General News

Locust Biopesticides: a Tale of Two Continents

Locusts and grasshoppers cause extensive damage to crops in many parts of the world, and their control traditionally necessitates the application of large quantities of chemical pesticides over extensive areas (and not always those suffering the crop damage). Emerging concern about the environmental and health impacts of the insecticides led, during the 1990s, to the development of biopesticides for locust control in Africa and Australia. This year, locusts have hit the headlines in both continents, and it seems a good time to examine what contribution the biopesticides are making to locust control.

In Australia, rains in February broke a 2-year drought and also triggered the most serious locust outbreaks since 2000; further outbreaks are expected as overwintering eggs hatch this spring. Meanwhile, Africa is threatened with the worst locust plague for 15 years. FAO (Food and Agriculture Organization of the UN) has described the desert locust (*Schistocerca gregaria*) situation in northwest Africa as alarming; despite intensive control activities, an upsurge is underway. It warns that a full-scale plague in the region may occur before the end of 2004 and has called for international assistance to help prevent this.

The last desert locust plague in Africa, in 1986–89, took several years, more than US$300 million and some 1.5 million litres of insecticide to bring under control. It was as a consequence of this that the international community, concerned about the nontarget effects of these quantities of pesticides on the environment and human health, initiated the development of alternative control methods. The LUBILOSA (Lutte Biologique contre les Locustes et les Sauteriaux) programme, which began in 1989, developed Green Muscle®, a mycopesticide based on an African strain of the fungus *Metarhizium anisopliae* var. *acridum*. In 1993, Australia's CSIRO (Commonwealth Scientific and Industrial Research Organisation) began a project in collaboration with LUBILOSA to undertake parallel development of a mycopesticide for locusts and grasshoppers in Australia, and this led to Green Guard®, based on an Australian strain of the same subspecies.

Green Muscle® was subsequently recommended by the pesticide referee group of FAO for use in environmentally sensitive areas. The product was licensed to Biological Control Products SA (Pty) Ltd (BCP) for the southern and eastern African markets. BCP registered it in South Africa and started commercial production in 1998. A French company was approached for the West African market. It managed to obtain a sales licence (APV) from the Comité Sahélien des Pesticides in 2001 for the CILSS (Comité permanent Inter-etats de Lutte contre la Sécheresse dans le Sahel) zone, but subsequently failed to get commercial production off the ground. Presently, negotiations are under way with the French daughter of an American company. Meanwhile, the pilot production plant at IITA supplies spores at cost price for trials. The national plant protection service in Niger (funded by Lux Development) integrated Green Muscle® in its anti-locust activities in 2000 and 2001, in conjunction with extension activities coordinated by LUBILOSA. However, full integration is not yet possible because of the limited capacity of the IITA plant.

Although projects (see below) continue to demonstrate its efficacy, Green Muscle® has yet to be widely adopted for anti-locust operations. More data are needed to allow it to be optimally targeted, and one group is working at the grassroots level to integrate the technology for smallholder farmers. Many rely wholly on chemical pesticides and the quantities and costs can be enormous. For the current crisis, FAO reported that 4.1 million hectares across five North Africa countries were treated between October 2003 and May 2004 at a cost of more than US$40 million in an attempt to forestall the threatened plague. (By contrast, the total bill for the 12-year LUBILOSA project was about US$17 million). Whereas chemicals may be needed for a quick 'knock-down' to protect adjacent crops, it is becoming increasingly apparent that mycoinsecticides have a clear role in environmentally sound, preventative locust control.

It is a rather different story in Australia, which saw the world's first operational use of a *Metarhizium*-based mycoinsecticide against locusts in the 2000–01 season. Until earlier this year, a prolonged drought meant locust numbers remained low and there has been limited need for control operations. However, although it has by no means replaced chemical insecticides, Green Guard is on the threshold of becoming an integral part of the Australian anti-locust strategy (alongside fenitrothion and fipronil) and is set for full registration there in September. It is an invaluable technology for areas where chemical insecticides are inappropriate – in conservation areas and the expanding organic agriculture sector.

Control of locusts and grasshoppers in Australia is coordinated by the APLC (Australian Plague Locust Commission), which is responsible for managing outbreaks that constitute an interstate threat, and assisting states to manage intrastate outbreaks. Collaboration between APLC, CSIRO and a commercial partner (initially SGB Pty Ltd, latterly Bio-Care Technology Pty Ltd after their acquisition of SGB) facilitated the progression from research to trials to operational use and integration into the national strategy. In contrast, the locusts and grasshoppers targeted in the LUBILOSA programme affect a large number of countries in Africa and beyond, which creates both regulatory hurdles for the product and additional obstacles in the need to obtain a consensus in the affected countries for a solution. Regulatory procedures (for biopesticides as a whole) are being addressed at national and regional levels, but funding creates a further barrier, with commitment to locust and grasshopper biocontrol needed from international donors as well as national and regional bodies. As the article below demonstrates, scientists and other stakeholders have not been idle. But it needs donors to buy into locust biocontrol in Africa if the Australian story is to have a chance of being repeated. A large consortium of donors contributed to the development of Green Muscle® and funding for research into its use continues. Many donor governments have declared strong commitment to sustainable development and poverty alleviation in Africa. Funding the implementation of the Green Muscle® technology provides an opportunity for donors to contribute towards these goals by supporting a sustainable locust and grasshopper control technology in Africa that not only has proved successful in trials there, but also is being adopted into the national strategy in Australia.

A Strong Case for Green Muscle®

Green Muscle®, a mycoinsecticide based on *Metarhizium anisopliae* var. *acridum*, was developed by the LUBILOSA programme whose partners included AGRHYMET-CILSS (Centre Régional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle – Comité permanent Inter-états de Lutte contre la Sécheresse dans le Sahel), CABI Bioscience and IITA (International Institute of Tropical Agriculture). The 12-year programme turned a research success (the formulation of fungal spores in oil) into a commercial product by addressing production, storage, formulation and application issues. It demonstrated the practical application of biopesticides in the harshest of environmental conditions (deserts) against an extremely mobile and difficult target pest (the locust). The safety and efficacy of Green Muscle® against the major acridid species in Africa, such as desert locust (*Schistocerca gregaria*) in West Africa and brown locust (*Locustana pardalina*) in southern Africa, was demonstrated in field trials in collaboration with African national programmes. Since then, a number of projects have continued with assessing Green Muscle®'s impact on pest species (not just in Africa), and conducting environmental impact studies and ecological research that will allow applications to be timed for optimum efficacy.

Central and Southern Africa

As part of a project on environmentally sustainable control of red locust (*Nomadacris septemfasciata*) in central and southern Africa, funded by the UK Department for International Development (DFID) and led by Imperial College London, several field trials have been conducted with Green Muscle® in Zambia and Tanzania over the last 4 years. These included operational scale treatments against red locust nymphs during the wet season and against adult locusts during the dry season (these large-scale applications were co-funded by FAO [Food and Agriculture Organization of the UN] Technical Cooperation Programme funds). The overall results from the trials indicated that red locust nymphs and adults were susceptible to the fungus and that spray applications caused significant population reductions.

The efficacy studies were accompanied by environmental impact studies to determine the effects of the biopesticide on nontarget invertebrates relative to a chemical pesticide standard. These studies showed the biopesticide to have significantly less impact on nontarget species than the chemical pesticide. Indeed, the only nontarget effects recorded were on nontarget grasshoppers. This result is not unexpected and whilst it should not be dismissed as irrelevant, its significance needs to be placed in context. First, the direct nontarget effects from spray applications of the biopesticide are still far less than with a chemical. Second, long-term effects through establishment and cycling of the pathogen through target and nontarget species are likely to be negligible; studies on persistence and sporulation of cadavers in the field indicated high levels of scavenging and predation such that cadavers could rarely be found, making horizontal transmission extremely unlikely.

Supporting ecological studies were conducted to elucidate the effects of temperature and locust thermoregulatory behaviour on performance of the pathogen. These studies provided valuable insights into the mechanisms employed by locusts to combat infection and into the costs of mounting a defence response. The studies of thermal biology also contributed to the development of a GIS-based model that enables us to predict variability in performance of the biopesticide in time and space, based on measures of ambient temperature. The outputs from the model suggest that the biopesticide should be highly effective against red locust nymphs throughout the species' range during the wet season. It should also be effective against adults in the dry season, although speed of kill is slower and more variable (indicating the need to target adults earlier rather than later in the dry season).

Overall, the assessment of locust control experts who participated in the trials (which included national plant protection officers and representatives from the International Red Locust Control Organisation for Central and Southern Africa [IRLCO-CSA] who have the mandate for locust control in the region), was that the biopesticide provided satisfactory control and, given its limited environmental impact, should be considered for red locust control in the future. A commercial producer in South Africa (BCP) has extended registration for the biopesticide from South Africa to Zambia and Namibia, with registration dossiers currently under review in Tanzania, Mozambique and Sudan.

Southern Europe

Locusts and grasshoppers are key pests across extensive parts of southern Europe, North Africa and western Asia; for example, Moroccan locust (*Dociostaurus maroccanus*) is a pest in the Mediterranean region, eastern Europe and western Asia, and Italian grasshopper (*Calliptamus italicus*) has pest status in

Italy, France, Spain, Russia and the new Central Asian republics. Quite apart from the damage inflicted on agriculture, many affected areas are unique ecosystems and the use of chemical insecticides threatens biodiversity. The ESLOCO (Protecting Biodiversity through Environmentally Sustainable Locust and Grasshopper Control) project, funded by the European Union (EU) and led by CABI Bioscience and Imperial College London, was set up to address the problem of providing control while protecting the environment by adapting Green Muscle® technology for Europe and Asia.

As part of the ESLOCO project, numerous lab, semi-field and field studies were conducted in Spain to evaluate the performance of Green Muscle® against Moroccan locust and Italian grasshopper. Whilst speed of kill was shown to be variable and generally slower in the field than in the lab, the overall results indicate that the biopesticide can provide effective control of these two pest species. In particular, the final large-scale trials in Spain demonstrated significant reductions in field populations with better overall control than that achieved with the chemical pesticide malathion.

Extensive investigations were conducted to evaluate the environmental impacts of the locust biopesticide. These ranged from molecular studies of pathogen stability, through studies on establishment and potential for competition with indigenous pathogens, to field-scale studies monitoring impact on nontarget invertebrates. These comprehensive studies indicate that the *M. anisopliae* var. *acridum* isolate used in the biopesticide could potentially establish in Spain, but is unlikely to displace microbial competitors or impact on the majority of nontarget taxa. The one exception is that the exotic pathogen does infect other species of Orthoptera. Once again, this not unexpected result should not be dismissed, but its significance should to be put in context; the host range of the pathogen is considerably narrower than any of the chemical alternatives currently available for use and direct nontarget effects are substantially less with the biopesticide than with a chemical.

To assist in understanding the variability in effectiveness of the biopesticide and develop an appropriate use strategy a pathogen performance model was developed. Based on an understanding of locust thermal biology and the effect of locust body temperature on pathogen growth, the model uses environmental temperature to predict speed of kill of the pathogen. Using historical data and a GIS platform, the model has been used to derive maps which describe likely pathogen performance across the locust season in different years and at different locations in Spain.

The outputs show expected performance of the biopesticide, expressed as number of days for 90% of a locust population to die following treatment. The efficacy maps reveal that there is spatial variation in expected pathogen performance across Spain (and beyond) at different times. In general, the biopesticide is expected to work more quickly during the early part of the season, compared with later. That said, effectiveness varies with age of locusts at time of application; high levels of mortality before 20 days might be important if locusts are 4th instars, but will extend to 30 days if the treatment is against 1st and 2nd instars. Thus, the model reveals three important points with respect to use strategy:

1. Environmental conditions in the early-mid season appear to be more conducive for pathogen growth, suggesting the best opportunity for using the biopesticide will be in April and May in most of the locust-breeding areas.

2. Given that the pathogen is relatively slow to act, applications against early instars will increase scope for using the biopesticide. This emphasizes a need for accurate forecasting and surveying to identify locust populations before they reach their very apparent stage in the field (by which time they are already 3rd or 4th instar).

3. Generally, the model confirms that pathogen performance is variable and that control of Moroccan locust with the biopesticide will not be possible at all times. Understanding this is essential to optimizing use of the biopesticide.

The Green Muscle® dossier has been revised to include results from the efficacy and environmental impact studies and brought in line with the requirements of European Commission Directive EU 91/414 Annexes IIB and IIIB. The relevant parts of the dossier are being translated into Spanish and are due to be submitted to the Spanish regulatory authorities shortly.

West Africa

DANIDA (Danish International Development Agency) has funded a regional programme for environmentally sound grasshopper control in the Sahel (PRéLISS: Project Régional de Lutte Intégrée contre les Sauteriaux au Sahel), which is being implemented in Niger, Senegal, Burkina Faso and Cape Verde. The partners in this project are IITA, AGRHYMET, the Danish National Environment Research Institute (DMU) and the Danish Heath Society (DDH Environment and Energy A/S). A major focus is the integration of Green Muscle® into a sustainable approach to the management of grasshoppers (notably Senegalese grasshopper, *Oedaleus senegalensis*) in the Sahel. The decentralization of national plant protection services in many Sahelian countries and new tools, notably microbial biocontrol, create an opportunity to develop environmentally friendly options for grasshopper control in the region by integrating ideas from agricultural research, natural resources management and rural development. The project is working with a range of stakeholders including farmers, village brigades, plant protection officers and national and regional organizations to develop, test and implement this new approach.

Green Muscle® forms the basis of the IPM strategy under development by PRéLISS. Although the LUBILOSA programme has already done most of the research necessary for the development of the product, some questions remain. It is, for example, not yet clear what the optimum dose to apply is under various circumstances. Since the price per kilogram is relatively high, there is considerable pressure to lower the dose as much as possible to be able to compete with chemical insecticides. Field trials conducted in the first 2 years of PRéLISS indicated that the current recommended dose of 50 g/ha for grasshopper control can be reduced to 25 g/ha. This year's trials will hopefully confirm this result. The price per hectare will then be brought into the range of competing products.

Another line of investigation is the mixture of Green Muscle® with low doses of relatively benign chemical insecticides, like pyrethroids. The rationale for this is that farmers do not have much confidence in a product that takes more than a week to yield observable results. For psychological reasons, a fair proportion of grasshoppers should be dead or at least twitching before the end of the day on which they were treated. Initial results of trials in Senegal indicate that the approach could work, but the dose of the chemical product should be further reduced.

One problem with the large-scale application of chemical insecticides is that they often have a more serious effect on natural enemies than on the target insect. This has long been suspected in the case of locust and grasshopper control. For that reason, PRéLISS is studying the impact of natural enemies on grasshopper populations. It has already been established that those attacking egg pods play an extremely important role in regulating populations. In some areas, they often destroy 60–80% of eggs. Another group of natural enemies that turns out to be important is birds. A number of bird species in the Sahel specialize on grasshoppers and others switch to grasshoppers when the latter reach certain densities. The project has found that birds have an important regulatory effect at low to medium grasshopper densities.

Given the effect that chemical insecticides have on nontarget insects and even birds, it is easy to see that large-scale applications may be counterproductive. Current grasshopper population upsurges will be suppressed, but the disappearance of many natural enemies will create the conditions for the next upsurge. To get a better idea of this, the project is developing an ecological model that includes grasshoppers, their natural enemies, their impact on crops and the effect of various control methods. Provisional results show that, indeed, applications of chemical insecticides tend to increase the chance of future outbreaks. The important role of various natural enemies is also confirmed.

Two new approaches to grasshopper control are being studied: the potential for releasing an exotic egg parasitoid in the genus *Scelio* and a pathogenic protozoan, *Nosema locustae*. Release of the exotic *Scelio* would create a new parasitoid/host association, because *Oedaleus* does not occur in its native range. However, the potential effects on indigenous *Scelio* spp. and on nontarget grasshoppers need to be studied. *Nosema locustae* is already used to some extent in North America. Although it does not provide significant immediate control, it does become established in the population and causes reduced fitness, especially lower fecundity, over many years. The project is studying the merits of releasing *N. locustae* in areas of West Africa with recurrent high grasshopper densities.

In order to assist decision makers in selecting the best control method and in targeting their limited resources to areas most likely to experience grasshopper upsurges, the ecological model is being integrated into a GIS-based decision support tool. Ecologically sensitive areas, like national parks and reserves and important bird areas (IBAs), have been mapped into the tool, so that it becomes easier to avoid them when chemical control has to be carried out. The programme will predict areas at risk of high grasshopper populations based on the population densities of the previous year, any control measures taken and the most recent egg pod surveys. It will also show the effects of any of the possible control methods on grasshopper densities, crop yields and populations of natural enemies.

At the end of the present phase of the project, the ecological model and decision support tool will be at an advanced stage. However, several seasons of validation will still be necessary. In addition, end users of the tool need training in its use and agencies collecting meteorological and other data used in the model need to be sensitized and convinced to supply the information either free of charge or for a reasonable fee. The project is presently seeking funding for a second and last phase to achieve its goals.

The principal beneficiaries of the PRéLISS project will be the resource-poor farmers who will gain a grasshopper control technology of minimum risk to themselves, their animals and the environment, yet will enhance agricultural production. At the same time, agricultural and environmental stakeholders will gain a control approach that compromises neither's goals. The project is therefore putting a lot of effort into the sensitization and training of farmers. This is mainly done in close collaboration with local NGOs. A special approach has been developed in Niger in collaboration with the Ministry of Agriculture, FAO and Lux Development (Luxemburg). In villages where farmers have organized themselves, cooperative shops (non-profit) are established and stocked with quality seeds, fertilizers and pest control products, which are provided to the farmers at cost price. Spray equipment and protective clothing can be hired. PRéLISS is supporting the setting up of 16 shops in areas prone to grasshopper outbreaks. Green Muscle® and the pyrethroid Decis® are delivered to the shops at subsidized prices. Special village brigades are trained in monitoring grasshopper populations and proper application techniques. The advantages of an IPM approach are explained to the farmers. During the first 2 years, most of the Green Muscle® delivered to the shops was purchased. Farmers who used it were generally happy about the absence of toxicity, although the slow action of the product caused some anxiety.

Implementation of Green Muscle® Technology in Africa

The various projects above continue to build on the considerable achievements of the LUBILOSA programme that developed the biopesticide technology.

However, challenges still remain to the widespread adoption and implementation of Green Muscle® in Africa. Experience in South Africa, for example, reveals that demonstrating efficacy, achieving registration and establishing production capacity are not sufficient for technology acceptance. Registration remains a serious obstacle because of the time and cost involved in registering the product in all the countries affected by locusts and grasshoppers. This exceeds the resources of the single company presently producing Green Muscle®. In the current projects we have encouraging support from FAO and regional locust control organizations, together with an effective and motivated producer who wish to see the product a commercial success. Nonetheless, given the complexities of locust and grasshopper control (i.e. donor-funded programmes with generally preventive control actions taken in areas/countries far away from the ultimate beneficiaries) and the fact that the benefits of the technology are linked in part to 'non-market' environmental values, we believe that there is still a need for further support to ensure adoption of this promising and innovative technology. Ultimately, widespread adoption rests with donor commitment to purchase the product and pay for protection of the environment as well as controlling locusts and grasshoppers.

Further Information

LUBILOSA: www.lubilosa.org/

Desert Locust Information Service:
www.fao.org/NEWS/GLOBAL/LOCUSTS/Locuhome.htm

ICOSAMP (Information Core for Southern African Migrant Pests) News:
http://icosamp.ecoport.org/bulletin.html

AGRHYMET Info:
www.agrhymet.ne/agrinfo/bulletin03_2003.pdf

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Operational Use of Green Guard® for Locust and Grasshopper Control in Australia

Australian farmers, State government authorities and the Australian Plague Locust Commission (APLC) will shortly have a viable alternative to traditional chemical pesticides for control of locust and grasshopper pests threatening grazing pasture and agricultural crops in chemically sensitive areas. Green Guard®, a mycoinsecticide containing conidia of *Metarhizium anisopliae* var. *acridum* (isolate FI-985), is now being produced commercially by Bio-Care Technology Pty Ltd following the acquisition of SGB Pty Ltd (the original suppliers) in 2003. Full registration of the product in Australia is expected by October 2004. However, extensive large-scale field testing of various formulations of this product has been undertaken by the APLC since 2000 under a series of special use permits issued by the Australian Pesticide and Veterinary Medicines Authority (APVMA).

The development of Green Guard® to this stage was driven in part by an increasing trend towards organic farming in Australia during the late 1990s and a reaction by many farmers to overuse of chemical pesticides. Produce grown under the 'clean and green' banner promised higher returns for farmers from domestic and international markets. The development of a major organic beef industry in the remote grasslands of western Queensland and South Australia, considered to be a significant breeding and 'outbreak' area for the Australian plague locust, *Chortoicetes terminifera*, also forced the APLC to rethink its strategy of early intervention with chemical control to reduce locust populations and migrations into the intensive cropping areas of eastern and southern Australia. A survey of cattle producers in this area in 1999 determined that at least 50% of suitable locust habitat could become inaccessible to the APLC for future control operations if there was no acceptable alternative to chemical pesticides (primarily fenitrothion) available. A range of options was explored and of these, use of the fungus *Metarhizium anisopliae* var. *acridum*, applied as a biopesticide registered as Green Guard® (a CSIRO [Commonwealth Scientific and Industrial Research Organisation] initiative), showed the most promise. To further develop the product and coordinate research opportunities and funding, the Locust and Grasshopper Biocontrol Committee was formed with representatives from CSIRO, State departments of agriculture (Queensland and New South Wales), the APLC and landholder groups. Funding from each of these groups assisted with important lab and field efficacy studies on each of the major locust and grasshopper pest species affecting agriculture in different areas and crops, e.g. APLC – Australian plague locust, (pasture and cereals); Queensland – spur-throated locust, *Austracris guttulosa*, and migratory locust, *Locusta migratoria*, (pasture and sorghum); New South Wales and landholders – wingless grasshopper, *Phaulacridium vittatum*, (orchards, vegetables, lucerne and pasture).

During 1999/2000, a series of aerial trials (total of ca. 4000 ha treated) applying ultra low volume (ULV) formulations of Green Guard® determined that effective control (>90%) of Australian plague locust nymphs could be achieved at a dose of 25 g (1×10^{12}) conidia per hectare applied at rates of 500 ml to 1 litre/ha of carrier oil (Caltex Summer Spray oil) through Micronair AU5000 rotary atomizers. Previously rates as high as 50–125 g/ha had been tested. Based on the efficacy of this lower rate the APLC entered into an agreement with the commercial producer (SGB) to purchase a minimum of 500 kg of conidia annually (equivalent to treatment of 20,000 ha at the 25 g/ha dose) for a period of 3 years. This guaranteed 'market', whilst small, enabled small-scale commercial production and provided a degree of financial certainty that allowed SGB to plan longer term, scale up production, build better facilities to improve output and tackle problems associated with quality of product, drying of conidia, stability of formulations and long-term storage of large quantities of conidia. In short the production progressed from the scale needed to support a small research programme to a commercial operation.

The nature of the product formulation was critical to the successful development of Green Guard® as an operational ULV pesticide. The CSIRO team under Richard Milner (r.milner@ento.csiro.au) worked closely with the APLC to develop a formulation that could be easily transported and mixed in the field while not causing blockages in aircraft spraying equipment. The result was an oil concentrate containing 300 g of dry conidia per litre of corn oil. This was then diluted in a low viscosity mineral oil (Caltex Summer Spray oil) to give the required concentration for ULV application. Corn oil was chosen as its viscosity assisted in keeping the conidia in suspension and it mixed readily with the mineral spray oil. The oil concentrate was supplied in 20-litre heavy-duty plastic buckets (allowing easy access for remixing) each containing 14 litres of oil and 4.2 kg of conidia. The choice of Summer Spray oil as the diluent was made following advice from National Association for Sustainable Agriculture Australia (NASAA), the main organic farming certifying organization, that this oil could be applied with the Green Guard® ULV concentrate to certified organic properties.

Using this ULV formulation the APLC developed and refined a standard 'incremental drift spraying' application technique for blanket aerial treatments with Green Guard® based on field trial results and wind tunnel tests. In the wind tunnel evaluations the formulation was run at operational flow rates through a Micronair AU5000 atomizer using various blade settings (to vary cage rpm [revolutions per minute] and droplet size) with an air velocity of 200 km/h (to duplicate aircraft flying speed). The spray droplet spectrum produced at each blade setting was determined using a Malvern laser analyser and the results were used to model down-wind deposition patterns under varying wind speed conditions using the Gaussian Diffusion Model (GDM) developed by Ian Craig and Nicholas Woods (Centre for Pesticide Application & Safety, University of Queensland, www.aghort.uq.edu.au/cpas/). The final spraying technique (still in use by APLC today) employed a 100 m spacing between spray runs made at right angles to the prevailing wind, a VAR (volume application rate) of 500 ml/ha, 45° blade setting with Micronair AU5000 (cage rpm – 6100, VMD [volume median diameter] – 96 microns, span – 1.24), a release height of 10 m and a flying speed of about 200 km/h.

Fortuitously, the development of a robust ULV formulation and increased production coincided with a major outbreak of Australian plague locust in eastern Australia. Working under an emergency use permit issued by the NRA, between October 2000 and January 2001 the APLC treated 71 blocks covering some 23,000 ha with Green Guard® . This area comprised approximately 12% of the total area treated during the outbreak, the remainder being treated with fenitrothion or fipronil. Green Guard® was used in areas where chemical pesticides could not (organic properties, national parks, endangered vertebrate species habitat and areas bordering wetlands). Field assessments demonstrated that effective control of nymphs (>90% mortality) was achieved at a dose of 25 g/ha in 500 ml/ha of spray oil over a range of vegetation types and densities. Depending on temperature (both day and night) the time taken to reach this level of mortality varied from 10 to 12 days when maximum day temperatures reached 34–42°C (minimum night temperature of 20–25°C, summer conditions) to 14 to 18 days at 22–30°C (minimum night temperature of 10–15°C, spring conditions). Continuing development of the fungal infection in locusts on warm nights proved to be an important factor that enhanced the usefulness of Green Guard® for control operations in the hot conditions often encountered during the summer plague locust season in Australia.

Following this successful demonstration of Green Guard® as a viable alternative pesticide, work progressed towards implementing it on a fully operational scale. Steps in this programme included improving production and storage procedures, determining effective rates for the control of other locust and grasshopper species, development of a formulation that could be used by farmers with high-volume ground control application equipment (e.g. boom and nozzle) and a complete data package, including toxicology and nontarget effects, to support the registration of Green Guard® for commercial use in Australia. Progress to date has been steady.

A suspension concentrate (SC) formulation was developed and tested (15 trials over 230 ha) on a variety of high value, organic horticultural crops threatened by wingless grasshopper (fruit trees, olives, vineyards, pine trees and lucerne) and Australian plague locust nymphs (improved pasture). Various forms of high-volume water application equipment commonly used by farmers were used to apply this formulation to check for problems with mixing, coverage or blockages. It performed well and at a dose of 50 g conidia per hectare gave farmers effective and economic control. Farmers can currently choose between 1 and 3 ha pack sizes. An emulsifiable concentrate (EC) formulation is under development and should be available by late 2004.

The APLC maintains a supply contract with the new commercial producer, Bio-Care Technology Pty Ltd who is also investigating an expansion of production to include a growing market in China. If successful this arrangement would increase the long-term viability of Green Guard® production in Australia. Current production yields using self-aerating culture bags are about 90 g of FI-985 conidia per kilogram of growing substrate (boiled rice). The dry spores (<5% moisture) are stored as a dry powder or as formulated product at 4°C. Long-term storage tests have shown that the material stores well for a least 18 months under either condition. Current costs for Green Guard® ULV are AU$ 12/ha (using 25 g/ha dose) with an additional AU$ 0.80/litre for the Summer Spray oil. The Green Guard® SC costs farmers AU$ 36/ha.

The APLC also developed a mechanical system for premixing the Green Guard® ULV and Summer Spray oil at airstrips prior to loading into spray aircraft. This had been a major problem during past control operations due to the time consuming and labour intensive nature of the manual mixing process. This new system proved highly efficient during major control operations in February 2004 when 12,500 ha with very high densities of Australian plague locust nymphs were successfully treated on several organic beef production properties in southwest Queensland.

A submission for the commercial registration of Green Guard® has been with the APVMA since mid 2002. As well as the usual problems associated with the registration of a new pesticide, the long review process has concentrated heavily on the possible effects that large-scale aerial use of Green Guard® may have on the environment and nontarget species. Questions from the reviewing authorities have largely been answered and the APLC and Bio-Care Technology Pty Ltd are confident that the product will be registered by October 2004.

It is also worth noting that in the current registration submission, the application rates are based on vegetation cover rather than on locust species. Modelling studies by Joe Scanlan (Queensland Department of Natural Resources, j.scanlan@dnr.qld.gov.au) and field data collected by the APLC indicated that locusts and grasshoppers in tall, thick vegetation pick up most of their lethal dose of spores from the vegetation and require a high dose per hectare, while locusts in short or sparse vegetation require a much lower dose per hectare. Low vegetation is a common feature of Australian plague locust and wingless grasshopper habitats. Therefore a dose of 25 g/ha would usually prove effective against these two pests, although situations do occur where locusts are present in tall or thicker grasses or crops and a 50 g/ha dose would be more effective. Tall, dense vegetation is common in migratory locust habitats so a 50 g/ha dose will be used against this species. The spur-throated locust is almost always found roosting in tall, dense grass or in trees. Many more spores are required to cover the high surface area of this habitat so a higher dose of 75 g/ha is required for this species.

The use of Green Guard® technology in Australia by the APLC and other groups involved in the control of locust and grasshopper pests is likely to increase in the future as widespread use of traditional chemical pesticides in specific areas becomes harder to justify due to economic, environmental or social constraints. Increased production of Green Guard® funded by the APLC and the groups represented by the Locust and Grasshopper Biocontrol Committee provided an impetus for continuing commercial production and registration of the product. It also provided the APLC with the quantities of material required to investigate and ultimately demonstrate efficacy of Green Guard® at an operational level.

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The Fight to Overcome Bridal Creeper in Australia

Australian efforts to bring the environmental weed bridal creeper, *Asparagus asparagoides*, under control are continuing. A concerted effort by the CSIRO (Commonwealth Scientific and Industrial Research Organisation) and the Cooperative Research Centre (CRC) for Australian Weed Management, in collaboration with community groups, schools and landholders, has led to one of the most successful biological control programmes in Australia.

This South African plant was introduced into Australia as an ornamental in the mid 1800s, but soon naturalized and invaded natural bushland. It is now a major environmental weed across the whole of southern Australia and is one of Australia's 20 'Weeds of National Significance'. Bridal creeper is a climber that can smother vegetation and take over large areas of land. In dense infestations, the underground tubers, representing up to 90% of the weed's biomass, form 'mats' under the soil surface that prevent native plants from growing. Birds that feed on bridal creeper's bright red berries spread the seeds and are responsible for the establishment of satellite populations kilometres away from the main infestations.

Three biological control agents of bridal creeper have been released in Australia: the leafhopper, *Zygina* sp. in 1999, the rust fungus, *Puccinia myrsiphylli* in 2000 and the leaf beetle, *Crioceris* sp. in 2002. A national redistribution programme was set up in 2002, with financial assistance from the Australian Government's Natural Heritage Trust, to fast track the release and spread of the first two agents across the entire range of bridal creeper infestations.

Since then, CSIRO staff have taught on-ground groups and landholders the basic skills needed to identify, release and monitor the impact of the agents. A website (www.ento.csiro.au/bridalcreeper) has been developed to provide detailed information about the programme and various protocols. A national database of release sites linked to a web-based interactive map has facilitated keeping track of the releases. According to database entries, the leafhopper and rust fungus have now been released at a total of 827 and 1031 sites, respectively, across southern Australia. These are, however, an underestimate of numbers because not all collaborators have provided details about their releases.

Both the leafhopper and the rust fungus damage bridal creeper by attacking the leaves. The leafhoppers feed on mesophyll cells and their damage is seen as white variegations on the leaf surface. The rust fungus infects stems and leaves and is easily recognizable as yellow circular areas on the upper sides of leaves and by corresponding orange sporulating pustules on the under side. Severe infestations of both agents result in reduced photosynthesis, premature defoliation and reduced tuber production.

Last year, reports of natural spread of the rust fungus of up to 1 km from release sites after one year were very encouraging. In 2003, the rust was also seen to cause severe defoliation of plants in the middle of the weed's growing season. This was particularly apparent in Western Australia, New South Wales and Kangaroo Island in South Australia. This extensive damage prevented bridal creeper from flowering and producing fruits in spring and also severely diminished the underground reserves. These are exciting outcomes which will make a significant contribution towards reducing the spread of this weed and the density of existing populations.

It is still early days for the *Crioceris* sp. leaf beetle, the third agent released against bridal creeper. Establishment has only been confirmed at a few sites in Western Australia, and more work is required to determine the best time and number of insects to release. The leaf beetle has one to two generations per year, consumes young expanding leaves and shoots, and only lays eggs on shooting tips. Both adults and larvae are difficult to handle and consequently this agent will be unsuitable for mass rearing by community groups and schools. However, once the beetles are established at release sites, community groups could become involved in redistributing them to new sites.

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Improving Biocontrol of Weedy Blackberry in Australia

The invasive and destructive blackberry, *Rubus fruticosus* aggregate, is one of southern Australia's most important 'Weeds of National Significance'. Its impenetrable thickets reduce the production, recreational or aesthetic value of land and block access to waterways. It is now estimated that blackberry occupies 8.8 million hectares of Australia, an area larger than Tasmania.

A new attempt towards the biological control of blackberry began in April 2004 with the first release of additional strains of the rust fungus, *Phragmidium violaceum,* from Europe. There had been two earlier introductions of this rust fungus into Australia – an illegal one in 1984 and, in 1991, an official release of another strain of the fungus. These introductions had mixed results. In some areas they had practically no effect on blackberry while in others they severely defoliated bushes.

Work in the 1990s by the Cooperative Research Centre (CRC) for Australian Weed Management led to a much better understanding of the genetic variation in blackberry and provided the basis to improve the biological control of this troublesome weed. Eight additional European rust strains were selected because together they can affect a wider range of Australian weedy blackberries. Results from specificity tests showed that these rust strains do not pose a threat to commercial blackberry cultivars and Australian native *Rubus* species. After the required consultation process, Biosecurity Australia cleared the strains for release on blackberry.

The current strategy is to release the additional rust strains at different time of the year at a few experimental release sites in the Manjimup region in Western Australia and the Tumut region in New South Wales and the first releases were made in April 2004. All eight rust strains were released at each site to maximize the chance of at least one type finding local blackberries to its liking.

Outcomes from this work will assist in determining the best season for releasing the rust strains in order to increase their chance of establishment before large-scale releases are undertaken across Australia. Molecular tools will be used to determine establishment rates of the rust strains, as they can not be distinguished morphologically from the existing populations of the rust in Australia. The long-term effectiveness of the additional rust strains released will be assessed in future years by monitoring changes in blackberry biomass along permanent transect lines set up at the sites.

Other partners in this research include the Western Australian Department of Conservation and Land Management, the Western Australian Department of Agriculture, and the Australian Government's Department of Agriculture, Fisheries and Forestry.

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New Florida Home for Biocontrol

On 9 July 2004 a dedication ceremony was held for a new purpose-built quarantine facility dedicated to the biological control of invasive plants and arthropods in Florida. On this date the University of Florida's Institute of Food and Agricultural Sciences officially began operations in its Biological Control Research & Containment Laboratory (BCRCL) as part of its Indian River Research & Education Center in Ft. Pierce. The 17,000 square foot (1580 m^2) facility, funded by the Florida Legislature, will be used by entomologists to contain, evaluate, rear and release host-specific insects for biological control of invasive plants and arthropods. Work will be conducted in a cooperative environment with the Florida Department of Agriculture and Consumer Services.

The BCRCL features two sections, one for containment and another for non-containment. The containment section includes two laboratories, one for research on biological control of arthropods and another for research on biological control of invasive plants. Also in the containment area are a maximum security laboratory, a fumigation room, a pass-through autoclave, a fume hood room, six climate-controlled rearing rooms, a diet preparation room and six spacious greenhouses. Within the non-containment area are two additional laboratories, a conference room, a camera room and seven offices. Maintenance and operation of the facility is funded annually by a grant from the Florida Legislature.

In Florida, more nature is lost annually to invasive plants than to development. An estimated 1.5 million acres [over 600,000 ha] in central and south Florida are consumed by three of the most well-known invasive plants: Brazilian peppertree (*Schinus terebinthifolius*), melaleuca (*Melaleuca quinquenervia*) and Australian pine (*Casuarina equisetifolia*). The Mexican bromeliad weevil (*Metamasius callizona*) is endangering populations of Florida's native bromeliads, or 'airplants'. The cycad aulacaspis scale (*Aulacaspis yasumatsui*) is devastating one of the area's most popular landscape plants, the king sago (*Cycas revoluta*). Research for the biological control of these invasive pests is currently being conducted by BCRCL scientists.

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Parasitoids of Mealybugs on Coffee in Cuba

The 1990s in Cuba were important years for researching and introducing new phytosanitary strategies with a view to converting an agriculture dependent on chemical products towards a sustainable one. This transformation has involved the development of integrated pest management (IPM) and, in particular, one of its most effective tactics: biological control. Coffee has been one of the crops that recently received the benefits of the new strategies, but species lists and biological and demographic studies remain inadequate. This article records the results of surveys for mealybug (pseudococcid) natural enemies carried out in Cuba's coffee-growing regions.

Mealybugs are among the main pests of coffee. They attack different parts of the plant and are very difficult to control with chemical products. Before effective biological control strategies can be developed, more effort must be devoted to aspects of basic research such as taxonomy. This includes the characterization of the indigenous beneficial fauna, information which can be used in the development of an appropriate control strategy.

Surveys were conducted in different seasons in the central and eastern regions of the country, where there are important coffee-producing areas. Samples of leaves, branches, fruits and roots infested with mealybugs were taken to the laboratory, where the natural enemies were reared out.

The following encyrtid primary parasitoid species and genera were reared from mealybugs on coffee during the surveys, most of which have been used successfully in biological control programmes in other countries:

- *Coccidoxenoides perminutus* Girault (= *Coccidoxenoides peregrinus*, *Pauridia peregrina*): used against *Planococcus citri* in Bermuda (1951, 1953) and *Planococcus kenyae* in Kenya (1938)
- *Hambletonia pseudococcina* Compere: used against *Dysmicoccus brevipes* in Hawaii (1935–36)
- *Leptomastidea abnormis* (Girault): used against *P. citri* in Italy (1953)
- *Leptomastix dactylopii* Howard: used against *Nipaecoccus viridis* in Hawaii (1925) and *P. citri* in Spain (1948), the USSR (1948) and India (1983)
- *Blepyrus* sp. (=*Euryrhopalus* sp.)
- *Chrysoplatycerus* sp.: *C. splendens* was used against *Pseudococcus affinis* in South Africa (1939–40)

Other encyrtid genera collected are known from the literature to be hyperparasites: *Coccidoctonus* sp., *Gahaniella* sp. and *Prochiloneurus dactylopii* (Howard) (a new record for Cuba).

Also found was *Diadiplosis cocci* Felton, a small cecidomyiid fly whose larva develops under the ventral surface of its mealybug host. The larvae can live in either the aerial parts of the plant or the roots, feeding on the body contents of their hosts and acting as ectoparasites.

The search for new and promising natural enemies associated with pseudococcids needs to continue. Nevertheless, the knowledge acquired from these recent surveys allows us to begin work on methods for improving the conservation of the beneficial biota in the crop. It is also important to have identified the indigenous natural enemies in case it becomes necessary to develop strategies of mass propagation and augmentative release of these potential agents in order to maintain control of mealybug populations on coffee.

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IPM Systems

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

Learning from Failure

Two participants in a smallholder IPM project in Malawi have written an account of its failures[1]. Far from being driven by disenchantment, this atypical project output gives a useful assessment of the lessons that were learnt, and from which future projects can plan. Given the acknowledged poor uptake of IPM by smallholder farmers in Africa, this examination of the reasons for the failings of an IPM project is an important addition "to the small but growing literature that documents the learning process in technology development with and for resource-poor farmers."

In fact 'failure' is hardly a fair description of the Farming Systems IPM (FSIPM) project in southern Malawi, which was funded by the UK Department for International Development (DFID). It largely met its project objectives, but in their paper the authors are assessing how far the project is likely to contribute to its 'supergoal' of 'Improved incomes for resource-poor farmers'. They say that although it is too early to make a formal assessment, in their opinion it is unlikely to succeed in this sense.

The 3-year FSIPM project was designed to a blueprint which assumed pests were the major constraint on smallholder production. Reconnaissance surveys and on-farm trials showed that this was not the case. The paper's authors (an agricultural economist and an IPM specialist) argued that, in Malawi at least, smallholder IPM will only be effective within the context of improving crop management (e.g. improved fertility and better varieties) to increase yields. Without higher yields there is no economic incentive for IPM. IPM strategies are more likely to be accepted by farmers if they are clearly linked to technologies which raise cash incomes.

It would be wrong to assume that the project continued blithely without addressing the perceived shortcomings as they became apparent. In fact, the project made the learning process an integral part of the project, rather than leaving it to later external review. During the project, which tested 18 IPM strategies (including three farmer-developed strategies) against seven major pests and diseases of maize, beans, pigeon pea and sweet potato, 'new learning' was identified at the end of each crop season, and both the mistaken assumption that preceded it and the changes made to the project as a result of the new learning were recorded. The recent paper summarizes these into six lessons.

1. *The project addressed the wrong problem.* The assumption that crop losses from pests were a critical constraint was incorrect. Although the smallholder farmers of southern Malawi do experience severe losses following pest outbreaks, this is less of an issue than poor soil fertility and the high price of fertilizer. IPM can have a role, but as one component of a broader integrated strategy to improve crop productivity, not as a stand-alone solution for improving smallholder livelihoods.

2. *Farmers had little economic incentive for adopting IPM.* Smallholders everywhere need to perceive an economic benefit before they will adopt a new farming technology. The assumption that the high costs of pesticides would make IPM (with reduced pesticide applications) economically attractive failed to take into account how little, if any, pesticide farmers apply to food crops. IPM does have potential in some vegetable cash crops where farmers are prepared to make greater investments (in pesticides, weeding, etc.) but this needs to be market-led and linked to wider efforts to raise productivity and incomes. Varietal resistance and classical biological control are the most attractive approaches from the farmers' point of view, since the costs are borne by the national agricultural system.

3. *Pest damage varied between sites and seasons.* The project was designed on the assumption that the target pests were equally serious everywhere in every season, which they were not. As a consequence, some of the on-farm trials gave inconclusive results. Reasons for farmers overestimating pest incidence varied from confusion over names to a wish to be included in a project that might provide valuable inputs. The problem was exacerbated by the need to fulfil socioeconomic targets for inclusion of different farming household types.

4. *The 'basket' of technologies was almost empty.* The project was expected to test IPM technologies developed in earlier projects but almost all of these proved inappropriate, so the project had the additional task of developing alternatives to test. A common misconception is that resource-poor farmers will adopt labour-intensive IPM practices. New interventions may also not be adopted because they conflict with something the farmer is already doing (whether or not it is effective), or they may prove to be economically beneficial only under certain circumstances (e.g. high pest pressure).

5. *Standard research methods had their limitations.* Statistical rigour and verification did not fit easily into the context of testing IPM strategies in the on-farm trials (especially in view of the problems described above), and while qualitative approaches lend themselves more easily to location-specific interventions and interventions that vary with the pattern of events, they are difficult to validate. Participatory rural appraisals (PRA) that use group discussion tended to produce a "chorus line of mutually agreed responses", and individual interviews provided better insight into how and why a farmer chooses a particular course of action.

6. *Farmer participation was not optimized.* Farmers found it difficult to assess the results of the on-farm trials; the factorial design included several treat-

ments on the same plot and farmers did not have a directly comparable control to look at. Other interventions were difficult for farmers to understand because of gaps in their knowledge (e.g. about pest biology), and training in farmer field schools (FFS) was not always enough to allow them to evaluate a strategy as well as the researchers.

The paper goes on to discuss why, despite identifying failings and making efforts to redesign the project to meet farmers needs better, it still proved largely unsuccessful in contributing to the supergoal. Some successes are also highlighted. Why these succeeded where other interventions failed backs up the explanations for the failures.

- *An IPM strategy needs to be market-led.* In Malawi, pigeon pea has a large internal market and export potential. Farmers ranked it as their second most important cash crop, but *Fusarium* wilt was identified as a constraint to production. One IPM option assessed was planting with a new variety, ICEAP 00040. This proved to have a promising combination of attributes: as well as good resistance to *Fusarium* wilt, the new variety gave high yields with large seeds that are easy to process and have good taste and colour. These attributes led to a high demand for the new variety from processors and consumers, and it was approved for release.
- *IPM needs to form part of improving crop management.* Infestation by the parasitic weed *Striga* is a symptom of low soil fertility. One of the IPM strategies tested for its control involved green manures (*Tephrosia vogelii*, *Crotolaria ochroleuca*). These contributed directly to improving soil fertility and, although there was no evidence that *Striga* incidence was reduced, maize yields were increased. There is thus an economic incentive for this IPM technique and work on it is continuing as part of a soil fertility research programme.

The authors note that project learning usually takes second place to technical results. Where initial expectations are not met, donors and scientists are often reticent about exploring what went wrong. However this paper draws out the relevance of these issues for agricultural research with African smallholders in the firm belief that “a fertile error is better than a sterile truth.”

[1]Orr, A.; Ritchie, J.M. (2004) Learning from failure: smallholder farming systems and IPM in Malawi. *Agricultural Systems* **79**: 31–54.
(Available online at www.sciencedirect.com)

Web: www.nri.org/research/farmsys-ipm.htm

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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.

Lessons on FPR from Vietnam

A major difference between FPR (farmer participatory research) and the traditional top-down model of extension is that through FPR farmers learn to solve their problems rather than being told what to do. For scientists and extension staff engaged in FPR, facilitation skills are as important as technical ones, yet they are rarely trained in how to communicate with farmers. New ways of improving communication between all FPR participants have been piloted as part of the latest phase of a project to improve disease management in Vietnam, funded by ACIAR (Australian Centre for International Agricultural Research). This article highlights two of the approaches developed and tested in the CABI Bioscience-led project, and is concerned not with what gave most effective disease control but what improved the process of finding out.

Letters to Mother

Writing reports is probably the least-favourite activity in any project. The problem is particularly acute in FPR, as most of those involved, and particularly farmers, will have little or no experience of expressing their ideas about it on paper. CABI Bioscience FPR specialists have developed a novel method* to help all those involved to write about their participatory research activities more easily.

The answer does not lie in teaching farmers to write like scientists. The scientific style does little to help people who are usually reluctant to write in the first place – the flow of words slows and ideas struggle to emerge. Instead, farmers are encouraged to imagine that they are writing to their mother (or someone else close to them). By creating a familiar situation – explaining what you have been doing to someone you are used to talking to – the barrier is lowered. Another advantage of this approach is that people write in the language they find easiest to use. Translations can be done later, and once the scientists have the ‘letter’, they can analyse it for key points.

To summarize what happens, people are asked to imagine that they are writing home to describe what they have been doing. This is usually done in groups, and the time taken has varied from about 20 to 45 minutes. The idea behind the scheme is to get people to relax, to provide just enough information to explain what happened and to reveal some of the pain and pleasure of their work. Writing can also be participatory, which helps all involved to learn more about what others are doing and how they approach their work.

A simple scheme is to ask writers to explain in their 'letter':

- What things went well and why?
- What things didn't work and why?
- How would you improve what you did?
- What results did you obtain?
- What are you planning to do next?

The 'letter' approach was used not just by farmers, but by facilitators and teachers – extension staff and scientists – to express how they felt about what they had been doing. This provided input, for example, from all participants on experiments conducted in farmers' fields, which gave useful insights into how the views of farmers, extension staff and scientists varied, and how these changed as the research progressed (whether or not the experiments were a 'success'). The 'letters' did not always give adequate detail, but they did convey a sense of what happened. A refinement suggested by the report authors is to extend the activity so that the trainers write back as 'mothers' asking their 'offspring' to tell them more, perhaps to explain some events that are not clear, while providing encouragement by saying how pleased they were to hear about what they had been doing.

One aspect of traditional report writing remains: the letters need to be done on the spot, and people have to be encouraged to write them, or they become another chore to delay or ignore.

FPR is still at an early stage of developing a menu of successful methods. The 'Letters to Mother' approach simplifies the reporting procedure, but also gives important insights on what happens when researchers collaborate with farmers.

Looking at Interviews

Talking to farmers is a key skill for anyone engaged in FPR. Yet extension staff and scientists – even social scientists – have little if any formal training in conducting interviews. They need to acquire this skill if they are to be able to find out what farmers are doing and why they are doing it. Some have a natural talent for interviewing but others underestimate the difficulties of obtaining information from farmers and using this to jointly develop new approaches. Good interviewing skills include asking the right questions, listening in the right places and then responding as researchers, plant protection officers or extension workers to help the farmer do better. How can these skills be taught? To explore one approach, an 'Interviewing farmers' exercise was included in a one-day workshop on communicating research outputs to farmers, held in My Tho in March 2004.

The pilot exercise centred on studying a series of photographs that showed farmers being interviewed. Workshop participants were asked not to try and guess what was being said or discussed, but to treat the images as a stimulus for considering what happens during interviews. Various photos had clues suggesting that the interview was going well, or not, but participants were asked also to think about general events that happen during interviews. Suggestions included thinking about a similar experience: a photo of people relaxing at a farmer's house after visiting her fields might lead them to discuss whether, in a similar situation, the participants had learnt something new about what the farmer was doing. Another photo showing a large group of visitors to a farm could lead to discussions about whether the size of the visiting group affected how easy it was to find out about the farmer's problems. Yet another illustrated visiting scientists talking to each other and almost forgetting the farmer was there.

Although participants seemed hesitant at first, they began to suggest how the interviews could have been improved. Holding an interview is a crucial tool in the basket of methods used in FPR. The photo sheet method piloted here will not transform a participant into an expert interviewer, but it is a potentially quick method for helping to demonstrate some of the pitfalls and problems encountered when talking to farmers – and it encourages people to think about what happens when *they* conduct an interview.

*The idea was suggested by Dr Tom Preece, PhD supervisor to Eric Boa, when the latter was writing his thesis.

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Natural Methods for Rice Blast Control: Farmers' Experiences

Blast caused by the ascomycete fungus *Pyricularia grisea* (sexual stage: *Magnaporthe grisea*) is a severe disease in paddy (rice) growing areas in India and can cause heavy damage under favourable disease conditions. It has been found that a single 'spot' can disseminate at least 5000 spores to a healthy crop under such conditions. This success story shows how tribal farmers in Andhra Pradesh were able to control the disease by using locally available resources.

Prabhatnagar-Reddigudem is a village in the Paloncha mandal of Khammam district, Andhra Pradesh. Every year in this village they grow paddy on up to 1200 acres (485 ha). The amount of money they spend per acre for plant protection is very high while productivity per acre has been decreasing year on year. In 2003, the farmers experienced severe blast on all 1200 acres. They do not have access to Department of Agriculture information and they did not know what to spray. Instead, they approached the local pesticide dealers who are the pest management advisors in the villages. They recommended the costly fungicides tricyclazole, propiconazole and edifenphos, but even spraying these chemicals did nor allow the farmers to control the disease. At this point, the farmers came to hear about non-pesticidal management (NPM) practices that were being followed in the neighbouring village of Punukula. They approached the farmers there, who advised them to approach CWS (Centre for World Solidarity), a premiere NGO based in Hyderabad, which is promoting this form of sustainable agriculture in five Indian states.

CWS advised them to prepare and spray a mixture of cow dung, urine and asoefetida on their fields. The mixture was prepared using 5 kg cow dung, 5 litres cow's urine and 250 g asoefetida for each acre to be treated and fermenting it for 5 days; 100 g/acre lime powder (calcium chloride) was added to the fermented mixture before it was sprayed on the fields. Most of the farmers adopted this practice and successfully controlled the disease. The farmers said that the cowdung–urine–asoefetida mixture not only arrested the spread of the disease but also initiated the growth of new tillers. They recorded an increase in yield of 4–5 quintals (400–500 kg) with this method.

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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.

IOBC Fifty in 2005

The General Assembly of IOBC/WPRS (International Organization for Biological and Integrated Control of Noxious Animals and Plants, Western Palaearctic Regional Section) will take place in Dijon, France on 17–21 September 2005. As well as the formal General Assembly, there will be a scientific meeting and a celebration of the 50th anniversary of IOBC.

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Fruit Flies on the Net

A new database, the Tephritid Fruit Fly Workers Database, was launched in May at:
www.tephritid.org/nafa/srv/en/nafa.home

The online database, which has been established by the Insect Pest Control Section of the Joint FAO/IAEA (Food and Agriculture Organization of the UN/International Atomic Energy Authority) Division of Nuclear Techniques in Food and Agriculture, has grown out of the IOBC (International Organization for Biological and Integrated Control of Noxious Animals and Plants) annual newsletter. The site includes news, a directory of workers and a publications database.

Because of the economic importance of many tephritid species and their threat to fruit and vegetable production and trade worldwide, they are becoming increasingly important and a tremendous amount of new information on them is made available each year. The goal of the new database initiative is to facilitate collection and sharing of information to allow tephritid workers worldwide to keep up with developments in this fast-moving field. To register electronically, go to the website

International Fruit Fly Symposium

The 7th International Symposium on Fruit Flies of Economic Importance will be held in Salvador, Bahia, Brazil on 10–15 September 2006. This symposium series is organized under the umbrella of a geographically balanced steering committee from the international community of fruit fly workers.

Although the growing importance of fruit flies worldwide means that there are now some two thousand pure and applied scientists working in this field, the fruit fly community, including researchers and action programme and industry representatives remains a close one. The 4-yearly international symposia grow larger every time, fuelled by scientific vigour and some spectacular area-wide control successes, but the focus is on organization to allow interactions between all participants.

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International Journal of Tropical Insect Science

CABI International and ICIPE (International Centre for Insect Physiology and Ecology) have entered into a new publishing collaboration to improve the outreach and impact of the former journal *Insect Science and its Application,* now named the *International Journal of Tropical Insect Science.*

This is the 24th year of publication of *Insect Science and Its Application* since its founding in 1980 by Kenyan entomologist and first Director of ICIPE, the late Thomas R. Odhiambo, and the African Association of Insect Scientists (AAIS).

The first issue the *International Journal of Tropical Insect Science*, which is a special issue, has now been published and is entitled 'African pollination ecology: conserving and using pollination as an essential ecosystem service to sustain human enterprise and biodiversity.' The diversity and complex ecology of pollinators, and the essential ecosystem services they provide, as well as the possibilities they pose for judicious commercial exploitation, represent important reasons why insect science and its applications is a crucial discipline for tropical development.

For more information about *International Journal of Tropical Insect Science* see:
www.cabi-publishing.org/ijt

EWRS Symposium

The 13th European Weed Research Society (EWRS) Symposium will be held in Bari, Italy on 20–23 June 2005. This is the latest meeting in a long and historical series, which provides a forum for scientists to present their work on a broad range of weed science topics either as oral presentations or posters.

Web: www.EWRS-Symposium.com

Bioherbicide Workshop

The 7th International Bioherbicide Group Workshop will be held in Bari, Italy on 24 June 2005 as a satellite meeting of the EWRS symposium (above). These workshops bring together scientists with a common interest in microbial control of weeds, and are an opportunity to share and discuss results. The workshops also provide a mechanism for considering future needs and research directions.

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ILEIA Updated

ILEIA (Centre of Information on Low External Input and Sustainable Agriculture) has launched a new ILEIA/LEISA website. This includes online versions of *LEISA magazine, ILEIA Newsletter* and regional magazines, together with a calendar of events, a directory of workers/organizations and a discussion forum. The information on the website can also be accessed through 19 'areas of interest' to help users find what they need more easily. The website can be accessed at:
www.leisa.info or www.ileia.org

ILEIA is also now issuing a quarterly news brief, E-LEISA, to bring readers up to date with field-based experiences and developments. It includes highlights from the global edition of the *LEISA Magazine* and directs readers to information collected, analysed and published by ILEIA and its regional partners, which is available on the website.

A CD-ROM of all the articles published by ILEIA in the *ILEIA Newsletter* and the *LEISA Magazine* in the period 1984–2003 is also available. The nearly one thousand articles reflect 20 years of practical field experiences described by field practitioners and development workers worldwide. The articles also reflect the development of interest and knowledge on ecological and participatory approaches in agricultural development that have taken place since the early 1980s. Articles on the CD-ROM are indexed by volume, author and topic and are available in HTML or PDF format. The CD-Rom is free for those in the South, and costs €10 for organizations and individuals from the North.
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Conference Report

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

Caribbean Fruit Fly Meeting

The Regional Workshop on Management of Tropical Fruit Flies, hosted by the Ministry of Agriculture in Grenada on 16–19 March 2004, provided an opportunity for 18 participants from the countries of the Caribbean basin to assess the threat fruit flies pose in the region, to develop action plans for each country, and to acquire the knowledge and technical expertise necessary to combat fruit flies.

Fruit flies constitute some of the world's major insect pests of fresh fruit and vegetables. A number of species are known to be present or are threatening countries in the Caribbean basin. These include *Anastrepha* species such as West Indian fruit fly (*A. obliqua*), Mexican fruit fly (*A. ludens*), Caribbean fruit fly (*A. suspensa*) and South American fruit fly (*A. fraterculus*), *Bactrocera* species and in particular carambola fruit fly (*B. carambolae*), and Mediterranean fruit fly or Medfly (*Ceratitis capitata*). Because the range of crops that can be attacked is broad and the impact on trade can be enormous, the need for capacity building in the region to combat fruit flies was seen as a priority. However, fruit flies are just one example of the phenomenal challenges faced by the region from invasive species. By developing the capacity to deal with fruit flies, countries also develop the capacity to deal with the wider problem.

The Grenada meeting formed part of the IPM Project under the EC-CARIFORUM Caribbean Agriculture and Fisheries Programme (CAFP). Workshop participants were drawn from all CARIFORUM countries (except Haiti) and the French Antilles. The workshop was implemented by CAB International's Caribbean and Latin America Regional Centre (CLARC) in collaboration with the US Department of Agriculture (USDA), Agriculture Research Service (ARS) and Animal Plant Health Inspection Service (APHIS), the University of Florida, the Florida Department of Industry, FAO (Food and Agriculture Organization of the UN (FAO), and the Joint FAO/International Atomic Energy Agency (IAEA) Division of Nuclear Techniques in Food and Agriculture. Partner agencies also provided materials and support including funds to cover attendance of resource persons and the participant from Guadeloupe. The workshop was designed to provide support and capacity building to countries at risk that must manage tropical fruit flies. The emphasis was on training representative technical staff from regional ministries of agriculture on prevention, surveillance, control and eradication of fruit flies and related issues. Specifically they learnt to:

- Identify the key fruit fly pests that are established or threatening the region
- Undertake surveys and surveillance activities
- Fully understand the various options for prevention and management of fruit flies
- Be fully conversant with the key technologies, such as trapping, eradication, biological control and cultural control
- Develop linkages with key experts and institutions
- Create national and regional strategies for dealing with fruit flies

The workshop used a mixture of formal lectures, hands-on practical exercises and participatory discussion sessions, and drew on the expertise of a group of international experts. It began with an overview (M. Kairo), which outlined expectations for the course, followed by lectures on the fruit flies of economic importance in the region (A. Norrbom) and the biology and ecology of the major species (A. van Sauers Muller & M. Kairo). Participants from Bahamas, Barbados, Belize, Dominica, Dominican Republic, Guyana, Jamaica, St Kitts & Nevis, St Lucia, St Vincent & The Grenadines, Trinidad & Tobago and Guadeloupe & Martinique then presented country reports. The content of these varied, depending on the history and severity of the fruit fly problem in the reporting country. Aspects covered included an overview of the country's agriculture and trade in fresh fruit and vegetables, which fruit flies are present, their economic importance, the main crops affected, pathways for entry and national capacity to combat them, and on-going and proposed prevention and management initiatives.

Next, a series of lectures dealt with the possible management approaches and methods: area-wide management (W. Klassen), sterile insect technique (SIT) *and* the economics of area-wide SIT (W. Enkerlin), reduced-risk tactics (O. Liburd) and biological control (T. Holler). The field trip that followed used the fact that Grenada is currently grappling with the West Indian fruit fly, a pest that has only recently been reported there, as an opportunity for participants to experience first hand the problems associated with the management of fruit flies. The trip focused on observing the Grenada programme against *A. obliqua.*

Case studies on initiatives against fruit flies were presented by participants from Grenada (West Indian fruit fly), Surinam (Carambola fruit fly), Florida (Medfly) and Mexico/Guatemala (Medfly/ *Anastrepha* spp.). These described the detection of the fruit fly and the immediate response to it, identified the major hosts, their economic (trade) value and the impact of the fruit fly invasion (e.g. trade restrictions), outlined management activities, highlighted public awareness campaigns, listed the resources available to combat the pest and the collaborators, and discussed what the next steps might or should be.

Subsequent panel discussions (led by M. Shannon & N. Leppla) dealt with the options for managing invasive fruit fly threats through prevention, detection and control. Control options considered included chemicals and the practicalities of using them, and the realities of using SIT operationally. The development, organization and management of an emergency response were also considered. Participants then learnt about international standards relevant to fruit flies and the FAO regional project on fruit flies (G. Pollard) and US activities and scope for partnership (M. Shannon & C. Cohen).

The penultimate sessions concentrated on practical aspects, including collecting and recognizing fruit flies (A. Norrbom) and their natural enemies (T. Holler), and on partnerships, networking and information (M. Kairo). Training materials were produced as a manual, which is available for interested parties in participating countries. Lastly, based on the discussions and practical experience, participants prepared action plans for implementation when they returned to their countries.

As part of the workshop, discussions were held to explore how prevention and management efforts in the Caribbean might be mounted, and general recommendations on a prevention/management strategy for fruit flies were agreed. These covered the need to develop sustainable solutions, given the correlation between the increased threat from invasive species and increased trade; the need for the development of prevention and management strategies, recognizing the impact of the close cultural and economic links on increasing the threat; the need for the current status of fruit flies (monitoring, suppression, regulations, public awareness and training) to be evaluated; options for management; an outline of the key elements of a prevention management programme; and the feasibility of a SIT approach and other options.

In the long-term, it was concluded, costs for area-wide control are expected to be lower than conventional control and thus provide socioeconomic and environmental benefits as well as sustainable control. Implementation of such an approach should also help build capacity in prevention and management to deal with future threats, and foster the development of collaborative networks across the region.

This highly successful workshop met its goal in providing participants with the necessary tools, training and information to be able to spearhead activities in their countries. For further development of the ideas discussed at this workshop, buy-in by the regional ministries of agriculture and donor organizations is required.

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Florida Fruit Fly Meeting

The 5th Meeting of the Working Group on Fruit Flies of the Western Hemisphere was held in Fort Lauderdale, Florida on 16–21 May 2004, co-hosted by USDA–ARS (US Department of Agriculture – Agricultural Research Service) Subtropical Horticulture Research Station, USDA–APHIS (Animal and Plant Health Inspection Service), Miami, and IFAS (University of Florida, Institute of Food and Agricultural Sciences). The meeting was attended by over 210 participants, with about a quarter of these coming from more than 30 overseas countries. Participants were from the fields of entomology, chemistry, genetics, biology and taxonomy, and included consultants, managers and regulators who are actively involved in all aspects of tephritid fruit fly detection. Presentations covered methods of detection, control and eradication, as well as biological control and regulatory procedures.

Participants reviewed research and formulated new goals and approaches to management strategies and action programmes for Mediterranean fruit flies or Medflies (*Ceratitis capitata*) and species of *Anastrepha, Bactrocera, Rhagoletis* and other tephritid fruit flies, which present a serious threat to production. For example, APHIS estimates that agricultural losses would be about US$1.5 billion a year if medflies were to become established in the continental USA.

During the plenary session an opening address, 'Future perspectives of SIT', was given by Donald Lindquist. There were a further seven oral presentations: Jesus Reyes, IAEA (International Atomic Energy Authority) – FAO (Food and Agriculture Organization of the UN), Guatemala: 'A multi-institutional approach to implement fruit fly low prevalence and free areas in Central America: outcomes and constraints'; Pedro Réndon, USDA–APHIS–PPQ (Plant Protection and Quarantine): 'Efficacy of the sterile insect technique (SIT) combined with releases of braconid parasitoids'; Walther Enkerlin, IAEA–FAO, Austria: 'Trapping guidelines for area-wide fruit fly programs'; Jane Levy, USDA–APHIS–PPQ: 'Application of the APHIS irradiation rule for movement of fruit fly host material'; José Luís Zavala, SAGARPA (Secretaría de Agricultura, Desarrollo Rural, Pesca y Alimentación, Mexico): 'Systems approach guidelines for *Anastrepha ludens*'; Carol Lauzon, California State University, Hayward: 'The role of microbial endosymbionts in the life history of fruit flies'; and Ron Mau, University of Hawaii, Manoa: 'Overview of the Hawaii area-wide fruit fly IPM education program'.

Sessions for reviewing and discussing poster presentations covered basic and applied biological studies, detection methods, control and eradication methods, biological control, the sterile insect technique, regulatory procedures, and programme management. These were followed by roundtable discussions for each topic to assess research findings and technical needs. The occasion also provided an opportunity for Special Interest Groups (SIGs) to meet, including the Caribbean Initiative Planning Group; Bob Griffin (USDA–APHIS–PPQ) led a meeting on the risk analysis process; and in a further meeting, ARS–APHIS, CDFA (California Department of Food and Agriculture) and Florida DPI (Division of Plant Industry) considered *Batrocera* trapping.

The 6th Meeting of the Working Group on Fruit Flies of the Western Hemisphere will be held in Salvador, Bahia, Brazil in September 2006, in conjunction with the 7th International Symposium on Fruit Flies of Economic Importance [see Announcements, this issue].

Web: http://conference.ifas.ufl.edu/flies

IOBC/WPRS Tackles Plant Pests and Diseases

The IOBC/WPRS (International Organization for Biological and Integrated Control of Noxious Animals and Plants, Western Palaearctic Regional Section) meeting, 'Management of plant diseases and arthropod pests by BCAs and their integration in agricultural systems' was held at the Istituto Agrario di San Michele all'Adige (IASMA) and the Centre for Research and Development of Crop Protection with Low Environment and Consumer-Health Impact (SafeCrop Centre) in Italy on 9–13 June 2004. It brought together three IOBC/WPRS working groups: Biological Control of Fungal and Bacterial Plant Pathogens, Integrated Control in Protected Crops, Temperate Climate and Integrated Control in Protected Crops, Mediterranean Climate. The meeting focused on mechanisms of disease, mode of action of biocontrol agents and integrated pest management of plant pathogens, and insect pests on grapevine, apples, strawberry, horticulture and small soft fruits.

There were 36 lectures and 68 posters presented in eight oral and two poster sessions under the themes: (i) combined management for control of pests and diseases, (ii) integrated control of diseases, (iii) risk characterization of BCAs (biological control agents), (iv) management of soil borne diseases, (v) mode of action of BCAs, (vi) postharvest, (vii) combination of control means and (viii) integrated management of diseases. Presentations covered scientific research (laboratory and field trials) and commercial development of BCAs (*Trichoderma* spp., *Verticilium lecanii*, *Clonostachys rosea*, *Beauveria bassiana, Metarhizium anisopliae* and *Coniothyrium minitans*) in countries such as Spain, France, UK, Italy, the Netherlands, Denmark, Germany, Austria and Israel.

There were also discussion sessions after presentations, and a roundtable, 'What will be the future for biological control agents (BCAs)?' Interesting presentations at this roundtable included Dr Elzbieta Ceglarska (Project Officer, European Commission [EC]) on 'EU policies in biocontrol research and biocontrol implementation', Dr Massimo Benuzzi (R&D Manager, Intrachem Bio Italia S.p.A.) on 'The industry point of view on problems in developing BCAs', and Dr Sergio Franceschini (Intrachem Bio Italia S.p.A.) on 'EU registration problems and possible solutions'. Dr Ceglarska gave a good overview of EU FP6 (the European Union Sixth Framework Programme) pointing out that new topics will be included in 2006, particularly on legislation hot issues and funding for registration of BCAs.