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General News

Biological Control of the Mexican Bromeliad Weevil

The Mexican bromeliad weevil, *Metamasius callizona*, is destroying native bromeliad populations throughout south Florida (USA). Southern Florida has 16 native species of bromeliads, of which 12 are susceptible to attack by the weevil. The female weevil lays her eggs in the bromeliad leaf and soon after the larva emerges it bores into the plant's stem. After extensive feeding by the weevil grub, the plant dies before producing seeds. The weevil was first detected in Florida in 1989, certainly as a result of infested plants being imported from southern Mexico[1]. In 1993, a tachinid fly parasitizing the related bromeliad-eating weevil *Metamasius quadrilineatus* was found in the montane forests of Honduras. It turned out that the fly was a new species, and therefore was recently described and named *Lixadmontia franki* in honour of University of Florida (UF) Professor J. Howard Frank[2]. Early observations in the laboratory indicated that the fly readily parasitizes the larvae of *M. callizona*, thus becoming the focal point of a biological control programme directed against the 'evil weevil', as bromeliad aficionados call it.

Female *L. franki* are ready to find hosts approximately eight days after mating. It is unclear yet whether the female fly deposits mature eggs or neonate larvae deep among the bases of the leaves of a weevil-infested plant. Whichever the case, the young tachinid maggot burrows through the macerated plant tissue and frass produced by the weevil larva. Once a host is contacted, the maggot bores through the host's integument quickly to live as an endoparasitoid. Susceptible weevil hosts are in the third to fifth instar, rarely in the second and never in the first instar. Parasitized weevils continue to feed and often advance to the next instar; they may even construct a pupal chamber made of macerated plant tissue and saliva. However, parasitized weevils always die before pupating. Usually, only one mature *L. franki* larva emerges from a parasitized host, but it is not uncommon to see two or three larvae come out of a cadaver. On rare occasions, as many as five to nine maggots will emerge from a single host; in these cases, the resulting adult flies are much smaller than their solitary counterparts. One to two days after emerging from its host, the fly larva will pupate. Total time from penetration of a host to pupation is 2-3 weeks at 21°C; pupal incubation time is three weeks.

The technology for producing large numbers of flies in the laboratory was initially developed with *M. quadrilineatus* at the Escuela Agrícola Panamericana in Honduras[3]. Larvae of *M. quadrilineatus* were placed inside pieces of bromeliad stem set in plastic cups. Weevil feeding on the plant material for three days was necessary for successful parasitism. Most final instars of the parasitoid exited their host 13–16 days after initial exposure to the flies. The technology was subsequently refined and expanded for *M. callizona* in the quarantine facility at UF's Hayslip Biological Control Research and Containment Laboratory at the Indian River Research and Education Center. Pineapple crowns obtained from local grocery stores are exposed to *M. callizona* females for one week, after which they are removed. The pineapple crowns are held at 25°C for three weeks, at which time the weevil larvae inside the crowns should be in the third instar. Twelve infested crowns are placed five days per week in a large parasitization cage containing 150–300 adult *L. franki* of mixed ages; crowns remain in the cage for ten days. Afterwards, the crowns are placed in a smaller cage to monitor the emergence of any adult flies that were hiding in the crown at the time of its removal from the parasitization cage. Weevil larvae are collected from the pineapple crowns, placed in plastic cups and fed fresh pineapple leaves twice weekly. Puparia of maggots that emerge from hosts are placed in cups with moistened paper towel and held in a rearing room at 21°C and with >70% relative humidity. As adult flies emerge, they are sexed and either placed in the breeding colony or accumulated in a small portable cage to await release in the field.

From June 2007 to January 2008, releases of over 1200 adult *L. franki* were made at seven sites throughout south Florida. These sites include the Lake Rogers Northwest Equestrian Park in Hillsborough Co., Loxahatchee National Wildlife Refuge in Palm Beach Co., Enchanted Forest in Brevard Co., Big Cypress National Preserve and Collier Seminole State Park in Collier Co., Highlands Hammock State Park in Highlands Co., and Savannas Preserve State Park in St Lucie Co. The tree vegetation at these sites varies from mixed pine–oak to oak–palm to cypress. Flies taken to the release sites were 5–10 days old as adults. Releases always took place at about 9:00 a.m. in an area where a large weevil population was known to exist. The number of flies released varied from 51–164 with an equal sex ratio or slight female bias.

Evaluation of establishment of *L. franki* begins six weeks following a release. The procedure uses sentinel pineapple crowns obtained from local grocery stores and infested with third instar weevils. These are placed in the release site in 0.6 × 0.6 × 0.1 m trays with hardware cloth (metal mesh screening used outside windows for mosquito-proofing) bottoms. Six crowns are placed in each tray and eight trays are placed in the site for each evaluation period. The trays are suspended in the forest canopy by a nylon rope secured to four eyelets attached to the four corners of the top side of the tray. The trees from which the trays are hung are selected by marking off lines to each cardinal direction from the centre of where the fly was released. In each direction, a tree with at

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least five medium to large bromeliads is selected for hanging a tray. Four trays are suspended near the central point of the release site.

The sentinel plants are collected after they have been in the field for two weeks and taken to the laboratory where they are held in cages for emergence of adult flies. Once the sentinel pineapples reach an advanced stage of decomposition, they are dissected and all weevil larvae are removed and placed in plastic cups with food. The larvae are monitored daily for pupation (= unparasitized) or emergence of fly larvae (= parasitized). Establishment is determined by the presence of the fly's F_2 generation in the exposed weevil hosts in the sentinel plants.

So far, *L. franki* has only been recovered at one site in one evaluation period, at the Lake Rogers Park following the first release on 29 June 2007. Two adult females emerged from the sentinel pineapple crowns and host cadavers were found in the decomposed plant material. Since *L. franki* originates from cool, shady, moist, high elevation tropical forests, there has been concern about the fly's ability to adapt to a hot, low elevation subtropical environment. This recovery confirms that released *L. franki* females are able to find hosts in native bromeliads during the humid but hot Florida summer, their adult progeny are able to find mates in subtropical oak hammocks, and the F_1 females are able to locate infested pineapple crowns to produce a second generation. As additional releases continue, establishment may be aided by the cooler but drier winter and early spring months.

The ultimate goal of the programme is to reduce the populations of the Mexican bromeliad weevil such that it is no longer a significant ecological pest of an important part of the state's floral natural heritage. Once this goal has been achieved, a programme for repopulating devastated areas with small plants grown from seed specifically collected from a number of hard-hit areas can begin.

[1]Frank, J.H. & Thomas, M.C. (1994) *Metamasius callizona* (Chevrolat) (Coleoptera: Curculionidae), an immigrant pest, destroys bromeliads in Florida. *Canadian Entomologist* **126**, 673–682.

[2]Wood, D.M. & Cave, R.D. (2006) Description of a new genus and species of weevil parasitoid from Honduras (Diptera: Tachinidae). *Florida Entomologist* **89**, 239–244.

[3]Suazo, A., Arismendi, N., Frank, J.H. & Cave, R.D. (2006) Method for continuously rearing *Lixadmontia franki* (Diptera: Tachinidae), a potential biological control agent of *Metamasius callizona* (Coleoptera: Dryophthoridae). *Florida Entomologist* **89**, 348–353.

Further information:
www.savebromeliads.ifas.ufl.edu and www.fcbs.org

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Biocontrol of Whitefly on Coconut Palms in the Comoros

A whitefly that has been attacking coconut palms in the Comoros in the Indian Ocean since 2000 has been contained by classical biological control, according to a report from the French organization CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement) in December 2007.

Aleurotrachelus atratus was first described from coconut in Brazil but has spread extensively, especially to tropical islands. In the Comoros, infestations reached economically damaging levels. According to the Ministry of Agriculture, it resulted in a 55% drop in coconut yields on the three islands of Ngazidja (Grande Comore), Ndzuani (Anjouan) and Mwali (Moheli); Ngazidja, the largest island and site of the capital Moroni, was by far the worst affected. The insect attacks the fronds and feeds on the palm sap, excreting honeydew on which sooty mould fungi develop. Sooty mould causes the characteristic dark colouring seen on the upper side of the fronds on affected palms. The whitefly problem was all the more serious because coconuts play a vital role in Comoran society.

In the absence of any means of controlling the new pest, a research programme, aimed at identifying and introducing a biological control agent in the region, was launched in 2005 by CIRAD and the Agriculture, Fisheries and Environment Research Institute (INRAPE) in the Comoros within the Crop Protection Network for the Indian Ocean (PRPV). The programme has now been completed.

During the two years of the programme, the researchers found a species new to science in the aphelinid genus *Eretmocerus* (since described as *Eretmocerus cocois* Delvare[1]), which was effectively parasitizing populations of the whitefly in the Indian Ocean islands of Réunion (France) and Maore (Mayotte: geographically part of the Comoros archipelago but administered by France). After testing showed it to be specific to the pest whitefly and, in particular, that it was not a threat to endemic whiteflies in Comoros, it was introduced for the first time in early 2007, into an experimental cage on Ngazidja. Three hundred females collected in Réunion were introduced to the cage, which was placed on a heavily infested coconut palm some two metres tall. The female parasitoids are attracted by their host and lay eggs under whitefly larvae on the fronds of coconut palms. Eggs are deposited on the integument of second- and third-instar larvae, and after hatching the parasitoid larva pierces and enters the host's body. As a solitary endoparasitoid, it consumes the whitefly larva and eventually forms a parasitoid mummy.

Eight months after the release, the team checked that the introduced parasitoids had acclimatized to the semi-natural conditions of the experimental cage on Ngazidja, and also recorded it on Ndzuani, where it apparently arrived by itself. They found that the phytosanitary condition of the coconut groves in the Comoros had improved significantly. Whitefly larval densities had been cut by 12% on Ngazidja, 62.5% on Ndzuani and 73% on Mwali. Production had increased, which resulted in a drop in coconut prices, to the benefit of consumers.

The main objective set for the programme, i.e. to bring whitefly population levels below a damage threshold using a natural parasitoid, was thus achieved. However, the whitefly–parasitoid balance will need to be monitored for the first few years after acclimatization, to confirm the success of the operation and measure the increase in coconut palm growth and coconut production on the three islands.

[1]Delvare, G., Genson, G., Borowiec, N., Etienne, J., Anli-Liochouroutu, A.K. & Beaudoin-Ollivier, L. (2007) Description of *Eretmocerus cocois* sp. n. (Hymenoptera: Chalcidoidea), a parasitoid of *Aleurotrachelus atratus* (Hemiptera: Aleyrodidae) on the coconut palm. *Zootaxa* (in press)

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Classical Biological Control Introductions to Manage Olive Fruit Fly

California produces about 99% of the olives commercially grown in the USA. These olives may be cured to produce the 'California black olive' commonly found on pizza and deli-sandwiches (i.e., table olive) or they may be pressed to produce top quality virgin olive oil that is used in cooking and salads. Prior to 1998, the major arthropod pests of California olives were olive scale, *Parlatoria oleae*, and black scale, *Saissetia oleae*. These pests were controlled with minimal insecticide usage. Olive scale was completely controlled by the parasitoids *Aphytis maculicornis* and *Coccophagoides utilis*. Black scale was best managed by pruning olive trees to facilitate air movement and increase canopy temperatures, which desiccates the early developmental stages. Growers occasionally used insecticides against moderate to high black scale populations.

The Olive Fly Threat

The olive fruit fly (OLF), *Bactrocera oleae*, was discovered in California in 1998, and quickly became the primary olive pest throughout the state. OLF is the primary pest of olives worldwide and causes much damage in parts of the Mediterranean basin and Africa. This tephritid only threatens the California olive industry because the larvae develop only in olive fruit. However, OLF adults are quite frequently found within nearby crop systems (e.g. citrus), where they are most likely seeking food (e.g. honeydew, yeast, bird excrement) and water. OLF larval stages are extremely damaging to olives. Table olive processors maintain a 'zero tolerance' level for OLF infested fruit. This means that the presence of OLF maggots or pupae within a single fruit will be enough to cause rejection of a grower's entire crop. Rejected shipments may be used for oil, but bring less revenue to the grower because of the cultivar used (i.e., cultivars vary with respect to oil content, flavour, and size) and lack of fruit maturity (i.e., table olives are harvested green). Although fruit destined for the oil press can withstand more OLF injury (10–30% depending on the time of processing after harvest) than table olives, control of OLF is still important because significant reductions in oil quality result from the damage caused by larvae to the fruit pulp, which allows entry of fungi and bacteria that increase pulp acidity. Commercial growers face a continual threat of re-infestation from the unknown number of ornamental and landscape olive trees in the state.

Current management recommendations are to apply GF-120 NF Naturalyte Fruit Fly Bait (Dow AgroSciences LLC) once weekly or twice monthly from two weeks prior to olive pit hardening (early June) until fruit are harvested in the fall (for table olives) or winter (for oil production). This means that most olive growers have transitioned from occasional treatments for arthropod pests (i.e., black scale, olive scale) in their orchards to as many as 32 treatments in one season for OLF. Repeated applications of GF-120 may impact biological control agents (e.g. green lacewing adults), which may feed upon foliar residues.

Progress towards Classical Biological Control

A classical biological control introduction programme was initiated in 2004 to reduce dependence on chemical controls. Biological control of OLF varies throughout its range in Europe, Africa, and the Middle East. No 'silver bullet' natural enemy has been recognized that is effective throughout the geographical range of OLF. Thus, various braconid species were shipped to the quarantine facility at the University of California at Berkeley. These included species that were naturally associated with OLF: *Bracon celer*, *Psyttalia concolor*, *Psyttalia* nr. *humilis*, *Psyttalia lounsburyi*, *Psyttalia ponerophaga*, and *Utetes africanus*. Additionally, *Diachasmimorpha kraussii*, *Diachasmimorpha longicaudata*, and *Fopius arisanus* were also considered as potential 'new associations' with OLF. These natural enemies were imported from South Africa, Kenya, Pakistan, and Hawaii. Cooperators on the project that aided in collection and importation of natural enemies included Alan Kirk and Kim Hoelmer, USDA-ARS European Biological Control Laboratory, Montferrier-sur-Les, France; Russell Messing, University of Hawaii, Kauai Agricultural Research Center, Kapaa, Kauai, Hawaii; and Vaughn Walton and Rob Stodder, University of Stellenbosch, Stellenbosch, South Africa. As part of the effort to evaluate them as potential biological control agents of OLF, biology studies were conducted in California. The following species have been evaluated using OLF eggs or larvae as hosts: *B. celer*, *D. kraussii*, *D. longicaudata*, *P. concolor*, *P. ponerophaga, P. lounsburyi*, and *F. arisanus*. Also of significant importance to a classical biological control programme is the assessment of the potential non-target impacts of the agents selected for introduction and establishment. Studies to date indicate that *P. lounsburyi* and *P. ponerophaga* preferred only OLF for reproduction and did not reproduce in the non-target tephritid species (i.e. the weed biocontrol agents *Chaetorellia succinea* – attacks yellow star thistle; and *Parafreutreta regalis* – attacks cape ivy) offered to them. Permits have been issued for the field release of these two parasitoids.

Efforts are presently underway to establish permanent populations of *Psyttalia lounsburyi* throughout the olive growing regions of California. Currently, the parasitoid is being tested in field cages to determine its ability to effectively impact OLF populations under semi-natural conditions in both coastal (e.g., Sonoma and Napa Counties) and interior (e.g., Fresno, Tulare, Yolo, and Sacramento Counties) regions. For this, OLF adults are caged on branches that have susceptible stage olives. After the inoculated OLF reach a development stage (e.g., second-instar) that is susceptible to the parasitoid, adult *P. lounsburyi* are added into cages. Successful parasitism is determined, as well as parasitism rates and parasitoid development times. Additional parasitoid species will be evaluated after permits are issued and rearing methods improved.

Once field cage trials have indicated promising candidate species for the various release locations (i.e., interior vs. coastal areas), we will begin general field releases in California. Follow-up fruit sampling and analyses of population dynamics of flies and parasitoids at release and non-release sites will be conducted to determine field impact, using standard sampling methodologies. These will include (1) visual assessment of olive fruit infestation levels at harvest periods, (2) adult OLF phenology and density assessment with pheromone traps, and (3) monthly collections of infested fruit from the tree and ground to rear parasitoids and determine effectiveness. Trapping, fruit sampling, and parasitoid recruitment methodologies will be used to quantify indispensable mortality and evaluate the ultimate extent of biological control success.

Further Reading

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Weaver Ants in Biological Control: Bringing History Up to Date

Weaver ants (*Oecophylla* spp.) are famed in the biological control world for being the first recorded biocontrol agents (their use in citrus was first described in 304 AD in China). Now Paul Van Mele[1], who has worked with weaver ants in Southeast Asia (*O. smaragdina*) and West Africa (*O. longinoda*), has reviewed literature on the use of *Oecophylla* over the last century. He points out that a scant 70 published references from Asia and fewer than 25 from Africa since the 1970s indicates they have been largely neglected by researchers. He draws on the work that has been published to highlight the potential for these generalist predators to reduce pest numbers and therefore pesticide use in conservation biological control in tree crops.

The author begins by looking at societal perceptions of weaver ants up to and during the colonial era, and some little-known facts emerge. For example, despite the long-standing use of weaver ants in China, some Vietnamese scientists lay claim to *their* country being the origin of weaver ant use in citrus. Certainly, traditional knowledge and a holistic world view have influenced the way in which research has been conducted in that region. A different picture emerges in Africa, with *Oecophylla* often being perceived as a nuisance insect. Colonial entomologists focusing on plantation crops tended to favour science-driven (classical biocontrol) solutions which needed no farmer input, so weaver ants were largely neglected by them. Not until *O. longinoda* was shown to control coconut 'gumming' disease (which in fact turned out to be caused by a coreid bug) did its reputation begin to gain acceptance among European scientists.

Van Mele identifies some *Oecophylla* 'champions' from this period, including Michael Way who pioneered the work on weaver ants as biological control agents in coconuts in Zanzibar. His publications (1953–54) indicated how the detailed information provided on biology, behaviour and ecology could be used to enhance control of pests. This was followed by more work in this crop in the Solomon Islands by Eric S. Brown (1959).

The author then presents a series of crop case studies, reviewing literature on *Oecophylla* in coconut, cocoa, citrus, cashew, mango and timber through to the present day. Although Van Mele found a paucity of literature, he has assembled a list of just over a hundred references.

Research in coconuts, citrus and cashew allowed weaver ants to be incorporated into pest management strategies.

- The pioneering work in coconut, described above, continued in ex-British colonies, although it took 40 years for acceptable methods of weaver ant establishment and management to be developed. Research conducted largely in East Africa showed that the type and management of non-crop vegetation and intercrops was critical in managing competing ant species; the exclusion of *Pheidole megacephala*, in particular, had a marked effect on the efficacy of weaver ants in promoting better yields.
- Research in citrus pest management in Asia grew out of the emergence of insecticide resistance, and was significant in that it required scientists to work with farmers, drawing on and enhancing traditional knowledge. Notably, farmers had already evolved methods for controlling the competing black ants (*Dolichoderus thoracicus*) and optimizing the performance of weaver ants, and were knowledgeable about which intercrops to avoid.
- A management system using weaver ants to control all main pests in cashew was successfully developed in Australia and led to increased yields and profits. The task was made easier because there is no serious competition from other ant species, and harvesting methods do not bring people into contact with the weaver ants at this stage.

Making progress in other crops has been more difficult. In cocoa, coffee and mango, the perception of weaver ants as a nuisance during harvest has been a major hurdle. This is a common perception in plantation crops worldwide, yet methods have been developed to reduce this nuisance[2]. But in these three crops there are other factors.

- In cocoa, weaver ants have the capacity to control a range of pests, including the mirid/capsid bugs that are major pests in West African cocoa. But the complex ant mosaic has proved difficult to manage, while measures to combat serious disease constraints in cocoa (e.g. open canopy architecture) do not always favour weaver ants. In addition, policies of blanket spraying against pests have disrupted weaver ant activity and the establishment of IPM schemes.
- Limited research has been carried out on weaver ants in coffee, but mutualistic relationships with key scale insect pests hinders promotion of them for beneficial purposes.
- Research indicates that weaver ants control mango pests, including the devastating fruit flies, and increase fruit quality and yields. But in both Asia and Africa, farmer interviews reveal that the large size of mango trees means the beneficial impact of weaver ants in this crop may be missed – even when it is recognized in citrus. Tree size also means pickers often have to climb them, and in these circumstances ant aggressiveness is a real issue. However, people have developed cultural and harvesting methods to overcome this problem.
- The potential for weaver ants in timber crops is largely untapped although research has indicated they reduce important pests in a number of timber species.

Van Mele concludes that *Oecophylla* has considerable actual use and potential, both alone and as part of a pest management system, where research builds on traditional knowledge. For each of the above crops he summarizes what he sees as the potential for research activities with farmers. He suggests that emerging markets for organic and sustainably managed products provide an opportunity to value what has already been achieved.

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A Community Based Biocontrol Programme for Blackberry in Australia

European blackberry (*Rubus fruticosus* aggregate) has become one of southern Australia's worst environmental weeds. Deliberately introduced in the mid 1800s, it quickly became invasive and is now one of Australia's twenty Weeds of National Significance (WoNS). Dense infestations of blackberry outcompete native plants and prevent their germination, destroy native animal habitat and impact on the amenity of public lands. In agricultural areas, blackberry thickets replace pasture, exclude livestock and prevent access to waterways.

Blackberry infests about nine million hectares – more than the area of Tasmania. Australia plays host to at least 14 different but closely related species of weedy European blackberry and many of these have the potential to spread further.

The blackberry leaf-rust fungus *Phragmidium violaceum* has been present in Australia for more than 20 years following unauthorised and authorised introductions. It coevolved with blackberry in Europe and provides useful control in some areas of southern Australia but not others.

Now additional strains of the leaf-rust fungus are being released as part of a national programme to enhance biological control of European blackberry. In early 2004, eight strains were approved by Biosecurity Australia for release at experimental sites in New South Wales and Western Australia. The strains are now being mass-produced and released across the country as part of a three-year coordinated national project that began in June 2006. These releases are being made in partnership with landholders and land managers and the guidelines developed to help the community make these releases can be seen at:
www.ento.csiro.au/weeds/blackberry/project.html

Stakeholders have been invited to put in expressions of interest and from these the most suitable sites for release are chosen. Selected landholders are then provided with release kits with easy-to-follow guidelines. The kits were initially distributed in New South Wales, the Australian Capital Territory, South Australia, Queensland and Western Australia. Releases in Tasmania began in late 2007. There is also a parallel state-based release programme being undertaken by the Victorian Department of Primary Industries.

Stakeholders participating in the programme are asked to provide voucher blackberry specimens, which are identified and used to generate a national map of blackberry taxa. This will eventually be a major knowledge tool in the fight against this WoNS.

Molecular tools are being employed to assess establishment and persistence of the strains over time at specific sites, while their impact on blackberry growth parameters is measured using fungicide exclusion techniques.

It is hoped that these strains (or new recombinant genotypes), will establish in areas they are climatically suited to and on blackberry species they favour. Where these strains become active, they should help to contain current infestations and slow the weed's spread. It will take several seasons to measure the cumulative impact of the additional strains but it is already obvious that the rust disease was not very severe at most sites in the 2005 and 2006 growing seasons because of the drought.

The project is a research partnership between CSIRO, the Victorian Department of Primary Industries and the University of Tasmania, with financial support from the Australian Government Department of Agriculture, Fisheries and Forestry under the *Defeating the Weed Menace Initiative*. It is led by Dr Louise Morin from CSIRO Entomology and the Cooperative Research Centre for Australian Weed Management.

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ESA 2007 Awards for Biocontrol and IPM Scientists

Amongst the Entomological Society of America's (ESA's) award winners in 2007 was Mark Hoddle (Director of the Center for Invasive Species Research, Entomology Department, University of California, Riverside) who received the Syngenta-sponsored Recognition Award in Entomology, awarded to entomologists who have made or are making significant contributions to agriculture. Since joining the Center in 1997, his research has focused on invasive arthropod pest species and their control with natural enemies. He is co-author of a new book on biological control to be published in the summer of 2008, and one of the principle organizers of the bi-annual California Conference on Biological Control and the International Symposium on the Biological Control of Arthropods.

Recognized for their contributions to IPM were Peter A. Follett and William D. Hutchison.

Peter Follet (US Department of Agriculture –Agricultural Research Service, US Pacific Basin Agricultural Research Center, Hilo, Hawaii) received the Distinguished Achievement Award in Horticultural Entomology for contributions to the American horticulture industry. His research programme focuses on developing new or improved pest management methods and postharvest treatments for quarantined pests that restrict the export of tropical fruits and vegetables from Hawaii. He is nationally and internationally recognized for his research on tropical invasive pests, pest risk management, and high temperature and irradiation quarantine treatments.

The Distinguished Achievement Award in Extension, for outstanding contributions in extension entomology, went to William (Bill) D. Hutchison (Professor of entomology and extension entomologist, University of Minnesota). His outreach and research focus includes the development of ecologically based

IPM for vegetables and grapes, with a goal of reducing economic and environmental risk. In 1996, he and several graduate students developed the VegEdge website to support timely access of research-based vegetable IPM results for growers, vegetable processors, crop consultants and extension staff in the Midwest Region. VegEdge is home to factsheets, real-time monitoring data for several insect pests, and the Minnesota Fruit & Vegetable IPM News, a joint effort with the Minnesota Department of Agriculture IPM Program. During the summer months, VegEdge receives more than 2500 requests per day. Dr Hutchison has been very responsive to the needs of vegetable producers in the North Central Region. He recently led a multi-state effort to better understand migratory behaviour and insecticide resistance in *Helicoverpa zea*, an effort that combines traditional research with data from multiple cooperators, to assist growers and IPM field representatives with real-time and strategic decision making.

Indian Company Receives Award for Pheromone Work

Pest Control (India) Private Limited, Bangalore (PCI), who established India's first and so-far only fully-fledged commercial pheromone synthesis facility, was awarded the 2007 National Award for R&D Efforts in Industry in the area of agro and food processing industries by DSIR (Department of Scientific and Industrial Research, Government of India). The award, principally for their work on sugarcane borer pheromones, was presented by the Director General, Council of Scientific and Industrial Research at a function organized jointly by DSIR and FICCI (Federation of Indian Chamber of Commerce and Industry) in Delhi on 15 November. Their pheromone facility is housed at PCI's Bio-Control Research Laboratories (BCRL), which themselves broke new ground when first built in 1981 as India's first commercial biocontrol laboratories.

Sugarcane borers cause up to some 55% reduction in yield and require active intervention throughout most of the crop season. Long crop duration, the nature of the crop canopy, the concealed habits of the various pests and overlapping generations make chemical control difficult and expensive. However, although the pheromone constituents for the major sugarcane borers were identified and the efficacy of sex pheromones for managing them was validated during the 1980s, the absence of indigenous commercial pheromone synthesis facilities and a simple, cheap and portable water trap meant the technology was not adopted in India.

This has changed with PCI's establishment of the pheromone facility at BCRL and their pioneering of commercial in-country pheromone synthesis. Their pheromone technology for four species of sugarcane pests now provides a stand-alone and environmentally friendly method of pest management. Perfecting this technology meant developing protocols for synthesis of eight different compounds to over 95% purity on a laboratory scale, scaling up for commercial production at affordable rates, blending the compounds in appropriate ratios for each sugarcane borer species, and production of lures. PCI also designed and patented a cost-effective, easy-to-use, portable, water-based trap – the Wota-T – for use with the pheromone lures. An innovative lure holder prevents immersion of the lure in water and at the same time protects it from sunlight.

The success of the enterprise is reflected in the sale of 150,000 lures and 92,000 water traps in the first three years. The award citation also notes PCI's collaboration with national and international organizations in the synthesis and supply of pheromone lures for a range of pests including white stem borer of coffee, coconut beetles and cocoa pod borer. PCI now sells its products and traps both within India and abroad.

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Hitting Heads against Walls

Biocontrol scientists generally think of conservation in terms of biodiversity, but 'conservation' can have a non-biological meaning; although that does not rule out biological control.

A report in *Deuschtse Welle* (www.DW-World.De) in December 2007 described how bacterial treatment was showing promise for cleaning Europe's historic buildings of the grime and soot that not only detract from the buildings' aesthetic appeal, but can also damage the fabric of the monuments: sulphur dioxide in the air reacts with the limestone that many monuments are built with to form a damaging gypsum layer that causes the stone to flake. This makes removing the deposits a tricky task, and a task made more complex because surfaces such as marble develop a 'noble patina', a surface change that occurs naturally as buildings age and adds to the character of the stone.

A multidisciplinary team from several Italian institutes, led by Francesca Cappitelli (Agricultural Faculty, University of Milan), carried out a small-scale trial with the sulphate-reducing bacterium *Desulfovibrio vulgaris* on one of Milan cathedral's marble spires, and found the process to be less damaging and more effective than a chemical treatment often used by conservators. The bacteria metabolize the sulphates into gases which diffuse into the air without damaging the underlying noble patina. Cappitelli and her team have obtained an Italian patent for the biocleaning process, and have applied for an international patent.

In contrast, although chemical cleaning methods have been considerably improved in recent decades, they can still corrode the surface of the stone; Cappitelli's study found the chemical treatment they used ate away more than the deposits and changed the granular structure of the stone's surface. There are also concerns about the human and environmental toxicity of the chemicals.

But is biological treatment risk free? Rightly, the article went on to consider its possible adverse impacts. But what a pity that it quoted Peter Martin from the Masonry Conservation Research Group at Aberdeen's Robert Gordon University, who, while correctly pointing out that scientists have to be careful not to introduce something that creates new problems, unfortunately cited the cane toad as his example of "some of the biological control systems that have gone wrong."

While cane toads could undoubtedly compete with gargoyles on Europe's ancient cathedrals for last place in a beauty contest, could he not have chosen a more appropriate example? Or perhaps he couldn't find one; biological control disasters are actually rather rarer than the press would have the public believe.

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. As in many recent issues, we are featuring microbials and biopesticides, focusing on some promising research.

Metarhizium: a New Sting in the Tale

Metarhizium anisopliae has many potential applications as a biopesticide against a wide range of insects, from disease vectors such as mosquitoes to agricultural pests – including locusts, which is where the technology has had most success. Many scientific and technical hurdles have been overcome in product development, yet the potential of *M. anisopliae* to play a greater part in insect biocontrol remains limited by efficacy in terms of pathogenicity (capacity to cause disease) and virulence (capacity to kill), and by cost.

A possible new avenue is signalled in a 'Brief Communication' in *Nature Biotechnology*[1], in which Chengshu Wang (Chinese Academy of Sciences, Shanghai) and Raymond St Leger (University of Maryland, USA) described how they inserted genetic material for a scorpion toxin into a naturally occurring strain of *M. anisopliae*, then demonstrated its expression by the fungus in the haemocoel of target insects and its lethal effects on the insects.

The neurotoxic venom of the scorpion *Androctonus australis* (AaIT) is one of the most toxic insect-selective peptides known. Wang and St Leger chose to insert genetic material coding for this into *M. anisopliae* strain 549, rather than a more host-specific strain, because strain 549's broad host range would allow them to test the modified fungus against both a mosquito (*Aedes aegypti*) and the lepidopteran tobacco hornworm (*Manduca sexta*). In terms of delivery, fungal biocontrol agents such as *Metarhizium* differ from bacteria and viruses in that they do not need to be ingested but can infect a host from contact application of the conidia (spores); hyphae penetrate a susceptible insect's cuticle and grow into its body. Wang and St Leger chose the promoter *M. anisopliae MCL1*[2] to drive the gene's expression because it produces rapid and high-level expression, but only in the insect's haemolymph, thus restricting expression to the period after the fungus has penetrated the cuticle.

Bioassays to assess the LD_{50} conidial concentration indicated that the genetically modified fungus (designated strain AaIT-549) increased fungal toxicity 22-fold against *M. sexta* caterpillars and nine-fold against adult female *A. aegypti* compared to the unmodified fungus. Survival times were also significantly reduced; using spore concentrations of the modified and unmodified strains high enough to kill most insects, survival times were reduced 28% and 38% for *M. sexta* and *A. aegypti*, respectively. Enhanced pre-lethal effects of AaIT-549 were also recorded, with caterpillars exhibiting reduced feeding, while mosquitoes showed reduction in responses to host presence sooner than with unmodified strain 549.

In a 'News and Views' article in the same issue[3], Matthew Thomas (CSIRO, Australia) and Andrew Read (Pennsylvania State University, USA) were impressed not only by the enhanced pathogenicity and virulence of strain AaIT-549 but also by the implications this – especially enhanced pathogenicity – has for the cost effectiveness of a bioinsecticide developed from such a strain. More rapid kill should give better control, while greater pathogenicity means less product should be needed. Also, while modified and unmodified spores have the same longevity, the persistence of treatment with modified spores should be longer because fewer spores are needed to cause a lethal infection – this should reduce frequency of re-treatment, and therefore cost once again.

Thomas and Read recognized the significance of Wang and St Leger's work as signposting a novel 'paratransgenic' method whereby pathogens could deliver molecules to control insects – or even microbes and viruses they carry. But none of the authors underestimate the hurdles.

Host specificity is an important environmental safety feature of a pesticide, biological or otherwise. Wang and St Leger noted that as this is mediated in *M. anisopliae* strains mostly through "recognition events on the cuticle", the presence of the transgene, which is active only post-penetration, should not compromise it. They showed that two non-target species (the fruit fly *Drosophila melanogaster* and the cockroach *Blatella germanica*) were unaffected by high topical doses of AaIT-549, but injecting the transgenic conidia killed them within four days. In any case, there is no reason to believe that the gene for the neurotoxin could not be inserted into strains of *M. anisopliae* with much narrower host specificity (e.g. var. *acridum*, the locust strain used in Green Muscle® and Green Guard®), although whether it would be as effective in any strain would need to be assessed. Wang and St Leger also pointed out the possibility of engineering the genetics of gene expression so that spores are not produced by cadavers (e.g. through over-expression of the extracellular chymoelastase (*Pr1*) protease, which causes a hyperimmune response that kills the fungus as well as being toxic to the insect) and there should thus be no onward transmission or environmental persistence of the transgenic strain. However, Thomas and Read note that non-hosts may be infected but mount an effective immune response, and in the presence of a big disease challenge even highly resistant hosts can succumb; in both cases expression of the toxin would increase mortality in these non-target hosts.

The inadvertent 'escape' of transgenes and their acquisition by other species/strains is a hotly debated issue in the field deployment of genetically modified (GM) organisms. Thomas and Read point out that the absence of a sexual cycle in *Metarhizium* minimizes the chances of the transgene being transferred between strains of *M. anisopliae.*

But Thomas and Read note that little is known about inherited variability in resistance to fungal infection in insects, and ask whether the selective pressure of a more virulent pathogen would lead to the development of resistance as it has done with chemicals. They suggest a detailed ecological analysis would be called for to quantify all these risks to non-target species.

Wang and St Leger point out that the AaIT gene itself has already passed a good few regulatory hurdles towards release; in earlier work researchers inserted the toxin gene into a baculovirus to get faster kill in lepidopteran larvae. However, the modified fungus is a step forward for two reasons. Firstly, it widens the potential targets from lepidopterans, which are the commonest hosts of baculoviruses, to targets in the Diptera, Orthoptera and Coleoptera which also tend to be less (or not at all) susceptible to *Bacillus thuringiensis* products. Secondly, *Metarhizium*, unlike baculoviruses, does not need a living host and is far more amenable to mass production. Although nothing hides the fact that it still takes days rather than minutes to kill its target, in terms of pricing, a more potent form of *M. anisopliae* could begin to compete with chemical insecticides.

The science and potential are exciting, but whether GM fungal pathogens enter the marketplace will come down to social and political as well as commercial factors. The US Environmental Protection Agency has already approved field tests of two recombinant strains of *M. anisopliae*, including one that over-expressed the *Pr1* protease referred to above. There are several genetically engineered insecticidal bacteria on the market, providing an obvious precedent for this work.

But quite apart from the reluctance of various sectors and parts of the world to embrace GM technology in any form, GM biopesticides raise specific issues. At present a traditional biopesticide has the virtue of being a 'green' and 'natural' biocontrol technology, something that separates biopesticides from chemicals and allows them to be used, for example, in organic farming. A GM fungus (especially one with something as emotive as a scorpion toxin) is a rather different kettle of fish. For example, the principle driver behind the adoption of *Metarhizium* for locust control in Australia (Green Guard®) is that a number of the key recession areas for the locusts are used for organic beef production. It is possible that a GM fungus could kill locusts even quicker or make the technology cheaper, but these benefits would have to be viewed against possible loss of the current driver for adoption. While all products should be evaluated and judged on their impacts (both positive and negative), that logic does not necessarily prevail. With GM technology currently excluded from 'green' agriculture, GM biopesticides may find themselves in no-man's land.

In the end, the health sector may provide the best opportunity for GM *Metarhizium*, and in particular its deployment against mosquitoes with the prospect of reducing deaths from malaria. If this technology were to prove able to rapidly deplete mosquito populations in urban settings, then it is likely to be accepted by people living in areas where malaria is endemic. And this could lead to much more, given the emergence of new mosquito-borne diseases in recent years and their trade- and climate change-fuelled spread.

[1]Wang, C. & St Leger, R.J. (2007) A scorpion neurotoxin increases the potency of a fungal insecticide. *Nature Biotechnology* **25**, 1455–1456. DOI:10.1038/nbt1357.

[2]Wang, C. & St Leger, R.J. (2006) A collagenous protective coat enables *Metarhizium anisopliae* to evade insect immune responses. *Proceedings of the National Academy of Sciences USA* **103**(17), 6647–6652.

[3]Thomas, M.B. & Read, A.F. (2007) Fungal bioinsecticide with a sting. *Nature Biotechnology* **25**, 1367–1368. DOI: 10.1038/nbt1207-1367.

Also see: Whetstone, P.A. & Hammock, B.D. (2007) Delivery methods for peptide and protein toxins in insect control. *Toxicon* **49**, 576–596.

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US Government Licenses *Chromobacterium*

A bacterium discovered by US Department of Agriculture – Agricultural Research Service (USDA-ARS) scientists, which is toxic to a variety of crop pests, has been licensed as a technology to Marrone Organic Innovations, Inc., of Davis, California and Natural Industries, Inc., of Houston, Texas.

In 2003 a team at the ARS Invasive Insect Biocontrol and Behavior Laboratory in Beltsville, Maryland, led by Phyllis Martin, discovered a species of *Chromobacterium,* which exhibited insecticidal activity, from soil rich in decomposed hemlock leaves collected from the Catoctin Mountain region in central Maryland. It was subsequently described as *C. subtsugae*.

The bacterial colonies are cream in colour when they start to form but turn deep purple in 24–48 hours in the presence of oxygen. The unusual purple colonies proved to be lethal to immature Colorado potato beetles (*Leptinotarsa decemlineata*). The colour comes from the pigment violacein, but tests with isolated pigment showed it was not involved in *C. subtsugae*'s toxic properties. Moreover, the related purple bacteria *C. violaceum* was not toxic to Colorado potato beetle when tested under the same regime as *C. subtsugae*.

Subsequently, the team showed *C. subtsugae* to be active against a wide range of other pests in laboratory assays. The bacterium is also stable in the environment, and readily ingested by most of the insect targets.

- The bacterium killed 80–100% of adults of the chrysomelid beetles *Diabrotica undecimpunctata howardi* and *D. virgifera virgifera* and 100% of pentatomid bug *Nezara viridula* (southern green stink bug) adults within six days; live bacteria were not needed to kill the stink bugs.
- When fed pollen-based diet containing bacteria, 50% of *Aethina tumida* (small hive beetles) died within five days, and survivors weighed 10% of control beetles.
- Weights of caterpillars of two moths, the tobacco hornworm (*Manduca sexta*) and the gypsy moth (*Lymantria dispar*) fed diet containing bacteria were 80% and 40% less, respectively, through feeding inhibition, although the bacteria did not have lethal effects in these species.
- The bacterium was also shown to have activity against the silverleaf whitefly (*Bemisia argentifolii*) and diamondback moth (*Plutella xylostella*).

The laboratory tests suggested that *C. subtsugae* produces multiple toxins that are responsible for its effects on the range of pests. Results from field tests confirmed the effects found in the laboratory. In July 2007, a patent was granted for use of the bacterium as a biocontrol agent against the pests. Additional studies will be conducted to determine potential toxicity to non-target insects.

The process of turning it into a biopesticide involves a number of steps, identified by Pamela Marrone of Marrone Organic Innovations as:

- Purify and identify the compound(s) causing the insecticidal activity and develop analytical methods for these compounds to detect them in fermentation for quality control purposes
- Develop a commercial fermentation process and scale up to large scale; optimize yields of microbe + associated insecticidal compounds
- Conduct initial up/down rat toxicity (oral) to determine toxicity range, then if that is acceptable, do a 'six-pack' set of acute tests (oral LD_{50}, dermal, eye, etc.) on the technical grade active ingredient (TGAI)
- Develop a commercial formulation
- Conduct acute toxicity and ecotoxicity tests on formulated material
- In parallel with the above, conduct efficacy studies in the laboratory, greenhouse and field
- Develop and submit an EPA (US Environmental Protection Agency) package

Further information

Martin, P.A.W., Gundersen-Rindal, D., Blackburn, M. & Buyer, J. (2007) *Chromobacterium subtsugae* sp. nov., a betaproteobacterium toxic to Colorado potato beetle and other insect pests. *International Journal for Systematic and Evolutionary Microbiology* **57**, 993–999.

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Yersinia Shows Promise as Bacterial Insecticide

A new species of bacterium isolated from diseased and dead grass grubs collected in various locations in the South Island of New Zealand is exciting scientists with its potential as a bioinsecticide for a wide range of insect pests.

New Zealand's AgResearch announced the discovery of the novel bacterium *Yersinia entomophaga* MH96 in November 2007. The genetics of this disease-causing organism have been confirmed, and it has been found to kill many insect species within two to three days of infection.

The most common bacterial biological control agent to date, *Bacillus thuringiensis* (*Bt*), includes many strains, each of which targets a specific insect sub-group. According to AgResearch, what makes this latest discovery of such significance is the wide range of insects the bacterium is active against, including beetles, grass grubs, moths and caterpillars; i.e. the major destroyers of agricultural and horticultural crops around the world. *Yersinia entomophaga* is the first *Yersinia* bacterium to be shown to contain potent insecticidal toxins, according to AgResearch Scientist Dr Mark Hurst.

Developing application methods for *Y. entomophaga* as a biocontrol agent will need to take account of its wide spectrum of activity. AgResearch notes that it could be delivered through a variety of technologies including seed drilling, or through bait which would be formulated to attract only target species. *Yersinia entomophaga* has shown limited survival in the field so long-term environmental effects are not anticipated. In addition, it has been shown to be safe to bees.

First discovered in 1996, it has taken Hurst and his team more than ten years to test and refine their discovery and secure the necessary patents. They are now ready to take the bacterium to the world as a marketable, commercial product. Biological control markets are largely untapped, as discoveries such as this are rare. Potential markets in New Zealand include dairy and field crop farmers; grass grubs and *Porina* spp. are major pastoral pests of New Zealand agricultural land used for dairy farming. Further afield, beetles are big destroyers of many field crops including maize, cotton and sugar cane, as well as turf grasses in global markets such as Australia, Europe and the USA.

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Aphid Harbours 'Jekyll and Hyde' Bacteria

Aphids are unable to manufacture a number of essential amino acids that the plant phloem on which they feed does not supply. Some of the symbiotic bacteria they harbour in their haemocoels synthesize the missing nutrients. Although it is known that interactions between aphids and their symbionts can be influenced by the plant species on which the insects are reared, the underlying mechanisms are not understood. Now research at the University of York, UK, has found that some of the symbionts could potentially be exploited as a novel way to control the aphids[1].

While studying interactions between black bean aphids (*Aphis fabae*) and their associated bacteria, the York researchers discovered an intriguing new category of organism that they dubbed 'Jekyll and Hyde' bacteria. Black bean aphids are polyphagous and thrive on a number of plant species. In most situations their internal bacteria are harmless or beneficial – this is their 'Jekyll' side. But on some hosts, the relationship between insect and bacteria was found to change and the bacteria exhibited a disruptive 'Hyde' side: the insects grew and reproduced very slowly, while the bacteria themselves proliferated to very high densities in a short time. Thus, results showed that *Aphis fabae* grew more slowly on the labiate plant *Lamium purpureum* than on *Vicia faba* (broad bean – a common host for *A. fabae*), and the negative effect of *L. purpureum* on aphid growth was consistently exacerbated by the bacterial secondary symbionts *Regiella insecticola* and *Hamiltonella defensa*, which attained high densities in *L. purpureum*-reared aphids.

Further investigations revealed that the amino acid content of the phloem of *L. purpureum* was very low; and *A. fabae* on chemically defined diets of low amino acid content also grew slowly and had elevated secondary symbiont densities. The researchers suggested that the phloem nutrient profile of *L. purpureum* promotes deleterious traits in the secondary symbionts and disturbs insect controls over bacterial abundance. The next step is to explore precisely how the aphids control their symbiotic bacteria, which may suggest ways in which the bacteria can be 'turned against' their hosts.

[1]Chandler, S.M, Wilkinson, T.L. & Douglas, A.E. (2008) Impact of plant nutrients on the relationship between a herbivorous insect and its symbiotic bacteria. *Proceedings of the Royal Society B* **275**(1634), 565–570). DOI: 10.1098/rspb.2007.1478

Training News

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

Where Participation Falls Down

The concept of farmer participation in training and research has gained wide acceptance in recent years. Reviewing whether initiatives are sustained and how well they work is a critical element of improving the approach.

Carchi Revisited

The province of Carchi in northern Ecuador is dependent on the potato, which has been grown there since time immemorial. In recent decades, agricultural intensification and its adverse ecological consequences meant farmers became reliant on pesticides. While these played a vital role in sustaining production, over-use and poor practices had adverse effects on environmental and human health.

Some six years ago, *BNI* reported an initiative to promote change, and particularly pesticide reduction, through participatory learning and action with farmer households[1]. The multi-institutional broad-based Eco-Salud project in Carchi was established in 1997 with the FFS approach at its heart. The FFSs experimented with use of technologies such as adult weevil traps, late blight-resistant potatoes, specific and low-toxicity pesticides, and pre-spray monitoring. After two seasons of FFSs, the application of IPM techniques had led to a reduction of pesticide applications from 12 (in conventional plots) to seven in IPM plots, while production was maintained or increased. FFS participants had also discovered how to maintain production with considerably less financial outlay.

The article noted that "The real test for an FFS is whether the practices learnt are adopted and work for the farmers in their own fields, year on year. Early evidence in Carchi is promising with farmers appearing highly motivated. FFS graduates are showing a willingness to experiment and adapt the IPM technologies they learnt in the FFS."

According to Marc Schut and Stephen Sherwood, writing in *LEISA*[2], this optimism was shortlived; they reported they had found "systematic translation of FFS (and FFS-like methodologies) from people-centred to more technology-centred designs." After an earlier LEISA article (2003) cited systematic erosion of the FFS methodology, Schut and Sherwood sought for the underlying reasons for the changes by visiting FFSs, interviewing FFS participants, graduates, facilitators and master trainers, and by holding meetings and workshops. They concluded that social factors rather than incompetency were responsible, and include three case studies documenting how different factors – donor demands, extensionist preferences, and distant supervision – altered how FFSs were conducted in different ways. They also identify the extremes of FFS 'by design' that they encountered, and how these touch all areas of FFS methodology.

They discuss how to 'protect' the FFS approach from being drawn back into the technology transfer top-down paradigm it should be challenging. They argue attention needs to be given to who is in the "driver's seat" and call for more conducive conditions for people-centred development. There has been some progress on this front in the Andean region. In Ecuador, for example, an initiative by agroecology networks is setting up a new collective charged with advocacy. Analogous national and regional activities are beginning to create a network of like-minded players.

[1]See: *BNI* **22**(4) (December 2001), IPM Systems: 'Potato IPM should focus on pesticide reduction'; www.pestscience.com/Bni22-4/IPM.htm

[2]Schut, M. & Sherwood, S. (2007) FFSs in translation: scaling up in name but not in meaning. *LEISA* **23**(4) (December 2007), 28–29. www.leisa.info/

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Unsustainability of Participatory Approaches in Sustainable Agriculture

In New Zealand, participatory approaches, usually research partnerships, are used to try and develop integrated, holistic models of sustainable agriculture. But the authors of a recent paper[1] argue that this means participatory methods, which were originally conceived "to facilitate positive change in marginalized communities," are being used in areas for which they are inherently unsuitable.

They argue that to understand where participatory approaches are and are not appropriate, one needs to consider their nature and purposes. The different participatory methodologies and philosophies generally share a demand for research participants to play a major role in determining the research agenda, determining and negotiating both outcomes and methods.

The paper considers two case studies, deliberately chosen because of their different social, economic and cultural contexts, Both are projects facilitated by state-owned Crop and Food Research (CFR) and are concerned with improving environmental and economic sustainability of cropping systems. The case studies were drawn up through semi-structured interviews with farmers, scientists, consultants and farmer representatives in the projects:

- Crop Science for Maori: a five-year project with Maori farmers in the remote and impoverished East Cape to develop organic vegetable production.
- Wheat Calculator Project for commercial wheat farmers on the Canterbury Plains. While the area is prime wheat-growing country and farmers want to improve profitability, it is susceptible to nitrate leaching, and this is worsened by intensification; because the aquifers deliver drinking water to many communities there is political pressure to preserve them.

Both case studies brought out the importance of farmers' groups. The existence of a farmers' group is an indication that farmers already desire change, and farmers' groups have a demonstrated role in facilitating research projects and providing a mandate for researchers. In the case studies here, they also proved crucial for the environmental component of both projects.

Despite some substantial criticisms, interviewees for both case studies thought their projects were successful, but in the judgement of the authors, the initiatives failed to heighten farmers' understanding of the environment, a key goal in any programme for sustainable agriculture.

Participants in the organic vegetable project admitted progress towards agreed goals has been "painfully slow" (perhaps because the timetable was unrealistic), but scientists and growers judged it a success because of the understanding, trust and respect built up, which has not been the case for previous non-participatory projects. However, while participants from the Maori community had a belief in the health and environmental principles of organic production, a far more important motivation was that, by reviving their culturally important cropping tradition, they might attract young people back to the region.

The Wheat Calculator project involved participatory development of a farmer-friendly decision-support software tool, the Wheat Calculator, to optimize timing of fertilizer and irrigation interventions. Two major benefits predicted in advance by CFR scientists were (a) a reduction in excess soil nitrate and (b) potentially increased profitability through optimized productivity and reduced expenditure. However, interviews with participating farmers revealed that it was increased profitability that mostly attracted them to the project. Moreover, they saw the Wheat Calculator not as a method of protecting the environment, but a measure to pre-empt nitrate-restricting legislation.

What is common to both case studies, therefore, is that the goals of the participants were at odds with the objectives of the scientists and policymakers.

In the case of the Crop Science for Maori project, participants were most concerned with improving quality of life: they hoped most of all that the project would provide a positive example of economic possibilities to attract young people who had migrated away. Realizing the health and environmental benefits of organic production, which were the stated aims of the project, were of secondary and tertiary importance (respectively).

With the Wheat Calculator project, the farmers' prime goal of greater profitability again suggests that improving quality of life was their main motivation. Although farmers were aware of the potential environmental effects of their farming practices, minimizing them was of lower (long-term) importance than maximizing profitability.

Thus both the case studies demonstrate the potential (and, in both these cases, realized) clash between the goals of policymakers and those of research participants – wherein lies the problem with participatory research, which by its very nature is supposed to serve the participants alone. In short, the authors argue, participatory research is not a methodology for realizing policy goals.

The case studies here also illustrate what tends to happen where this is attempted. The project facilitators find themselves prioritizing the different goals and making trade offs. Farmers need to see the research will contribute to their goals before they will participate, while the facilitators themselves need to make sure research is in line with the demands of the funding agencies.

[1]Bruges, M. & Smith, W. (2008) Participatory approaches for sustainable agriculture: a contradiction in terms. *Agriculture and Human Values* **25**, 13–23.

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Announcements

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

Harmonia in BioControl

For anyone who has missed it, the first 2008 issue of *BioControl* (Volume 53, No. 1) is devoted to the harlequin ladybird, *Harmonia axyridis*. Following a foreword that considers 'From biological control to invasion: the ladybird *Harmonia axyridis* as a model species', by Helen Roy and Eric Wajnberg, 19 further papers deal variously with its spread, distribution and impact (historical, current and potential) in the USA and Europe; research on aspects of its biology, phenology, ecology and population genetics; and current control measures and research relevant to its future management.

Web: www.springerlink.com/content/102853/

Royal Society Journal on Sustainable Agriculture

A special double issue of *Philosophical Transactions of the Royal Society B* is devoted to sustainable agriculture. The issues (Volume 363, Numbers 1491 and 1492: 12 and 27 February 2008) are edited by Chris Pollock, Jules Pretty, Ian Crute, Chris Leaver, and

Howard Dalton. Articles of particular interest to *BNI* readers are:

- 'Biological control and sustainable food production' by J. S. Bale, J. C. van Lenteren & F. Bigler (No. 1492, pp. 761–776).
- 'Integrated pest management: the push-pull approach for controlling insect pests and weeds of cereals, and its potential for other agricultural systems including animal husbandry' by A. Hassanali, H. Herren, Z. R. Khan, J. A. Pickett & C. M. Woodcock (No. 1491, pp. 611–621).

Web: http://journals.royalsociety.org/content/102022

LEISA on Pest Management

The December 2007 issue of the LEISA magazine on low external input and sustainable agriculture (Volume 23, No. 24) was devoted to 'Pest Management'. The articles cover development of IPM, and training and knowledge dissemination (using a variety of participatory methods) for a range of pests in developing countries.

Web: www.leisa.info/

Neobiota Conference

The Fifth European Conference on Biological Invasions, 'Neobiota: Towards a Synthesis', will be held in Prague, Czech Republic, on 23–26 September 2008. The meeting is being organized by the Institute of Botany, Academy of Sciences of the Czech Republic, Department of Invasion Ecology (Prùhonice) and Charles University Prague – Faculty of Science, Department of Ecology (in cooperation with the Czech University of Life Sciences, Prague). Conference topics include:

- Ecology of invasive alien plant and animal species
- Large-scale patterns of biological invasions: present and future
- Pathways and vectors: towards a general scheme
- Impact and risk assessment
- Conservation of biodiversity
- Prevention, monitoring, control and eradication
- Policy and legislation

The deadline for abstract submission for contributions (talks and posters) is 30 April 2008.

Email: neobiota@ibot.cas.cz
Web: www.ibot.cas.cz/neobiota/

Rice Black Bugs

The Philippine Rice Research Institute (PhilRice) has published 'Rice Black Bugs: Taxonomy, Ecology, and Management of Invasive Species'. This 800-page book reinterprets old problems and introduces new ecological techniques for the management of rice black bugs (RBB). In four sections, the book covers clarifications on its confusing taxonomy using traditional and modern taxonomic tools, country reports of RBB experiences, and approaches to management of RBB pest species.

Price: US$102 in developed countries,
US$52 in developing countries (both plus P&P).
Email: prri@philrice.gov.ph / joshiraviph@gmail.com
Web: www.philrice.gov.ph/

Conference Reports

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 here.

Biopesticides: the Regulatory Challenge

The RELU (Rural Economy and Land Use) funded research project, 'Biological Alternatives to Chemical Pesticides in the Food Chain: An Assessment of Sustainability', undertaken by the Department of Politics and International Studies in conjunction with Warwick HRI, held its final workshop in Warwick, UK, on 31 October 2007. The meeting presented findings from their project on the environmental and regulatory sustainability of biopesticides as alternatives to chemical pesticides in the food chain. The event was sponsored by RELU and Agraquest.

Changes in crop protection in recent years – including EU legislation leading to the withdrawal of some major pesticides from use, increased pest resistance to certain chemical pesticides, and a consumer/retailer trend towards produce with zero detectable residues – have meant the scope for the use of biological control agents has increased, yet their entry into the market place and (thus) uptake in farming systems has been lower than expected. The meeting presented findings from a three-year study into why this is the case and what the possible ways of rectifying the situation are.

Participants at the workshop heard the following presentations:

- Dr David Chandler (Warwick HRI, University of Warwick) and Professor Wyn Grant (Department of Politics and International Studies, University of Warwick): 'Biopesticides: environmental and regulatory sustainability.'
- Dr Don Edgecomb (Agraquest, Inc., USA): 'The Agraquest pipeline – biological and natural based technologies.'
- David Cary (Market Development Manager Exosect Ltd, UK) and Roma Gwynn (Rationale Biopesticides Consultants, Scotland): 'Regulatory

experiences of biopesticides in UK, EU and elsewhere.'

• Dr Peter C. Leendertse (CLM, Netherlands): 'Natural pesticide experiences from the Netherlands.'

• Richard Davis (Pesticides Safety Directorate – PSD, UK): 'The regulatory response: the biopesticides scheme.'

Dave Chandler and Wyn Grant noted that hypotheses for the lower than expected uptake of biopesticides include both regulatory and economic pressures. The burden of developing biopesticides tends to be shouldered by small- to medium-sized enterprises (SME), and gathering enough field based data for registration can be a lengthy and expensive process. With registration costs high, and a major cost for registration being efficacy testing of the product, it was suggested that a more appropriate model could be followed, whereby registration is granted and then efficacy testing carried out in the first five years after the product launch. The role of retailers in growers' decision-making was identified. They may have requirements that go beyond the existing approval system, and because they cannot endorse particular products do not usually promote the use of environmentally friendly alternatives. A cost–benefit analysis indicated a negative balance for R&D of products and for growers, but a positive balance for consumers.

Don Edgecomb gave a presentation on Agraquest's experiences of registration in the USA and an overview of its products. The majority are based on microbial metabolites or plant extracts; one of interest in the pipeline is the fungus *Muscodor albus* which produces volatile compounds against a wide range of fungi. The product and its formulation were discussed as a postharvest agent [also see *BNI* 28(4) December 2007, pp. 69N–74N].

Exosect mainly works on Lepidopteran pheromones and was the first company to have a product registered in the new Biopesticide Scheme in the UK. The key elements of the Biopesticide Scheme are pre-submission meetings, reduced registration fees and a Biopesticides Champion within PSD[1]. David Cary explained that SMEs often register a product based on the results of early trials and there is thus more limited opportunity for product optimization. Cary commended the new system on its new proportional fee structure and the ability the scheme gives a company to work out a realistic timeline before returns can be expected on a product. The pre-submission process was also commended as it enables companies to cut out any unnecessary work which is irrelevant to registration. He underlined his belief that the key to success is mutual recognition between European Union countries, therefore by-passing the need for registration in each country. Currently Exosect are working to develop 'concept orchards' which is a way of demonstrating the products' ability to work and gaining the trust of growers/end-users.

Peter C. Leendertse described the Netherlands' experience through Project GENOEG, which translates as 'effective use of natural pesticides' and was set up to facilitate registration of natural pesticides to the market and to create an inventory of effective natural pesticides. The project included aid with the registration of natural products, extension work educating growers and updating the list of effective 'products of natural origin' (PNOs). The project has helped with registration of ten PNOs, and without this help it is possible the applicants would not have started or succeeded in having their products registered. (See www.genoeg.net)

Richard Davis presented on behalf of the PSD (Pesticide Safety Directorate). He outlined how the Biopesticide Scheme was launched in order to increase availability of biopesticides in the UK. He explained that free pre-submission meetings were introduced to ascertain how many data would be needed to go forward to register a product, and gave an overview of the new fee structure. Pre-submission meetings are a vital component of the scheme ensuring that only work necessary for registration is carried out on products, avoiding extra costs to researchers. With the introduction of a new 'Biopesticides Champion'[2] researchers have an important first point of contact in the PSD, able to advise and offer assistance in the registration process. Disappointment was expressed, however, at the lack of people coming forward for advice/pre-submission meetings so far.

The outputs of the RELU project are to be written up as book to be published by CABI.

Further information on the RELU project and this meeting is available at: www2.warwick.ac.uk/fac/soc/pais/biopesticides/

Other useful websites:
[1]PSD New Biopesticide Scheme:
www.pesticides.gov.uk/environment.asp?id=1846
RELU, Rural Economy and Land Use Programme:
www.relu.ac.uk/
REBECA, Regulation of Biological Control Agents:
www.rebeca-net.de/

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[2]Lisa Moakes, Biopesticides Champion, PSD;
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By: Bryony Taylor, Biopesticides Group,
CABI Europe, UK, Silwood Park, Ascot SL5 7TA, UK.
[This report also appears in an adapted form in *International Pest Control* **50**(1).]

Indian Biopesticide International Conference: Biocicon – 2007

The Department of Advanced Zoology and Biotechnology, Palayamkottai organized a three-day international conference on Biopesticides at St Xavier's College from 28–30 November 2007. Dr Jelumn (Deputy Director, National Centre for Plant Protection Training, Hyderabad) in his introductory remark emphasized the need of registration of pesticides and biopesticides. Dr B. V. David from Sun Agro-Biotech, Chennai highlighted approaches in IPM and their impact on the environment. He also reported on usage of pesticides in various crops, and its impact on the environment, humans and domestic animals. Need and necessity of incorporation of biopesticides in agriculture was also highlighted. Rev. Fr Britto Vincent, S. J. Rector, Rev. Dr Antoney Leo Tagore, S. J. secretary and Rev. Dr Alphonse Manicakam, S. J. Principal of the college underlined the importance of biopesticides. Dr K. Sahayaraj, the Organising secretary of the conference, outlined the dynamics of the conference.

In the first day's technical session, Dr Hem Sexena, Indian Institute of Pulses Research, Kanpur; Dr Y.G. Prasad, Central Research Institute for Dryland Agriculture, Hyderabad; and Dr P. Jeyakumar, National Centre for Integrated Pest Management (IPM), IARI, New Delhi, delivered the lead papers on microbial insecticides, *Achaea janata* granuloviruses and biomolecules in pest management. Eminent scientists and researchers for various parts of India delivered 19 oral presentations on IPM, microbial insecticides and plant- and microbe-based biomolecules.

During the second day, Dr Pathipati Usha Rani, Indian Institute of Chemical Technology, Hyderabad; Dr Stephen D. Samuel, Regional Coffee Research Station, Thandigudi; and Professor Rohan Rajapakse, University of Ruhuna, Sri Lanka, chaired three sessions covering plant products in defoliators, other pests and stored products management, respectively. Young and senior scientists presented their findings from both laboratory and field research. In all, two lead papers, 20 oral papers and four posters including a poster by Dr Roman Pavela, Crop Research Institute, Czech Republic, on plant products and their use in pest management. All the presentations highlighted the importance of plants and their biomolecules in management of various pests. They also recommended utilizing various locally available plants in cost effective and environmental pest management.

During the third day deliberations were on natural enemies in pest control. The first session was chaired by Dr R. Sundararaj, Wood Biodegradation Division, Institute of Wood Science and Technology, Bangalore. He highlighted the distribution and role of various natural enemies, which dwell in sandalwood growing areas of South India. In this session five oral presentations were delivered on this aspect. The last technical session, chaired by Dr K. P. Sanjayan, G.S. Gill Research Institute, Chennai, was on biotechnology in pest management. He delivered an invited lecture on 'Induction of specific biochemical pathways in plants for pest management'. Junior, young and senior researchers presented six oral and 13 posters from various parts of the world including Bangladesh and Indonesia. All presentations were discussed adequately and suggestions were brought out and presented by Dr B. Victor from the Department of Advanced Zoology and Biotechnology.

Dr S. Vincent, Member secretary, Tamilnadu Council for Science and Technology (TNSCST), Chennai, chaired the valedictory function afternoon of the conference's third day. He pointed out the impact of various pesticides in various agro-ecosystems (both fresh and marine water bodies and terrestrial systems), the necessity of IPM, natural enemies, and plant-based and microbes-based insecticides in agriculture. He also highlighted the various avenues available for juniors and scientists in the field of biopesticides in TNSCST. The best paper presentation honoured ten young scientists. Rev. Dr Alphonse Manicakam, S.J. expressed the importance of conferences and symposia in the field of higher education, followed by an overall report on the conference read by Dr T. A. Sethuramalingam. Dr K. Sahayaraj, the Organising secretary, gave the vote of thanks and declared that he would like to start the Society for Advancement of Crop Protection and also an International Journal on Biopesticides.

By: Dr K. Sahayaraj, Organising secretary,
Biopesticide International Conference.
(BIOCCON-2007).

DOM Symposium on Microbial Formulation

The First International Domestication of Microorganism (DOM) Symposium on Microbial Formulation, held on 4–5 December 2007 in Uppsala, Sweden was attended by almost one hundred participants from over 20 countries in Europe, the Americas, Asia and Africa.

The symposium was opened by Professor Johan Schnürer (Swedish University of Agricultural Sciences [SLU]), the DOM programme director, who gave a brief outline of DOM research on safety assessment, fermentation and formulation. Professor Schnürer ended by extending an invitation for international research cooperation to both academia and industry. Dr David A Schisler (US Department of Agriculture – Agricultural Research Service, National Center for Agricultural Utilization Research [USDA-ARS NCAUR]) began the first morning with an invited presentation, 'Fermentation: prelude to success in the formulation of bioactive agents'. This was followed by presentations on 'Influence of the fermentation on the viability and efficacy of freeze-dried cells of *Pseudomonas fluorescens* Pf153' by Dr Isabella Bisutti (BBA Institute for Biological Control, Germany); 'DOM project approaches to stabilization of viable microorganisms' by Dr Sebastian Håkansson (SLU); 'Stabilisation of lactic acid bacteria: relevance of physical properties on formulation efficiency' by Fernanda Fonseca (Institut National de la Recherche Agronomique [INRA], France); and 'Freeze-drying of *Lactobacillus coryniformis* Si3' by Åsa Schoug (SLU). After lunch, Professor John H. Crowe (University of California, Molecular and Cellular Biology, USA) gave an invited presentation on 'The utility of trehalose for preserving microorganisms'. Professor Crowe is the 'elder statesman' of dry-preservation biology and his presentation was particularly well received. Subsequent presentations were on 'A gelatine capsule method to preserve and spread cells of *Pseudomonas putida* as biosensors of aromatic chemicals in soil' by Dr Aitor de las Heras (Centro Nacional de Biotecnología – Consejo Superior de Investigaciones Científicas [CNB-CSIC], Spain); 'Design of self-assembled metal oxide micelles for encapsulation of bacteria in bio-control applications', by Professor Vadim Kessler (SLU); 'Development of biocontrol agents adapted to environmental stress conditions' by Dr Neus Teixido (Institute of Agro-Food Research and Technology [IRTA], Spain); 'Product development for extended shelf-life of *Serratia entomophila*, a microbial control agent for grass grub in New Zealand' by Dr Trevor A. Jackson (AgResearch Ltd., New Zealand); and 'Development of a starter culture tablet targeting fermented milk applications' by Dr Erwan Henri (Danisco, France)

The second day began with an invited presentation by Dr Jan Dijksterhuis (Centraalbureau voor Schimmelcultures [CBS], the Netherlands) on 'Ascospores of thermotolerant fungi - nature's perfect formulations'. Dr Dijksterhuis' presentation on fungal cell biology attracted a lot of interest from the participants, in particular in connection with the relevance of fundamental biological studies for industrial formulations. He was followed by presentations on 'Development of vacuum-drying processes of PGPR *Pseudomonas* isolates for application in various agricultural systems' by Dr Jolanta Levenfors (Microbial Activity for a Sound Environment [MASE], Sweden); 'Comparison of different drying techniques for potential biocontrol agents' by Dr Dietrich Stephan (BBA Institute for Biological Control, Germany); 'Formulation of the yeast *Dekkera bruxellensis* for ethanol production' by Johanna Blomqvist (SLU); and 'First results about the fermentation and freeze-drying formulation of a *Metschnikowia pulcherrima* for the biological control of postharvest disease' by Dr Davide Spadaro (Agroinnova, Italy). The final afternoon began with Professor Peter J Lillford (Centre for Novel Agricultural Products [CNAP], University of York, UK) giving an invited presentation on 'Why organisms need a PhD in physical chemistry'. His humorous and forceful presentation was one of the highlights of the symposium. The final presentations were on 'The use of ATP technology to measure bacterial numbers and physiological status' by Dr Arne Lundin (Biothema AB, Sweden); and 'Optimization of large scale production and bioformulation of *Pantoea agglomerans* strain Eh-24' by Dr Tugba Adiyaman-Koltuksuz, Science and Technology Center [EBILTEM], Turkey.

Eleven posters were also displayed.

The scientific atmosphere at this first International Formulation Symposium with attendants from both industry and academia was very open, friendly and informative. December in Sweden is an extremely dark period of the year, but participants were warmed by the sights and sounds of traditional Swedish Lucia carol singers in white frocks and candle wreaths, a typical 'Julbord' (Christmas smorgosbord) with schnaps and singing, followed by a visit from the 300-year-old birthday boy and Uppsala's most famous citizen – Carl von Linnaeus.

The DOM programme is planning to arrange a course and a one-day symposium on: 'Microbes and Regulatory Systems' in the autumn of 2008, probably early October. Intended participants are industrial development staff, regulatory officers and university scientists and PhD students.
More information will follow on the DOM web site: www.mistra.org/DOM

SMCB & IOBC Meet in Mexico

The Sociedad Mexicana de Control Biológico (SMCB) and the International Organization for Biological Control (IOBC), Nearctic Regional Section, held a joint symposium, entitled 'Biological Control Without Borders' on 13–15 November 2007 in Merida (Yucatan), Mexico. The Symposium was held in conjunction with the SMCB's annual National Congress, and was attended by approximately 275 scientists and students from at least nine countries.

Plenary addresses were 'Augmentative biological control in Latin America: How far have we come?' by Dra Vanda Bueno (Brazil) and Dr Joop van Lenteren (Netherlands); and 'Holistic pest management: more than IPM?' by Dr Juan Barrera (Mexico). The meeting consisted of a roundtable discussion on 'Mass-rearing natural enemies in Latin America', convened by Dra Bueno; and four symposia: 'Ecological interactions between biological control and GM crops', organized by Dr Jonathan Lundgren (USA); 'Biological control and management of the Central American locust', organized by Dra Ludivina Barrientos Lozano, Dr Eduardo Slazar Solís and M. C. Juan Jasso Argumedo (Mexico); 'Biocontrol and IPM of protected crop pests in the Americas', organized by Drs Luis Cañas (USA), Les Shipp (Canada), Vanda Bueno (Brazil), Graeme Murphy (Canada) and John Sanderson (USA); and 'Biological control of weeds throughout the Americas', organized by Rob Wiedenmann (USA). The symposia featured dual-language slides to allow attendees to follow the presentations, regardless of the language in which the paper was presented. There were also 78 submitted papers and 60 poster presentations.

Prior to the Symposium and Congress, SMCB held its annual three-day National Course on Biological Control, which was attended by 182 students, and a workshop on managing Central American locusts, with 61 participants.

The SMCB holds its National Congress each year, but the 2007 meeting was the first one held in collaboration with IOBC.

Report compiled by: Hugo Arredondo Bernal and Luis Rodriguez-del-Bosque (SMCB), and Rob Wiedenmann (IOBC).

ESA in San Diego

The annual meeting of the Entomological Society of America (ESA) was held on 8–13 December 2007 in San Diego, California. Over 2850 people registered, including 700 students, making it one of the most attended meetings ever. Leon G. Higley of the University of Nebraska-Lincoln delivered an informative and insightful Founders' Memorial Lecture on the life and contributions to entomology of Dr Asa Fitch, one of the pioneer figures in American economic entomology. More than 1300 talks and approximately 670 posters were presented, making it practically impossible to take them all in. Fortunately, all presentations that were recorded are now freely accessible on the ESA website (www.entsoc.org) to those who registered for the meeting.

A record number of 70 symposia were conducted. The theme of the meeting was 'Making Connections', and a number of symposia reflected this theme in their topics. Thirty symposia directly connected to biological control and pest management were:

- Biocontrol: economic, social, and ethical factors shaping its success
- Classical biological control using pathogens and nematodes
- Successes, challenges, and frontiers in biological control of saltcedar in the western U.S.
- Biological control of knapweeds: lessons learned and questions raised
- Soybean aphid in the north central US: implementing IPM at the landscape scale
- Corn rootworm genetics: current status, goals for the future, and implications toward resistance management
- Lady beetle linkages: connections of the Coccinellidae
- Neonicotinoid insecticides: exposing and navigating their multifaceted ramifications for pest management in turf and ornamentals
- Greenhouse pest management: research, implementation and opportunities
- Colony collapse disorder in honey bees: insight into status, potential causes, and preventive measures
- Exotic forest pests: Are we making any progress?
- Invasive bark beetles in the forests of the United States
- Bark and wood boring beetles: innovations and initiatives with the U.S. Forest Service
- Influence of molecular technology on invasive species programs
- Invasive pests: a growing problem in a shrinking agricultural landscape
- Integrating integrated pest management
- Implementing IPM through conservation programs: opportunities, experiences, and strategies to move forward
- New developments from industry for insect pest management solutions
- Advances in *Bt* resistance: from mechanisms to monitoring
- *Bt* crops and resistance monitoring: innovation and influence in U.S. pest management
- Harmonizing laboratory methods to evaluate potential effects of GM crops on non-target arthropods
- Regulatory framework connecting the science and application of transgenic insects
- Recent advances in research of subterranean termites and their roles in population management programs
- Ecology of invasive mosquitoes: factors controlling their spread and ecological and public health impacts
- Prevention and management of vectors and pests of public health importance
- Recent advances in vector sand fly research: connecting laboratory and field efforts to develop novel approaches to leishmaniasis control
- Recent developments in insect repellents research
- Insect antiviral resistance
- Making connections between traditional and new approaches for host plant resistance research
- Diagnostic tools/protocols to detect arthropod-associated pathogens

The increasingly popular Linnaean Games was won by the team from the University of Arkansas. The Insect Photo Salon displayed hundreds of photographic images of insects and other arthropods that were submitted by members of ESA, and the Photographic Society of America. Exhibits from 54 private and public organizations and vendors provided information, demonstrated new technological apparata, and sold items such as imaging equipment, entomological supplies, jewellery, books, and T-shirts.

The 2008 ESA annual meeting will be held in Reno, Nevada on 15–20 November 2008. The theme of that meeting is 'Metamorphosis: A New Beginning'. You can *bet* on it being a good meeting.

By: Ron Cave, University of Florida.