at the 1997 Annual Meeting of the Entomological Society of America. This book* contains chapters based on the eight presentations made at the meeting and a further nine others, written especially for it, on aspects of the biological control of insects by insects or weeds by insects. The editors explain the background in their preface and their intention "to achieve a balanced treatment of the diverse viewpoints and approaches" in order to "stimulate thinking and activity in this neglected area of applied biology". Have they succeeded?

The majority of the contributors are from the United States – only three of the 17 chapters are by scientists from other countries and focus on work undertaken elsewhere. Consequently, the majority of chapters dwell on the consequences of past introductions into the USA and the need for more effective regulation of introductions into that country. However, the contributions from New Zealand (Barbara Barratt *et al.*) and Australia (Toni Withers *et al.*) outline the strict and apparently effective procedures already in force in their countries. Also, little mention is made of the 1996 FAO Code of Conduct for the Import and Release of Exotic Biological Control Agents which has provided the stimulus for debate and legislation in a number of developed and developing counties that so far lack mechanisms for regulating biological control introductions.

The book is a compilation rather than a coherent text, no effort appears to have been made to edit the individual contributions so as to avoid repetition and improve readability – for example, most chapters begin with similar statements defining biological control and non-target effects and cite the same references in support. The grouping of chapters into sections on Perspectives, Parasitoids and Predators, Weeds and, lastly, Pathogens is not the most satisfactory arrangement as chapters describing the past, current effort to avoid future problems, and techniques for detection or evaluation of non-target effects occur in each section. Most contributions are concerned with the long term impact of introduced agents but the chapter on *Trichogramma* (David Orr *et al*.) in the Parasitoid and Predators section and the three chapters in the Pathogen section deal with the, chiefly short term, consequences of augmenting entomopathogenic fungi and nematodes and the effects of *Bt* sprays on non-target forest Lepidoptera. There is no editorial comment, except in the Preface, and no conclusion or synthesis to complete the work.

In the Perspectives section L. E. Ehler provides an introductory chapter discussing issues raised by past classical biological control of insects and calls for "a sensible balance between economic reality and environmental ethics". Jeffrey Lockwood follows with a philosophical discourse on the need to monitor ecological processes rather than individual species when measuring non-target effects. Peter Stilling and Daniel Simbeloff try to measure the importance of non-target effects by considering the average number of recorded hosts of introduced biological control agents and their attack rates on non-target hosts in order to counter the view of many practitioners that non-target effects are both weak and infrequent. Finally, Russell Messing discusses the impact of concerns about non-target effects on the conduct of biological control and calls for clear streamlined national regulations to allay fears of exotic species and to ensure the future for cost effective and environmentally sound biological control of exotic pests. Elsewhere in the book P. B. McEvoy and E. M. Coombs attack the "lottery model" of biological control whereby practitioners are under pressure to introduce many agents quickly in the hope that they will sort themselves out and some will bring about control.

More generally valuable are the chapters including case histories summarizing experimental work or quantitative observations made to measure non-target effects. These provide the facts which can help refine methodology that will minimize the chance of unwanted side effects from future introductions. Barbara Barratt *et al.* show that pre-release investigations on host ranges of braconid weevil parasitoids introduced into New Zealand were generally predictive of post-release field results. Peter Follett *et al*. describe studies on the impact of introduced parasitoids on Hawaiian Pentatomoidea and Jian Duan and Russell Messing evaluate non-target impacts of introduced fruit fly parasitoids in Hawaii. John Obrycki *et al*. discuss non-target effects of the introduction of generalist aphidophagous Coccinellidae into the continental USA. Toni Withers *et al*. outline the procedures used in Australia for risk assessment of weed control agents, using an example of an agent recently approved for release. Svata Louda summarizes her ongoing work on the adverse impact of the introduced weevil, *Rhinocyllus conicus*, on native American thistles and in the next chapter the background to this work is discussed by James Nechols in an overview of musk thistle (*Carduus nutans*) control in North America.

Several of chapters deal, in part, with techniques for evaluating non-target effects but the contribution by Jane Memmott is devoted entirely to describing food webs and their potential as a tool for qualitative and quantitative analysis of interactions between plants, herbivores and natural enemies.

So, to answer the question, the book provides fuel for thought and some facts for discussion but is very much concerned with the USA and the problems resulting from a decentralized nation state and a multiplicity of agencies participating in biological control. Much of the book dwells on past actions and their consequences, some contributors are judgmental but neglect to allow for changing attitudes and the pressures placed on practitioners to find solutions to what were perceived to be major threats to agriculture. Other authors recognise the need to strike a balance between economic necessity and preserving the environment so that biological control can continue to be used as an effective means of providing long term suppression of exotic arthropod pests, plant pathogens and weeds with minimal disturbance of non-target species.

In conclusion, the book provides a useful compendium of views, case histories and techniques which will stimulate further debate rather than a balanced overview of the subject or a recipe for future action.

*Follett, P.A.; Duan, J.J. (*eds*) (1999)
Nontarget effects of biological control.
Boston; Kluwer Academic Publishers,
316 pp. ISBN 0 7923 7725 7.
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