Locust and grasshopper biocontrol newsletter No. 1

Objective:

To promote the utilisation of biological control agents in acridid IPM by the mutually beneficial exchange of information.

Edited by David Hunter and Chris Lomer

Background

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Biocontrol of locusts and grasshoppers is at a critical stage. At a time of increasing constraints on insecticide use, we have a biocontrol agent (Metarhizium) that has been developed through the LUBILOSA project with significant contributions from other workers in many parts of the world. Provisional registrations of Metarhizium products have been obtained in Australia, South Africa and the Sahelian countries (CILSS), and the product appears on the list of FAO approved agents for locust control. Operational use has had a start, including Australia where more than 23,000 ha of locust bands and swarms were treated during the 2000-2001 locust season. But to facilitate the expansion of operational use of biologicals, information on the most recent developments needs to be exchanged amongst researchers and to potential users. This newsletter aims to provide a forum for the dissemination of information not only on *Metarhizium* but other biologicals, including conservation biocontrol that have potential for locust control so that biologicals can become an increasingly important part of the integrated pest management of locusts and grasshoppers.

The working group as a network

Chris Lomer and I thought that a good way to disseminate information would be through a locust and grasshopper biocontrol working group. And because a number of us are already part of the Association of Applied Acridology International (AAAI), it was thought a group could be set up under its auspices with limited effort. The idea of the working group is that this should be a medium for open exchange of information, disseminated through networking. To limit the amount of set up work Chris and I had to do, we have contacted one or two individuals in areas working on biologicals. These initial members of the working group are just a starting point. Everyone is encouraged to disseminate the newsletter to others they are working with, and to suggest additional members. Chris and I have done some initial set up work. After the first newsletter, a co-ordinator will be elected, with democratic elections every year thereafter.

The first newsletter

This first newsletter is being sent out ahead of the symposium on biological control that will be held at the International Orthopterists Society meeting in Montpellier (August 19-24). The aim is to have the newsletter disseminate some of our most recent results and to raise some issues ahead of the symposium.

Please send us material for the second newsletter, which will include a list of names and emails of people working on locust biocontrol, and should appear in November 2001.

This newsletter is one of a range of AAAI activities to promote environmentally sound acridid control. Details of AAAI training courses in this area will be given in the next newsletter.

Please feel free to photocopy and pass this newsletter around. Subscription is free by emailing to david.hunter@affa.gov.au or Chris Lomer (clo@kvl.dk), or download from the AAAI web site.

Montpellier papers:

What is the place of biological control in acridid integrated pest management?

Chris Lomer,
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Control of grasshoppers and locusts has traditionally relied on synthetic insecticides, and for emergency situations, this is unlikely to change. Most locust control operations in Africa are conducted in 'crisis mode', and are affected by military situations which leave little room for flexibility. Nevertheless, there is a growing awareness of the environmental impact of acridid control operations, and the demand for a biological product is strong.

A decade of research on the entomopathogenic fungus *Metarhizium anisopliae var. acridum* has led to some astonishing field results. Contrary to some of the more pessimistic scenarios envisaged at the outset of the development projects, trials in Niger and Australia have shown that the fungus can be formulated and applied under standard operating conditions, and that control is effective and long-lasting. Most importantly, the products are highly selective, safe to use, and we have not been able to detect any side-effects. This means that the natural enemy fauna is preserved and may be contributing to control. Certainly, birds are unaffected by Metarhizium. Metarhizium, like many biopesticides, thus offers a way of controlling pest outbreaks, without upsetting natural enemy populations. Metarhizium is a 'good' IPM technology which should lead to stabilisation of pest populations.

We can see an emerging IPM framework, based on good detection and prediction, chemical pesticides for swarm control and real emergencies, and Metarhizium for outbreaks with no immediate risk of crop damage. With Metarhizium established as part of the IPM portfolio, there will be scope to explore further biocontrol options, such as the microsporidian Nosema locustae and the hymenopteran egg parasitoids Scelio spp.

Symposium on biological control -- Wednesday August 22 at Orthopterists Society Meeting at Montpellier (19-22 August 2001)

BIOLOGICAL CONTROL AND ITS ENVIRONMENTAL CREDENTIALS

Moderators:
Chris Lomer, Royal Veterinary and Agricultural University, Copenhagen, Denmark
David Hunter, Australian Plague Locust Commission, Canberra, Australia

Concept:
Biological control of locusts and grasshoppers using oil formulations of the fungus *Metarhizium anisopliae var. acridum* is being increasingly accepted world-wide as a viable and effective control option. As a biological agent, it does pose some operational challenges, in terms of its slow speed of kill and sensitivity to temperature extremes. However, its advantages in terms of extended field persistence, possibly due to recycling, and excellent safety record are leading to its uptake in some situations. The session will review progress in implementing biocontrol world-wide and explore some novel options, and revisit some underestimated biocontrol agents. For wider implementation, biocontrol needs a squeaky-clean safety record. We will examine current experimentation on environmental impact and safety and pinpoint areas of concern for future research. We will also focus on some of the current constraints to the wider implementation of acridid biocontrol.

Symposium Program: Wednesday August 22, 2001

First half (25 minute talks with 5 minutes questions)

0830	**Jürgen Langewald**, Ralf Peveling and Ine Stolz. (International Institute of Tropical Agriculture, Benin; University of Basel, Switzerland) *Implementing biological control of grasshoppers in West Africa and evaluating environmental impact*
0900	**Dan Johnson,** Agriculture and Agri-Food Canada, Alberta, Canada *Safety and integration of mycoinsecticides with the activities of insect-eating birds*
0930	**Richard Milner** (CSIRO) and David Hunter (APLC) *Recent developments with the use of fungi as biopesticides against locusts and grasshoppers in Australia*
1000-1015	Coffee break

Second half: Progress reviews in the implementation of biocontrol
(12 minute talks with 3 minutes questions)

1015	**Ludivina Barrientos**, Technological Institute of Higher Education, Tamaulipas, México *Advances in Biological Control of locusts and grasshoppers in México*
1030	**Graeme Hamilton**, APLC, Australia *Biocontrol place in acridid IPM in Australia*
1045	**James Everts**, Alpha Diallo, Abdoulaye Danfa and Wim Mullié, LOCUSTOX, Senegal *New ecotoxicity data on Green Muscle*
1100	**Candido Santiago-Alvarez**, University of Cordoba *A short overview of locust biocontrol in Spain*
1115	**Carlos Lange**, CEPAVE, Argentina *Twenty years after the introduction of Nosema locustae in Argentina: an update*
1130	**Bonifacio Magalhães** (Embrapa, Brazil) and Michel LeCoq, (PRIFAS-CIRAD, France) *Development of a mycopesticide for locust control in Brazil*
1145-1215	Summary and introduction to panel discussion C. Lomer Panel discussion (led by J. Lockwood, J. Everts and C. Lomer) Points for action, areas for further research

Large-scale environmental impact of biological control and the future of grasshopper control in the Sahel

J. Langewald[1], R. Peveling[2] & I. Stolz[2]

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After many years of research and large scale field testing, isolates of the fungus *Metarhizium anisopliae* are now commercialised as the most effective biocontrols for grasshoppers and locusts available. In the context of the development of Green Muscle, most of the early large scale field testing was carried out in the Sahel and particularly in Niger. As a part of field testing, the ecotoxicological impact of the novel product was compared with standard synthetic insecticides. The results show that Green Muscle had no negative impact on non-target Hymenoptera and on soil dwelling non target arthropods. However, concerning Hymenoptera the studies also revealed the limits of field testing, even at a scale of 800ha plots, where data variability becomes a problem. With the limitations of ecotoxicological studies in mind, developing future grasshopper control strategies should be designed in a way, that even potential environmental hazards are avoided. Not only direct environmental impact needs to be studied, but also impact of food depletion on important grasshopper natural enemies or rare species. Particularly in the Sahel, where authorities are still following curative control strategies, and where the average annual area sprayed may be the largest world-wide, better control strategies are needed.

New Ecotoxicity data on Green Muscle

James Everts[1], Abdoulaye Danfa[2], Apha O. Diallo[2] and Wim C. Mullié[1]

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In general, biopesticides represent a lower environmental risk than synthetic compounds. However, their non-target toxicity, even when low, should be well known, in order to enhance the selectivity of applications to a technical maximum. All insecticides used against locusts that are evaluated by the Pesticide Referee Group of FAO, are submitted to tests with non-target species from the target habitat and field tests. In the present study first tier challenge tests were carried out with Green Muscle®, (active ingredient: acridid pathogen *Metarhizium (flavoviride) anisopliae var. acridum*) on five non-target organisms: a fish (*Oreochromis niloticus*), an aquatic hemipteran (*Anisops sardeus*), two terrestrial coleopteran natural enemies of locusts (*Pimelia senegalensis* and *Trachyderma hispida*), a parasitic hymenopteran (*Bracon hebetor*) and a termite (*Psammotermes hybostoma*). The tests were carried out according to Standard Operation Procedures for synthetic chemicals adapted for testing with pathogens, with the exception of *P. hybostoma*. The latter species was tested in a controlled field set-up. Results indicated that at extreme exposure Green Muscle® may be infective for *O. niloticus* and *A. sardeus*. The hemipterans are, irrespective of the dose, affected by the solvent (a mixture of mineral and organic oil) which partly covers the water surface, hampering breathing. In a field test, environmental factors (especially wind) appeared to attenuate this effect. *P. senegalensis* and *T. hispida* proved insensitive to direct exposure. *B. hebetor* was infected both through direct exposure as well as exposed as a larva in a host (*Ephesthia kuehniella*). The semi-field test with *P. hybostoma* indicated that the termites may be sensitive to the pathogen.

EUROPE

Biological control of locusts and grasshoppers in southern Europe

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Matt Thomas & Simon Blanford, NERC Centre for Population Biology and CABI Bioscience, Silwood Park, Ascot, Berks., UK.

Javier Celma and José Luis Collar, Aragonesas Agro SA, Paseo de Recoletos 27, 28004 Madrid, Spain.

Locusts and grasshoppers are key pests in several parts of Europe and the neighbouring regions. The Moroccan locust, *Dociostaurus* *maroccanus*, has been recorded as an important pest of pasture and crops in Spain for several centuries. Outbreaks also occur in other Mediterranean areas such as southern Italy, Crete, Sardinia, Morocco, Algeria and Turkey, as well as parts of eastern Europe and the former Soviet Union.

Chemical insecticides have to-date provided the only means for ensuring wide-scale control of locust and grasshopper outbreaks. The widespread use of such chemicals and their associated detrimental effects on the environment, combined with the hazard they represent to users and livestock, remains a major drawback to continued reliance on their use.

In light of this, in early 2000 a collaborative European research project entitled, 'Protecting Biodiversity through the Development of Environmentally Sustainable Locust and Grasshopper Control' (ESLOCO), was initiated. Its aim is to reduce the environmental impact of locust and grasshopper control operations through the development of a new environmentally sustainable strategy, based on the use of *Metarhizium anisopliae* var. *acridum*. Here we report on the first field trials conducted in Spain as part of the ESLOCO project. The results demonstrate that *M. anisopliae* var. *acridum* is highly infective to both Moroccan locust and Italian grasshopper, the two most important acridid pests in the region.

SOUTH AMERICA

The use of *Metarhizium anisopliae var. acridum* against the grasshopper *Rhammatocerus schistocercoides* in Brazil

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The control of grasshoppers in Brazil has been based exclusively on chemical insecticides (fenitrothion and malathion). However, as these products are known to be harmful to the environment, their massive use has caused concerns. To face the pressure against the use of chemical insecticides to control grasshoppers, the development of alternative methods became imperative. Some species of entomopathogenic fungi can supplement or even replace chemical insecticides in the control of grasshoppers. An integrated research project was initiated in Brazil in 1993 at Embrapa (Brazilian Agricultural Research Corporation) Genetic Resources and Biotechnology with the specific objective of developing bioinsecticides based on entomopathogenic micro-organisms, specially fungi, to control grasshoppers. Our activities were centred in surveys, characterisation, production, formulation, and field evaluation. Emphasis has been given to develop the fungus *Metarhizium anisopliae* var. *acridum*, the most promising candidate as biocontrol agent against grasshoppers. It has been demonstrated that this pathogen can be used efficiently in the control of *R. schistocercoides* in Brazil. We are now verifying its effects on non-target organisms including other Orthoptera, Diptera and Hymenoptera.

Twenty years after the introduction of *Nosema locustae* for grasshopper control in Argentina: an update.

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Nosema locustae is a spore-forming pathogen (Microspora) of the adipose tissue of orthopterans that was selected and developed in the USA as a microbial control agent of grasshoppers. When its development was well advanced but as early as two years before its registration in the USA (1980), a series of introductions into grasshopper communities began in Argentina that extended from 1978 to 1982. These applications were the first use of the pathogen outside of North America, and although considered experimental at the time, they were actually of a rather large-scale magnitude. Using inoculum of north American origin (spores produced either by the USDA laboratory in Bozeman, Montana, or by BioEcologists in Colorado) and following standard application procedures (spores on bran baits delivered to third-instar nymphs), *N. locustae* was introduced in a total of nine localities, seven in the Pampas region (Casbas, Gorchs, Lamadrid, Macachín, Pringles, Santa Rosa, Suárez) and two in northwestern Patagonia (Gualjaina, Zapala). Unfortunately, after the last introductions the work lost continuity. The short-term impact (control within seasons of applications) of the introductions will remain unknown because reports were not produced and data on infectivity and density reductions are not available. Similarly, the long-term outcome of the introductions was unknown for years until the pathogen was re-found in 1991 parasitizing three species of grasshoppers. Since then, every single opportunity for monitoring the presence of *N. locustae* in grasshoppers of the country is used. Up to now, establishment of the agent was observed in two well-defined areas: Gualjaina in Patagonia, and an area in the western Pampas surrounding three of the application sites. Infections were diagnosed in 14 species of grasshoppers, while 30 others, including some known to be experimentally susceptible and some occurring in sites where infection is present, were never found to be infected. Ten out of the 14 species with infections were melanoplines (Acrididae: Melanoplinae), two were gomphocerines (Gomphocerinae), and two romaleids (Romaleidae), which agrees with host range observations obtained in North America. Maximum geographic dispersion of the pathogen recorded was 160 km. Prevalences registered were normally much higher than in areas where *N. locustae* is known to be native (North America, India, South Africa), and unusually high prevalences (epizootics) of up to 75 % were not uncommon.

Although at the time of the introductions, *N. locustae* was employed in an inundative manner, expecting some short-term effects, it became a typical example of the colonisation (introduction-establishment) approach of using entomopathogens. It is also an example of what has been termed neo-classical biological control, in which an exotic agent is used to control a native pest. The establishment, spread and possible effects of a new disease over large areas in not just one but many hosts of different susceptibilities is a subject of high complexity. Even more so when quantitative data on abundances of hosts prior to the introductions are not available and some scenarios are also greatly influenced by other forces, like habitat disruption. In this context, the case of *N. locustae* in Argentina poses more uncertainties than answers, and it is the subject of much speculation. However, some interesting points can be raised:
1, given the levels of occurrence of *N. locustae* and knowing the negative effects well documented on hosts, the pathogen must be somehow affecting grasshopper communities in Argentina;
2, In areas where *N. locustae* became established, problems with grasshoppers were never since reported again, and they were recurrent and serious before the introductions. Similar areas in terms of climate, physiography, land uses, and composition of grasshopper communities, but with absence of *N. locustae* continue to suffer recurrent outbreaks;
3, No other microsporidium is known where *N. locustae* became established while establishment apparently did not occur where a native microsporidium, *Perezia dichroplusae,* is present;
4, Transmission being the key factor governing the epizootics of a pathogen, *N. locustae* appears to be operating in accordance to its efficient horizontal transmission, in contrast to the way *P. dichroplusae* does, which exhibits vertical transmission as its main mode of persistence.

The original concept for the use of *N. locustae* was “to augment natural control factors for the long-term suppression and maintenance of grasshopper densities”. Later commercial development obscured this initial concept, and false expectations were assumed by most people, expecting rapid reductions of pest grasshoppers. Although out of it native land, *N. locustae* appears to be operating in Argentina very much in the way it was originally conceived. In this sense, it would be of much interest to monitor for the presence of *N. locustae* in areas of introductions that have been conducted in other countries, like Mali, Niger, Cape Verde and Australia.

Prospecting Yields Three New Microbial Control Agents of Acridids in Argentina.

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The ongoing search for protozoan pathogens associated with grasshoppers and locusts in Argentina have recently yielded findings of three species of septate gregarines (Apicomplexa: Eugregarinida). They have been found in various species of melanoplines (Acrididae: Melanoplinae), and two of them appear to constitute previously unknown species. The characteristics of the other greatly agree with those reported for *Amoebogregarina nigra*, recently described by Kula and Clopton (1999; J. Parasitol., 85:

321-325) from *Melanoplus differentialis* in Southwestern Nebraska. Although eugregarines are regarded more as commensals rather than true pathogens, these findings might be useful for undertaking studies on their eventual effects on hosts (Center for Parasitological Studies (CEPAVE, UNLP).

NORTH AMERICA

MEXICO

Advances in biological control of locusts and grasshoppers in México

Ludivina Barrientos Lozano[1] Víctor M. Hernández Velázquez[2] & Richard J. Milner[3].

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Biological control is not a new strategy in México, its history extends over more than 60 years. This technique has been implemented successfully to reduce populations of diverse pests below economic importance levels, including *Aleurocanthus woglumi* Ashby, *Eriosoma lanigerum* Hausm., *Anastrepha ludens* Loew and *Spodoptera frugiperda* Smith.

In 1993, laboratory and field studies were initiated to develop a biological control strategy for locusts and grasshoppers. Major activities of this programme include: local surveying for entomopathogenic fungi, laboratory screening of isolates to identify more virulent strains, improve massive production quality of virulent strains, formulation and field evaluation of entomopathogenic isolates.

The National Centre for Biological Control (Centro Nacional de Referencia de Control Biológico-CNRCB) has, in its entomopathogen collection, 35 isolates of *Metarhizium spp.* (*M. anisopliae*, *M.anisopliae var acridum* and *M. flavoviride*) obtained from the Central American locust (*Schistocerca piceifrons piceifrons* Walker) in the States of Colima, Michoacán, Chiapas and Revillagigedo Island in the Pacific Coast. The isolates MaPL39, MaPL35 and MaPL40 are amongst the most virulent with median lethal times (MLT) of 5.5, 5.3 and 5.0 days, respectively.

A comparative analysis on Random Amplified Polymorphic DNA patterns between two Mexican isolates of *Metarhizium*, MaPL40 and MaPL32, and the Australian isolate of *Metarhizium anisopliae var acridum* (FI985), showed that the Mexican isolates and the Australian isolate have similar DNA fingerprints and belong therefore to the same variety.

Mexican isolates have been formulated in mineral and vegetable oils. Citroline mineral oil (derived from petroleum) gave the highest viability of *M. anisopliae* conidia at 7 and 27°C, causing 100% mortality 7 days after application.

Comparative studies between the Mexican and the Australian isolates were carried out over a range of temperatures against the wingless grasshopper (*Phaulacridium vittatum* Sjostedt). Seventeen days after treatment MaPL32 gave satisfactory results, with >90% mortality at temperatures between 20 to 35°C, but results were poor at 15°C; MaPL40 results were satisfactory between 20 to 30°C with unsatisfactory performance at extreme temperatures of 15 and 35°C; the Australian isolate FI985 provided >90% mortality at 20 to 35°C and 50% mortality at 15°C. Later mortality was low, however, it was better than mortality provided for the isolate MaPL32 at 15°C which was only 20%.
Mass production of isolates MaPL32 and MaPL40 is in progress to carry out more extensive field trials against the Central American locust from October 2001 onwards.

Treatment of bands of the Central American locust *Schistocerca piceifrons* with *Metarhizium anisopliae* in México

Ludivina Barrientos Lozano[1] Víctor M. Hernández Velázquez[2] & David M. Hunter[3].

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During September 2000, about 40 bands of *Schistocerca piceifrons piceifrons* near Tizimin, Yucatan, were treated with Mexican isolates (MPL-40 and MPL-32) of *Metarhizium anisopliae* var *acridum.* To limit the invasion of untreated bands from the outside, a site was chosen near the edge of the infestation.

Treatments were with knapsack sprayers at 50g *Metarhizium* in 1 litre of Citroline mineral oil/ha and after treatment, mortality was assessed by following the bands in the field. Weather was usually sunny in the morning with cloud and showers during most afternoons, with temperatures ranging from 20-25^{o}C at night to 32-35^{o}C during the day.

Before treatment and for a few days afterwards, most bands were large and dense, and for most of the morning were visible on the grass from a distance of tens of metres. While untreated bands remained dense and very visible for the duration of the experiment, treated bands began to break up by day 6. Treated bands that remained in the treated area began to decline 6 days after treatment with the decline reaching 86% by days 11-13 for bands treated with strain MPL-40 and >95% with bands treated with MPL-32. Bands that left the treated areas within 2-3 days of treatment had less opportunity to pick up *Metarhizium* from the vegetation declined by about 80% within 12 days of treatment.

The rapid decline beginning 6-9 days after treatment is similar to the rapid decline to a high final mortality obtained in Australia and Africa during hot weather. Both of the strains worked well, and future trials on a larger scale will facilitate the operational use of *Metarhizium* in México.

AUSTRALIA

Operational Use of *Metarhizium anisopliae* for Locust Control in Australia

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Between October 2000 and January 2001, over 23,000 ha of nymph bands of *Chortoicetes terminifera* were aerially treated with Green Guard®, a commercially produced ULV oil formulation of the FI-985 isolate of *Metarhizium anisopliae* var. *acridum*. During initial trials in late October, early to mid instar bands were aerially treated at very low to low doses (12-25 g in 500 ml oil/ha = 0.5-1.0 x 10^{12} conidia/ha). During the sunny, mild (maxima 20-27^{o}C) weather that followed, locust numbers rapidly declined in 8-12 days, with final mortality reaching >90%. Mortality was delayed slightly in drainage lines where vegetation was dense and with bands that invaded the treated area from the outside.

During November-January, bands were treated at 17 or 25 g/ha (0.7-1.0 x 10^{12} conidia/ha) as part of locust control operations. With nymphs treated in early November final mortality was >80%, but mortality took 2-3 weeks because days were hot and nights cool, providing only short periods of the warm temperatures that favour *Metarhizium* development. Between mid November and January, mortality was more rapid, with >90% of nymphs dying in 10-14 days. Nights were warm because weather was either hot or cloudy providing conditions ideal for *Metarhizium*. At 17g/ha (0.7 x 10^{12} conidia/ha), Green Guard® costs $US 4/ha, a price that is only slightly higher than most insecticides.

While the initial operational uses of Green Guard®, in environmentally sensitive areas and on properties producing organic beef, when word spread that this biological worked, other landholders asked for *Metarhizium* to be used. While some landholders preferred *Metarhizium* because of a general preference for avoiding chemicals whenever possible, others liked the management option of not having to consider withholding periods when sending livestock to market or harvesting crops.

During the coming year, Green Guard® will continue to be used as part of an integrated locust control program. During this program, fenitrothion will be the control agent of choice near crops with the slower acting but more persistent fipronil used as a barrier treatment in locust source areas in the interior. Green Guard® will be used in environmentally sensitive areas such as near water or where there are rare or endangered species, and on land holdings where withholding periods to market or organic status prevent chemical use. The aim will be to determine, under operational conditions, the control agent most appropriate for each situation.

***Beauveria bassiana* – Studies on its potential for control of wingless grasshopper**

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A major grasshopper pest in Australia is the wingless grasshopper, *Phaulacridium vittatum*. Outbreaks occur during periods of reduced parasitism following below average rainfall in the tableland areas of Tasmania, South Australia and Western Australia. Dense populations (50-100 or more/m2) can destroy large tracts of grazing land at times when forage is short and often invade high value crops such as grapes, vegetables, fruit and tree nurseries. The insect has an annual life cycle with overwintering eggs hatching in October, passing through 5 instars from October to late January/February when the adults fledge and lay eggs which diapause over winter. The main damage is done during the warmer months of December to March. Spraying chemical pesticides such as fenitrothion is effective in killing the grasshoppers present at the time of spraying but may give only short-term relief as the insects often re-invade within 1 to 2 weeks. Natural control from parasitism is important with wingless grasshopper and because of this, as well as concerns over residues and the re-invasion problem, farmers are usually reluctant to spray chemicals.

Trials with the biopesticide, Green Guard®, a product containing live conidia of *Metarhizium anisopliae* var. *acridum* (FI-985) which is now used for locust control in Australia, have given mixed results against wingless grasshopper. Control early in the season, when it is most beneficial, is often made difficult by prevailing temperatures often being too low for effective control with *Metarhizium*. Temperatures are often in the region of 10^{o}C at night and 20^{o}C during the day, well below the most effective temperatures for *Metarhizium* of 25-30^{o}C. *Beauveria bassiana* is a significant natural mortality factor and is known to be effective at lower temperatures than those required by *Metarhizium.* Consequently a study has been initiated to assess the potential of this fungus for control of grasshoppers under cool conditions.

Initial screening bioassays showed that isolates originating from wingless grasshoppers were highly virulent, while isolates from other hosts as well as the Mycotech Botaniguard isolate were less pathogenic. Isolates from wingless grasshopper were found to grow on agar plates over the range 10-32^{o}C with an optimum around 24^{o}C. Differences between isolates from wingless grasshopper were slight in terms of in vitro growth and virulence. A marginally more virulent isolate, FI-1437, was chosen for more detailed studies.

Comparisons between FI-1437 and FI-985 have shown that both strains are similar in virulence at 20^{o}C, but at lower temperatures FI-1437 is substantially more effective (Table). Other bioassays using lower doses of FI-1437 have shown that it is very effective under alternating 10-20^{o}C conditions and that there is no significant difference in the dose required and the time taken to kill between FI-1437 and FI-985. It is concluded that FI-1437 is a very promising control agent for wingless grasshopper and it is hoped to field test this isolate during the 2001/2002 season.

TABLE - Sporulation of wingless grasshoppers treated with either FI-1437 (*Beauveria bassiana*) or FI-985 (*M. anisopliae* var. *acridum*) at constant
10, 15 and 20^{o}C.

FI-1437 of *B. bassiana*

Dose	10^{o}C	15^{o}C	20^{o}C
Dose 1*	89**	93	77
Dose 2	82	87	77
Dose 3	32	46	56
Dose 4	0	3	7
Control	0	0	0

FI-985 of *M. anisopliae*

Dose	10^{o}C	15^{o}C	20^{o}C
Dose 1*	0**	50	79
Dose 2	0	4	50
Dose 3	0	0	0
Dose 4	0	0	0
Control	0	0	0

Doses for FI-985: dose 1 = 4×10^4, dose 2 = 4×10^3, dose 3 = 4×10^2, dose 4 = 4×10^1 conidia/insect.

Doses for FI-1437: dose 1 = 2.8×10^5, dose 2 – 2.8×10^4, dose 3 = 2.8×10^3, dose 4 = 2.8×10^2 conidia/insect.

** Number is percentage sporulation (n=30).

General

World-wide survey of regulations affecting biopesticides

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Biological pesticides (biopesticides, microbial control agents, microbiological pest control agents) are regulated in different ways in different countries. The Organisation of Economic Co-operation and Development (OECD) has conducted a survey in developed countries, and the International Institute of Tropical Agriculture (IITA) is in the process of conducting a survey in developing countries.

While some countries have developed specific regulations covering biopesticides, many countries use the basic legislation developed for chemical pesticides. *Bacillus thuringiensis* has been registered in this way in many countries. The specific issues associated with the registration of natural living organisms are quite different from those affecting chemical pesticides; microbial pesticides are not likely to cause pollution or non-target effects, but they are capable of reproduction in the field. Through many years of experience, the organisms commonly used in microbial pesticides are known to be safe to man, but more research is needed to determine their environmental impact when used repeatedly on a large scale. This impact is not likely to be pronounced; we might expect to see a temporary replacement of the indigenous micro-flora with the biopesticidal strain and a reduction in susceptible insect populations. Nevertheless, more research should be carried out, probably in the context of monitoring of operational-scale applications.

In general, the first-time importation of non-indigenous microbial control agents must conform to the FAO Code of Conduct on the Importation of Biological Control Agents, or equivalent national or regional (EPPO) regulations. These regulations are normally focussed at the species level, and most microbial pesticides are based on micro-organisms that are commonly isolated in all countries of the world, so in principle there should be no problem. However, authorities are tending to take a cautious line in agreeing to import exotic strains until more information is available on their potential environmental impact.

Microbial pesticides based on oil formulations of *Metarhizium anisopliae* var. *acridum* are currently being developed. Green Guard, an oil formulation of an Australian strain (FI-985) is registered provisionally for organic use in Australia, and Green Muscle, an oil formulation of a strain from Niger (IMI 330189) has provisional registration in South Africa and in CILSS (Sahelian) countries. Green Muscle appears also on the FAO list of approved products for locust control.

AFRICA

West Africa Regional Training Course on Biocontrol

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A USAID-AELGA and IITA/Benin-sponsored West Africa Regional Training course was successfully completed. USAID's Africa Emergency Locust/GrasshopperAssistance (AELGA) project and the International Institute of Tropical Agriculture (IITA) in Benin jointly launched a very successful regional training course on biological control of locusts and grasshoppers for Western Africa. The training was officially opened by the Acting Director for USAID/Benin.

The five-day intensive, technical course was conducted from 1-6 May at the IITA's Center, in Cotonou, Benin. The primary objectives of the training course were to:

a) provide researchers and crop protection technicians with state-of-the-art techniques for launching locusts and grasshoppers (l/g) biocontrol research, development and implementation initiatives,
b) enhance the capacity of participants to effectively transfer skills and knowledge in l/g biocontrol techniques to extension agents, farmers, NGOs and other potential partners,
c) encourage and promote national, regional and inter-regional initiatives and collaborations in l/g biocontrol strategies and implementation efforts, and
d) equip the participants with the tools necessary to sensitise and educate

decision makers and the ultimate end-users in the development and use of biological control agents as the key component of an IPM strategy for l/g management.

Fourteen qualified and carefully selected candidates from eight West African countries, including Benin, Burkina Faso, Cape Verde, Guinea Conakry, Mali, Mauritania, Niger and Senegal participated in the training course. The course, which included presentations on a wide range of topics on l/g biocontrol, laboratory and field work, panel discussions and country updates by participants put emphasis on the key techniques and strategies employed to research, develop, mass produce, commercialise, regulate and implement environmentally benign and safer alternatives for the control of locusts and grasshoppers in Sahelian Africa.

This is part of AELGA's regional training initiatives that target qualified senior technical staff and researchers engaged in the search and development of environmentally friendly alternatives using naturally occurring insect pathogens (disease causing organisms) that specifically attack target pests, i.e., locusts/grasshoppers. We are pleased to mention that AELGA had successfully conducted similar training courses for north eastern, eastern, south-central and southern African countries. In all these, we had been able to leverage sponsorships and valuable collaborations from regional and international organisations, host country ministries, field missions and other partners.

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