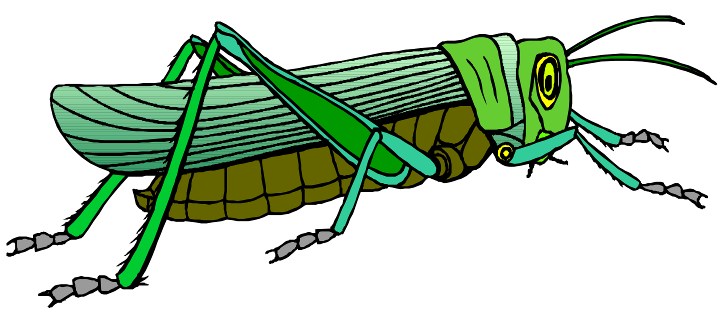
ADVANCES IN APPLIED ACRIDOLOGY - 2001

PUBLISHED BY

The Association for
Applied Acridology International

Solutions without Limits by Scientists without Borders



PREFACE

As pest management techniques, perspectives, and products have become increasingly sophisticated in the last 20 years, our capacity to adapt and transfer the methods and knowledge has declined. Formerly effective programs have dramatically diminished their roles in assisting afflicted regions. While the ability for any single nation to sustain a critical mass of expertise in acridid (grasshopper and locust) pest management has diminished, the quality of geographically dispersed experience and knowledge is extremely high. The *Association for Applied Acridology International* has brought together the world's leading practitioners in this field to develop and provide unbiased analyses along with culturally, technologically, economically, and environmentally appropriate methods for managing locust and grasshopper outbreaks. The *Association* is the first and only humanitarian-based, NGO of entomologists in the world, providing expert advice, training, and applied research to people and nations in need. The demonstrable capacity of grasshopper and locust outbreaks to reduce the standard of living, displace human populations, induce famine, and erode environmental quality demands the highest level of practical expertise and experience in order to rapidly build the capacity of agricultural communities to implement safe and effective prevention and control programs. The *Association* consists of 30 Associates/Affiliates from 21 nations, representing more than 300 years of collective experience and 13 Institutional Partners/Participants comprising the world's best organizations dedicated to the study and management of acridids.

It is my distinct pleasure to have facilitated the production of the second issue of *Advances in Applied Acridology*. The purpose of this report is to clearly and concisely summarize for the scientific and management communities the major developments in applied acridology within the last year. As such, the report is organized into sections that are intended to provide the reader easy access to the information. I would hasten to note that each author was limited to a single page of text in an effort to keep the report as "tight" and information-rich as possible. As such, the reader may find that an article of particular interest has rather less detail than desired. This is precisely why we have provided the email address of each author; I invite you to directly contact the authors for further information on matters of compelling interest. This format was very well received by a range of agencies, laboratories, and industries. Based on several comments, we have added a new feature to this year's issue – the in-depth analysis. We chose one "hot" field of applied acridology and had an Associate provide a provocative and insightful contribution on the topic.

The editing of this issue consisted of generating a consistent presentation of the information, spelling, grammatical corrections, formatting, and organization. In no case was the editing intended to alter the meaning of the text, nor was there any attempt to "standardize" the information or generate consensus. As such, the reader may find instances in which reports make claims that are not in agreement – and such is the nature of the *Association for Applied Acridology International*. We do not constrain our Associates or Affiliates to a particular "party line". They are the finest scientists and managers in the world of grasshopper and locust bionomics, and we allow them complete intellectual freedom and professional autonomy to assess situations in the most rigorous and objective manner possible. As such, complex events and technologies may be perceived differently by our various Associates and Affiliates, and the opinions and judgements of this publication are those of the authors.

Finally, if you have any suggestions for how we might make the next issue of *Advances in Applied Acridology* more useful, informative, or relevant, please do not hesitate to contact me by phone (1-307-766-4260), fax (1-307-766-5025), or email (lockwood@uwyo.edu).

Jeffrey A. Lockwood
Director, *Association for Applied Acridology International*
1 May 2001

TABLE OF CONTENTS

OPERATIONS AND LOGISTICS

COMMUNICATIONS: TRAINING, WORKSHOPS AND MEETINGS

COMMUNICATIONS: PUBLICATIONS

SURVEY, FORECAST, AND DECISION SUPPORT

Operational Use of a Decision Support System to Detect Locust Outbreaks in Australia

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The Australian Plague Locust Commission (APLC) is responsible for managing locust outbreaks in an area of over 3 million km^2. To enable early detection and control of small locust populations as part of a program of preventive control, the APLC integrates the latest locust and weather information into a Decision Support System (DSS). The basis of the DSS is information on locust distribution, habitat preferences and rainfall as analyzed in a Geographic Information System (GIS). Data on current locust distribution is collected by 8 survey officers who directly transfer locust survey data by radio link to the GIS. The transferred data is automatically overlaid onto a base map of preferred habitats obtained from 13 years survey data, and is compared with previous distributions. Locusts require green vegetation for maturation/laying and for offspring survival so locusts are more likely to be where rain has fallen. Potential areas of green vegetation are obtained from rainfall distribution as interpolated using a direct link to the Bureau of Meteorology weather data files. Actual green areas are later detected by National Oceanic and Atmospheric Administration (NOAA) data obtained 2-3 weeks later. When locust movement has been detected by light traps or when known populations of adults have accumulated the fat required for migration, locust migrations are modelled using a wind trajectory model. The data on locust distribution, migration, rainfall/greenness is integrated within the Decision Support System to APLC staff to forecast the extent and timing of locust outbreaks so outbreaks can be detected early and controlled.

Analyses of Grasshopper and Plant Communities in Argentina.

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Grasshopper and plant community relationships in southeastern Buenos Aires province are being examined. Twenty seven sites were selected in 2000 to represent a variety of vegetation types with different degrees of disturbance history. Grasshopper density and species composition were estimated at each site during 2000-2001. Plant community at each site was estimated by evaluating percentage canopy of ground cover of native perennial grasses, introduced perennial forbs, annual pastures, halophilous species, perennial pastures, native perennial forbs, introduced annual forbs, and plant species richness. Based on vegetation variables, sites were classified into five disturbance categories: native grasslands, halophilous steppes, pastures, moderately disturbed pastures and highly disturbed pastures. The work is a joint effort by La Plata National University (UNLP) and Benito Juárez county.

Exploratory surveys are currently being conducted in central Argentina (San Luis province) with the aim at finding undisturbed sites representative of typical western Pampas grasslands that might be useful for tracing what would be the original grasshopper fauna associated with such environments. If successful this would in turn allow an attempt at comparison with highly disturbed areas which is the overwhelming scenario in the Pampas.

Madagascar Makes Dramatic Advances in Survey Technology for Locust Control.

R. Brown, South Africa, Plant Protection Research Institute, rietdb@plant2.agric.za

At a conference held in Antananarivo from 14-15 December 2000, the national locust control organisation, CNLA, announced the closure of its emergency locust campaign in Madagascar and reviewed progress since its formation in 1998 (Randrianosolo *et al*, 2000; see Communications: Publications). From an African perspective, it is clear that the emergency campaign in Madagascar has ushered in a new era of locust control technology - one which is likely to revolutionize aerial application and surveillance of locusts in Africa in the 21st century. As in modern warfare, where necessity is the mother of invention (and resources suddenly become available!), a number of novel developments occurred during this locust emergency. These developments are described under appropriate headings; those pertaining to SURVEY, FORECAST, AND DECISION SUPPORT detailed here:

- *Dedicated aerial reconnaissance*: This campaign saw the introduction of a fleet of ultralight aircraft, equipped with advanced GPS map capability, for undertaking systematic and dedicated aerial reconnaissance for swarms. CNLA's "eye in the sky" type operation deployed these ultralight planes throughout all operational zones, systematically combing remote areas for swarm targets.

- *Digital capture and transmission of images*: The use of digital cameras to record and capture locust targets electronically, from the cockpit of reconnaissance planes in flight, also introduced something novel in to locust detection. On return to base these electronic images, with their GPS fixes, provided instant online information to controllers. Besides this, donors in either Brussels or Paris were provided with immediate visual evidence of targets on their e-mail.

- *Use of GPS technology*: These emergency operations were characterised by widespread use of GPS technology, both in the air and on the ground. Advanced hand held receivers were used throughout, either to record fixes or to navigate for purposes of interception or assessment.

CONTROL: CHEMICAL

Control of the Italian Locust in Russia: When do Fipronil Barriers Work?

M. Sergeev, Russia, Novosibirsk State University, mgs@fen.nsu.ru

In 2000, some new experiments with a water-based formulation of fipronil, Adonis® 40EC, were conducted in the Kulunda steppe (Novosibirsk Region, the southern part of West Siberia).

The steppe rangeland was divided into the experimental and control plots (about 10 ha each). The targets were represented by hopper bands (mostly 1st and 2nd instars) of the Italian locust (*Calliptamus italicus*). Fipronil was applied to 50% of the experimental plot, by alternating, 15 m wide swaths. The dose rate in the "barriers" was 4 g of a.i. per ha (i.e., 2 g of a.i. per protected ha). The results are summarized in the following table.

Treatment/Day	D0	D1	D2	D3	D5	D7	D15	D30
Adonis, Treated Swaths, #/m^2	25	7.5	5.6	0.6	0	0.5	14	16
Adonis, Untreated Swaths, #/m^2	25	15	21	18	27.2	21	21	15
Control plot, #/m^2	25	15	12	14	11.6	26	31	24
Average Mortality, %	-	26	no	34	no	58	44	37

The general efficacy of this experimental trial was low. The difference between this experiment and previous trials in the Volgograd and Irkutsk Regions of Russia (*Advances in Applied Acridology -- 2000*) can be explained by extremely low levels of young hopper migrations till the end of June, because of sufficient quantities of preferred foods.

Madagascar Provides Valuable Lessons Regarding Chemical Control of Locusts.

R. Brown, South Africa, Plant Protection Research Institute, rietdb@plant2.agric.za

The conference held in Antananarivo reviewed the emergency campaign in Madagascar. From this assessment it is evident that a new era of locust technology is emerging, including novel developments in chemical control:

! *Operational testing of insecticides*: Throughout CNLA's campaign, experimental testing and development work on alternative insecticides made good progress. The need to evaluate more effective and safer products under operational conditions was fully appreciated. Several multi-national chemical companies, such as AgrEvo, Bayer, and Dow, benefited from this helpful approach.

! *Monitoring of spray efficacy*: One of the criticisms raised during the last Desert locust plague in West Africa was the lack of reliable efficacy data on the products applied during operations (OTA Report, 1990; see Communications: Publications). In contrast, numerous post-treatment checks took place during CNLA's operations, either by their own PVA locust watch group or by local chemical suppliers. Moreover, in later spray contracts, a 20% monitoring and evaluation clause was specified.

Optimizing the Value of Diflubenzuron with the RAAT Strategy in the US.

J. Lockwood, United States, University of Wyoming, lockwood@uwyo.edu

Reduced Agent-Area Treatment (RAAT) is an IPM method for rangeland grasshoppers in which the rate of insecticide is reduced from traditional levels and untreated swaths (refuges) are alternated with treated swaths. The research conducted in Wyoming in 2000 in cooperation with Uniroyal Chemical was designed to address five objectives: 1) refine the use of Dimilin 2L (diflubenzuron) in a RAAT program via testing of: two volumes (355 and 710 ml), two rates (55 to 73 ml/ha), and two coverages (33 and 50% with 30 m swaths) applied to replicated, small-scale (16 ha) plots; 2) determine if these Dimilin-RAATs could be successfully used under adverse environmental conditions (ground temperature exceeding air temperature by ≥10ºC); 3) determine if the substitution of canola oil (an attractant and potential feeding stimulant of grasshoppers) for crop oil in the carrier formula allows the successful use of ultra-low coverage RAATs (25 and 33%); 4) assess the performance of Dimilin-RAATs (33% coverage) in a large-scale (372 ha) trial under operational conditions using canola oil as the carrier; 5) conclude a field evaluation of the effects of Dimilin (blanket application) on an adult-dominated infestation treated in 1999.

All Dimilin-RAAT methods (ml of Dimilin per ha - percent coverage - volume of carrier in ml) ranging from 30-50-710 to 22-33-355 applied under optimal thermal conditions resulted in ≥98% mortality at 21 d after treatment. Thus, applying 22 ml of Dimilin in 355 ml of total volume to one-third of the infestation was as effective as applying 30 ml of Dimilin in 710 ml of total volume to one-half of the infestation after 21 d. Higher rates, volumes, and coverages may lead to greater mortality at 14 d, but these marginal advantages are lost by 21 d.

In a striking consistency with our 1999 studies, application of 22 ml of Dimilin with 50% coverage provided >85% mortality at 14 d under all conditions on every treated plot. As such, it appears that the 22-50-355 RAAT strategy provides excellent mortality with just 38% of the Dimilin that would have been used in a traditional treatment. However, the 33% coverage treatments appear to be equally viable under the conditions of our trials.

Under hot conditions, Dimilin-RAATs were somewhat less effective. At 14 d, the mortality in these plots was generally 5 to 10% lower than the plots treated under cool conditions. By 21 d, all of the treatments conducted under hot conditions yielded ≥90% control and were statistically indistinguishable from the other plots.

The use of canola oil as a carrier of Dimilin in a RAAT program did not enhance control relative to crop oil under most conditions (comparisons of 33% coverage). Under hot conditions, the use of canola oil appeared to result in more rapid mortality. However, under cool conditions, Dimilin applied in crop oil was somewhat more efficacious. Under both optimal and adverse conditions, the 30-25-710 application of Dimilin with canola oil yielded ≥95% control by 21 d after treatment.

The large-scale operational test of the Dimilin-RAATs (30-33-710) was completely successful. At 7 d, grasshopper densities were reduced by 64% (from 42 to 18 grasshoppers/m^2). By 14 d mortality was 93%, and at 21 d the mortality reached 96%.

The grasshopper nymph population densities in the area that was treated when the grasshoppers were primarily adults in July of 1999 were assessed weekly from 15 May to 28 June, 2000. For 4 of the first 5 wk, the nymphal densities were significantly lower in the treated plots. On 14 June, the population density in the untreated plots was 8-times higher than in the treated plots (20.6 *vs.* 2.6 grasshoppers/m^2). In the 6^{th} week, the population in the treated plots increased markedly due to invasion from adjacent rangelands.

CONTROL: BIOLOGICAL

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 nymphal bands of *Chortoicetes terminifera* were aerially treated with Green GuardTM, 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°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 favor *Metarhizium* development. Between mid November and January, mortality was more rapid, with >90% of nymphs dying in 10-14 days. Nights were warm either because of hot or cloudy weather providing conditions ideal for *Metarhizium*. At 17g/ha (0.7 x 10^{12} conidia/ha), Green GuardTM costs $US 4/ha, a price that is only slightly higher than most insecticides. During the coming year, Green Guard will continue to be used as part of an integrated locust control program.

AAAI Develops Locust and Grasshopper Biocontrol Training Courses

C. Lomer, Denmark, Royal Veterinary and Agricultural University (KVL), clomer@yahoo.co.uk

The *Association of Applied Acridology International* offers the following training options in biocontrol and safe application of pesticides for locust and grasshopper control. The full course is intended as a "refresher" course, to enable experienced locust control officers to update their knowledge in modern integrated approaches to locust control. In particular, the course offers opportunities to learn about the monitoring of the environmental impact of control operations, and how to minimize such impact through the use of accurate and timely application of the most appropriate pesticide or biological control options. The course is flexible and modular, and course components could readily be combined with existing training programs to provide a complete and all-round introduction to locust and grasshopper control. Each module is one week in length, although owing to synergies and overlaps between courses, the full course of six modules can be completed in one month. For each module, the resource persons are suggested experts for the purposes of planning; other Associates may be involved in the course. Please contact *AAAI* for current schedules, costs, and locations of courses.

MODULE 1.	<u>Application of ULV Pesticides</u>. This module covers the use and application of ULV formulations of pesticides and Controlled Droplet Application (CDA). CDA enables a higher work-rate than conventional pesticide application, and is in widespread use for locust control operations. The novel fungal biopesticide Green Muscle is formulated for application by CDA, and this course is essential for the application of this biopesticide.
RESOURCE PERSONS:	R. Bateman, H. Wilps, H. Dobson, D. Brown.
TOPICS:	Theoretical aspects, Measuring droplet size, Calibrating ULV sprayers (hand, vehicle-mounted, aerial), Practical application, Monitoring coverage.
MODULE 2.	<u>Environmental Monitoring of Locust and Grasshopper Control Treatments</u>. A growing awareness of the potential damage to the environment caused by locust and grasshopper control treatments is making it essential for all locust control organizations to have the capacity to monitor the impact of their control operations.
RESOURCE PERSONS:	R. Peveling, I. Stolz, J. Langewald, C. Tingle, P. Spurgin, J. Everts, W. Mullié
TOPICS:	Theoretical aspects, Binomial sampling, Base-line data collection, Selection of indicators, Realistic sample collection schemes, Data analysis, Human Safety of new compounds and/or techniques, Update on Environmental Fate and Behavior evaluation techniques, Toxicology and Ecotoxicology, Risk Assessment, New Biomonitoring Techniques, Testing vs Monitoring, Ecotoxicology of Locust Control of Grasshopper Control.

MODULE 3. Collection of biocontrol agents and biopesticide development. Although Green Muscle is available for use in many parts of the world, some countries may wish to enhance their capacity in the study and collection of biocontrol agents, with a long-term view of developing their own biopesticide.

RESOURCE PERSONS: C. Lomer, D. Johnson, D. Moore, C. Lange, J. Langewald, B. Maghalaes, R. Milner

TOPICS: Theoretical aspects of insect pathology, Sample collection, Sample preservation, storage and characterization, Identification of insect pathogens, Bioassays, Steps involved in biopesticide development.

MODULE 4. Application and monitoring of *Metarhizium*/Green Muscle. The recently developed Green Muscle formulation of *Metarhizium* is now widely available. The product is formulated for ULV application and can be applied by applicators trained in this technique. However, the formulation is a living biological entity, and as such requires some care in handling and application. Also, because its impact is much slower than that of chemical pesticides, special monitoring techniques are needed.

RESOURCE PERSONS: J. Langewald, C. Lomer, R. Bateman, R. Milner, D. Moore, B. Maghalaes

TOPICS: Storage (germination test), Formulation, Application (or see MODULE 1), Monitoring (cage samples, field counts, sporulation tests).

MODULE 5. Conservation Biological Control (selective treatments). Much has been done in recent years to try to minimize the impact of chemical pesticide treatments on non-targets. Methods include choosing selective pesticides, reducing the area treated (strips and bands), and using selective formulations, such as baits. The course covers the rationale behind such concepts (methods for monitoring non-targets are included in MODULE 2), and methods of application.

RESOURCE PERSONS: J. Lockwood, N. Foster, D. Johnson, H. Dobson

TOPICS: Selection of pesticides to minimize impact on natural enemies and non-target organisms (focus on ecological service providers), Reduced Area/Agent Treatments (RAATS), Barrier treatments, Environmental impact evaluation.

MODULE 6. General Acridology. AAAI members are available to participate in fuller courses designed to complement the specialized Modules mentioned above.

RESOURCE PERSONS: *AAAI* Associates and Affiliates

TOPICS: Designed in consultation with the client.

Bioprospecting 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)).

APPLICATION TECHNOLOGY

Fipronil Applied as "Blanket" or "Barrier" Controls the Australian Plague Locust.

P. Spurgin, Australian Plague Locust Commission, peter.spurgin@affa.gov.au

During the latter half of 2000 a major plague of the Australian plague locust, *Chortoicetes terminifera* (Walker), threatened agricultural production throughout most of southern Australia. Aerial spraying programs undertaken by the APLC and South Australian State Department of Primary Industries used fenitrothion ULV and fipronil (the first large scale, operational use of this insecticide in Australia since registration in November 1999). These control operations were highly successful. Fipronil (Adonis 3 & 8.5 UL) was applied to ca.165,000 ha or 25 % of the total area treated using several application techniques.

The majority of band and swarm targets were "Blanket" treatments (block size of 1 to 5 km^2) using Adonis 3 UL applied at doses of 0.6 to 1.25 g a.i./ha with intervals of 50, 100 or 200 m between spray runs. These spacings were dependent on crosswind strength; <3 m/s - 50 m, 3 to 5 m/s - 100 m, >5 m/s - 200 m. Mortality of >95% was usually observed 3 to 5 days after spraying. However, when day temperatures increased above 30 ^{o}C there was rapid mortality in 1 to 3 days.

"Barrier" treatments with fipronil also proved effective. A number of large blocks (>5 km^2 up to 100 km^2) with high populations of nymphs in bands were treated rapidly using single spray runs spaced at 500 m intervals across targets. Adonis 3 and 8.5 UL were applied at flow rates to give a dose of ca. 0.6 g a.i./ha within a 200 m strip of vegetation down wind of each spray run. Previous trials suggested that at this dose the insecticide remained effective on vegetation for a minimum of 7 days. Bands of nymphs outside the treated strips usually moved into areas of treated vegetation within 3 to 5 days of spraying (daily band movement of 50 to 80 m depending on temperature, vegetation height and cover). Control (>95% mortality) in target areas was normally achieved within 10 days of spraying.

Use of "Barrier" treatments with fipronil will increase during future APLC control campaigns because it offers significant advantages to non-target insect species in target areas because only part of the block is sprayed and with a very low dose. The increased spacing between spray runs also maximizes the efficiency of a single spray aircraft, allowing more areas to be targeted during periods when spraying conditions are optimal. In addition, substantial cost savings are possible due to reductions in spray aircraft flying time and the quantities of insecticide that are used during control operations.

New Tests of Foggers Adapted from Aricraft and Helicopter Engines in Russia.

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Aerosol foggers of two types were used for control of the Italian locust outbreaks in the Kulunda steppe of Novosibirsk and Omsk Regions during June and July of 2000. The first type was described earlier (*Advances in Applied Acridology -- 2000*). The second type of fogger was constructed by the "Motor" Company (Omsk). Each fogger consists of a helicopter engine and 8 atomizers mounted on the vehicle. This type of the fogger can be used for spraying both chemical and biological water-based formulations. Average size of droplets is about 120-160 µm. The working rate is from 200 to 810 ha/hr. In comparison with foggers having optimum dispersion (the first type), this construction is cheaper.

In 2000, both types were used in Novosibirsk Regions. The general effectiveness of treatments (fipronil and different pyrethroid insecticides) was high, but the ecological consequences of such treatments should be studied in the future.

Vegetable Oil Carriers of Insecticides Serve as Liquid Baits for Acridids in the US.

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Although Reduced Agent-Area Treatment (RAAT) methods have been successful, there remains an excellent opportunity for further economic and environmental cost reductions through the manipulation of grasshopper behavior with plant oils. The use of recently discovered attractants and feeding stimulants of grasshoppers allows even greater reductions in the amounts of insecticides and protection of non-target organisms in RAAT programs. Fatty acids that elicit cannibalism in a wide range of grasshopper species are abundant in vegetable oils that can be used as inexpensive carriers of insecticides. These oil-based formulations draw grasshoppers into treated swaths and stimulate feeding on toxic vegetation.

Studies conducted in Wyoming have shown that three vegetable oils (corn, olive, and canola) had significantly greater levels of attraction than other oils at 1, 8, and 24 h after application to small arenas in the field. Rapeseed, peanut, and flax oil performed relatively poorly at 1 h, although flax oil became substantially more attractive by 24 h. Soybean oil was reasonably attractive throughout the course of the study, although not matching the level of the best three oils. Four of the vegetable oils (flax, corn, olive, and canola) had significantly greater levels of feeding on neutral substrates than the other oils at 1, 8, and 24 h. Rapeseed and peanut oils appeared to have relatively poor ability to induce feeding. Controlled, laboratory bioassays of grasshopper feeding generally reflected the trends seen in the small-scale field assays.

Because attraction and feeding stimulation are confounded in the field-based efficacy trials, a "marker" can be used to elucidate the mechanisms of control by revealing if grasshoppers attracted into a treated swath selectively fed on oil-treated vegetation. A well-developed technique for tracking the diets of insects is the use of carbon isotope ratios. By comparing the carbon isotope ratios of treated vegetation to the crop contents of a grasshopper, the possibility of a feeding preference for oil-treated vegetation can be directly assessed.

Our analyses revealed no significant difference in the isotopic profiles of C_3 plants treated with canola oil, and hence none of the grasshopper tissue samples from species feeding on these plants indicated a change in the isotope ratios. However, the C_4 plant (*B. dactyloides*; $\delta^{13} = -14.62 \pm 0.32$) treated with C_3 (canola; $\delta^{13} = -28.81 \pm 0.05$) translated into substantial changes in the isotopic signatures of the associated grasshopper (*O. obscura*). The 2-d crop contents of grasshoppers outside of the treated area reflected their preference for C_4 plants ($\delta^{13} = -14.41 \pm 0.15$), while the analysis of crop contents within the canola oil-treated plot showed a significant and diagnostic shift of ca. 10% in the stable isotope ratio ($\delta^{13} = -15.75 \pm 0.52$). The stable isotope ratios for the abdomens at 7 d also exhibited a 10% shift towards the C_4 profile (inside: $\delta^{13} = -16.97 \pm 0.82$; outside: $\delta^{13} = -15.55 \pm 0.36$). However, the femurs at 7 d showed only a 1% shift (inside: $\delta^{13} = -15.01 \pm 0.30$; outside: $\delta^{13} = -14.88 \pm 0.51$), and this probably reflects a slower rate of incorporation of the lipids into the leg muscle, as compared to the abdominal fat body.

Precision Spraying in Africa Debuts in Madagascar's Locust Control Program.

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The conference held in Antananarivo reviewed the emergency campaign in Madagascar. From this assessment it is evident that a new era of locust technology is emerging, including novel developments in application technology:

! *Precision spraying*: For the first time in large-scale locust operations in the African region, use was made of advanced, satellite-driven spray technology (DGPS). When coupled to automatic flow control, as in the SATLOC® agricultural spray system, it regulated aircraft speed, produced accurate and constant track spacings and delivered a precise dose of insecticide (Agricair, 2000; see Communications: Publications). Such automatic 'set-and-forget' technology has removed much of the uncertainty previously associated with aerial control of locusts. Precision spraying is of course the route to more ecologically sustainable locust intervention!

! *Functional control databank*: The computerised, satellite-based system fitted to some of the spray aircraft also logged the exact path flown (with print-out), together with spatial fixes of all spray sites and target areas. Full transparency and verification of all spray-work undertaken was now possible. At the same time an accurate reference database of the entire operation could be accessed.

ENVIRONMENTAL IMPACT

Biodiversity Sustained During Locust and Grasshopper Control in Europe.

D. Moore, United Kingdom, CABI, d.moore@cabi.org

Environmentally Sustainable Locust and Grasshopper Control (ESLOCO) is a new project to reduce the environmental impact of chemical pesticide control of locusts in Europe through the development of an environmentally sustainable control strategy based on the use of a mycoinsecticide.

The Moroccan locust, *Dociostaurus maroccanus*, is an important pest in Spain, affecting more than 500,000 ha of pasture and crops. Outbreaks of *D. maroccanus* also occur in other Mediterranean areas, such as Southern Italy, Crete, Sardinia, Morocco, Algeria and Turkey, as well as parts of eastern Europe and the former Soviet Union. Current control relies on broad-spectrum chemical pesticides. Many thousands of hectares are sprayed each year, often in areas of major conservation value, causing adverse effects on the environment.

The aim of ESLOCO is to reduce this environmental impact through the development of a new strategy, based on the use of an effective and reliable mycoinsecticide. This was previously developed for use in Africa by international collaboration through the LUBILOSA program. The mycoinsecticide is based on the naturally occurring fungus *Metarhizium anisopliae* var. *acridum* that specifically infects and kills locusts and grasshoppers. It is not toxic to humans and leaves populations of other non-target organisms unharmed. The mycoinsecticide has been tested extensively in Africa and its safety and efficacy are proven. The product is registered in South Africa and has been approved by the Desert locust Pesticide Referee Group of the FAO for operational locust control in conservation and environmentally sensitive areas.

ESLOCO will undertake: operational field testing, demonstration trials and training of users, demonstration of environmental safety, development of optimum use strategies appropriate for the target species and the environment, commercial-scale production, and finally, product registration and distribution. By meeting these objectives and establishing a new biocontrol technology and capacity in Europe, ESLOCO will deliver an overall reduction in environmental contamination caused by current locust and grasshopper control operations. There will be an immediate impact in preserving biodiversity in areas of international conservation importance, and a reduced hazard to operators and communities exposed to pesticide use. Additionally, through the associated advances in evaluation methods, production technologies, and regulatory procedures, it will create new opportunities for exploiting microbial agents for control of other pests in Europe.

ESLOCO is a three year collaborative research and implementation program between four research organisations and two commercial companies: Aragonesas Agro SA (Spain), CABI Bioscience (UK), Imperial College of Science, Technology and Medicine (UK), Natural Plant Protection (France), University of Bari (Italy) and University of Cordoba (Spain). ESLOCO is supported by the European Commission through the Quality of Life and Management of Living Resources Programme implemented under the Fifth Framework Programme (1999-2002), contract number QLRT-1999-01118 - Protecting Biodiversity through the Development of Environmentally Sustainable Locust and Grasshopper Control in Europe.

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Environmental Monitoring of Locust Control Operations in Malaimbandy, Madagascar.

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An environmental impact study of locust control operations was conducted in Malaimbandy, Madagascar, to monitor short- and medium-term effects of fipronil (Adonis® 4 UL) and deltamethrin (Decis® 17.5 UL) on terrestrial non-target organisms (Peveling et al., 2001). Full cover aerial treatments were applied under operational conditions to plots measuring 100 ha each in a replicated block design. The pesticides were sprayed at field doses between 3.2-4 g (fipronil) and 14-15 g (deltamethrin) per ha. Terrestrial invertebrates (epigeal and vegetation-dwelling arthropods, flying insects, the mound-building termite *Coarctotermes clepsydra*) and vertebrates (insectivorous lizards and mammals) were monitored over a six month period, starting one week before treatment.

The acute toxicity to epigeal and vegetation-dwelling insects was very similar among treatments, with median population reductions of 70% in the fipronil and 80% in the deltamethrin treatment. In contrast, fipronil was more toxic to spiders (60%) than deltamethrin (no significant effect). Moreover, with the exception of springtails, the effects of fipronil were generally more persistent. Deltamethrin did not affect *C. clepsydra*, but fipronil had a strong effect on this harvester termite, killing 80-85% of all colonies. No recovery was observed until 24 weeks post-treatment.

A significant decline, relative to pre-spray and control densities, of populations of two insectivorous reptiles, *Mabuya elegans* (Scincidae) and *Chalarodon madagascariensis* (Iguanidae), was noted in the fipronil treatment, ranging from 61% to 84% between 8-24 weeks post-treatment. No significant population reduction occurred in the deltamethrin treatment. Equally dramatic effects were observed in the lesser hedgehog tenrec, *Echinops telfairi* (Tenrecidae), which was not found in plots treated with fipronil. Analysis of the diet of these animals showed that termites, including *C. clepsydra*, are an important prey item, especially for *M. elegans* and *E. telfairi*, but also for the large-eared tenrec, *Geogale aurita*. Regression analysis revealed a significant relationship between the density of viable *C. clepsydra* colonies and the density of *M. elegans* and *E. telfairi*. The results provided evidence of a disruption of the food chain due to fipronil, resulting in an overall depletion of invertebrate prey (termites, epigeal arthropods) and a subsequent decline of several insectivorous vertebrates.

Acknowledgments

This study was funded by ONE, World Bank and the United States Agency for International Development (USAID).

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Minimizing Environmental Harm in Madagascar's Locust Control Program.

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The conference held in Antananarivo reviewed the emergency campaign in Madagascar. From this assessment it is evident that a new era of locust technology is emerging, including novel developments in environmental impact assessment:

! *Environmental monitoring*: Albeit late in the emergency, environmental monitoring accompanied the use of Adonis and deltamethrin, products which were in routine use in 1999. This was among the few times that ecological impact studies have run concurrently with an emergency locust campaign.

! *Disposal of containers*: Empties accumulating at forward bases in this campaign were transported to clearing centres, where they are being cleaned, crushed and shipped back to their country of origin. This contrasts with the West African experience, where according to the OTA Report (1990; see Communications: Publications), there was no policy in place for the disposal of used containers at the close of Desert locust operations.

SOCIOPOLITICAL AND POLICY ISSUES

General Policy of Locust Management in Indonesia.

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Since 1998 several islands of the Indonesian Archipelago have been subject to serious outbreaks of Migratory locust, *Locusta migratoria manilensis* (Meyen 1835). To face the situation, the French Ministry for foreign affairs furnished financial assistance with the technical support of CIRAD experts. The first survey was organized in 1998 to assess the locust situation in Sumatra. In 1999, a training seminar was organized from 12 to 17 July in Kotabumi, southern Sumatra (Lampung Province). In 2000, a new mission from 7 to 30 July allowed assessment of the situation which is still an object of concern in West and Central Kalimantan and in Sumba Island. A re-assessment was also performed in South Sumatra and Lampung Provinces. One-day seminars were organized in Kalimantan (2), Sumba (1), South Sumatra (2), and Java (1). Nearly 400 people from many backgrounds (from scientists to farmers) were included. Recommendations were made with regard to the short-term prospects, including emergency measures to help operators overcome outbreaks. On the medium- and long-term prospects, recommendations were made to set up a general policy for locust management in Indonesia based on IPM principles. In the near future (2001) a research program on Migratory locust population dynamics (in co-operation with the Ministry of Agriculture and some universities) will be implemented in Sumba and Sumatra, with the objective of acquiring a basic knowledge of the ecology of the Migratory locust in Indonesia and a better understanding of the dynamics of locust outbreaks in order to optimize surveys and control measures. Several "training of trainers" sessions will be organized, as well as training for local scientists, and a locust management unit will be organized and implemented in Java.

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Capacity Building Emerges from the Locust Control Campaign in Madagascar.

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The conference held in Antananarivo reviewed the emergency campaign in Madagascar. From this assessment it is evident that a new era of locust technology is emerging, including novel developments in policy. Of particular concern is the need for sustainable development. At the close of the campaign, Madagascar pushed for the co-ordination and running of its own program, along with capacity building in locust control. All too frequently in similar locust emergencies, expatriates are sent in with a fleet of sophisticated spray aircraft (from the donor country!), who do a satisfactory job and depart - leaving nothing behind (Brown, 1999; see Communications: Publications).

Development of a National Anti-Locust Center in Madagascar.

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Since 1997 Madagascar has fought against a major invasion of the Migratory locust which started from the outbreak area in the south-western zone of the country. Significant outbreaks of the Red locust also required many control measures. Since 1998, the responsibility for control operations has been transferred from the Plant Protection Service to the "Comité National de Lutte Anti-Acridienne" (CNLA, a national committee for locust control created for the circumstance). The control operations were funded by very diverse sources, including: government, the World Bank, FAO, European Union and various bilateral assistance programs (France and others). After many months of intensive control operations, the plague is not finished yet and many gregarious populations remain. However, the situation is definitely improved compared to those which prevailed in 1998 and 1999. It was thus recently decided to give the responsibility for survey and control to a perennial structure of the Ministry of Agriculture and to create a National Anti Locust Center (Centre National Antiacridien: CNA). Created on 12 April 2000, the CNA is a publicly-owned establishment which has administrative and financial autonomy and will be in charge of locust monitoring and control on all the national territories in remission as well as during invasion periods. The CNA must have all the necessary capabilities (financial, material, and human) and make all the decisions and directives for efficient locust control over all the territory. The administration of the CNA is located at Tuléar and the technical services at Betioky-Sud (in the outbreak area) in the buildings of the old "Centre Antiacridien de Betrioky-Sud," the CAB, which was until recently an operational division of the Plant Protection Service. In the short term, the objective of the CNA must be to finish controlling the gregarious locust populations and to re-establish a recession situation. It also must start to set up the basis of a perennial preventive control system for long-term prevention of Migratory locust plagues.

Desert Locust Control: A new FAO Commission for Northern and Western Africa.

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The survey and control of the Desert locust requires excellent co-operation at the regional and international levels. In Western and Northern Africa, the regional co-operation up to now depended on two organizations: OCLALAV and CLCPANO. The first ("Organisation commune de lutte antiacridienne et de lutte antiaviaire"; Common Organization for Locust and Bird Control), involves ten countries (Benin, Burkina Faso, Cameroun, Ivory Coast, Gambia, Mali, Mauritania, Niger, Senegal and Chad) of which half are not directly concerned with the preventive control operations.

The second ("Commission de lutte contre le Criquet pèlerin en Afrique du Nord-Ouest"; Desert locust Control Commission for North-West Africa) organization functions under the aegis of FAO (United Nations Organization for Food and Agriculture), and it ensures the coordination of the activities of Desert locust control in the countries of the Western Area not covered by OCLALAV, which is to say Algeria, Libya, Morocco and Tunisia, and also Mauritania. This institutional situation was for a long time regarded as inappropriate for effective preventive control of the Desert locust in the Western area.

Very recently, under the aegis of FAO, a new regional commission was created. This commission is called the "Commission de lutte contre le Criquet pèlerin en région occidentale" (CLCPRO; Desert Locust Control Commission for Western Area). Its aim is to promote at national, regional and international levels all actions, research and training necessary to ensure preventive control and to face the invasions of the Desert locust in the Western part of its distribution area, in Northwest and West Africa. This commission includes Algeria, Libya, Mali, Morocco, Mauritania, Niger, Senegal, Chad and Tunisia, countries containing main outbreak areas or directly concerned with the very first recrudescence.

The creation of this new commission (replacing for the Desert locust the roles of CLCPANO and OCLALAV) is a major event, which has been awaited for many years. It shows the importance that the States of the area grant to the Desert locust problem. It attests to the will of these States to be engaged in a renovated common policy of preventive control as well as to ensure the financial, technical and environmental durability of the effort. Finally, it augurs well for an efficient implementation of the EMPRES program of the FAO in reinforcing the national capabilities for preventative control of the Desert locust in the Western area.

FAO Launches EMPRES program for Desert Locust Control in Northern/Western Africa.

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The Desert locust remains a major potential for plagues in many States of Western Africa, including: Algeria, Libya, Mali, Morocco, Mauritania, Niger, Senegal, Chad, and Tunisia. These countries adhere to a common policy of preventive control to which they have contributed for many years, along with development agencies. They are unanimous in recognizing that this strategy of prevention is well adapted to the problem and that it is justified from technical, economic and environmental points of view. Each one of these countries has a national service, more or less independent, for the control of the Desert locust. However, the current national capabilities are obviously insufficient, in particular in the countries of the Sahel (Mali, Mauritania, Niger, Chad) which contain some of the main outbreak areas.

In light of the weakness of the regional capacities to control the Desert locust, FAO (United Nations Organization for Food and Agriculture) launched the EMPRES program, whose "Desert locust component" is designed to help the countries exposed to the invasions. One of the priorities of the program is the reinforcement of the national capacities to control the Desert locust (the other priority relates to the development of regional co-operation in order to increase the efficacy of the regional monitoring and control system).

The first component of the EMPRES program has been operational in the central area (countries around the Red Sea) since 1996. This program is now operational in the Western area. A regional workshop was recently organized by FAO in Nouakchott, Mauritania, from the 10 to 15 February 2001. This workshop was intended to prepare the planning and timing of phase 1, scheduled to last four years (01/2001to12/2004). Taking part in this workshop were the representatives of all the countries concerned with the EMPRES Western area (Morocco, Algeria, Tunisia, Libya, Mauritania, Mali, Niger, Chad, Senegal), the Officer in charge of the acridian group of FAO, the coordinator of program EMPRES central Region, the President and the Executive Secretary of the CLCPANO (Desert Locust Control Commission for North-West Africa), and the representatives of various donors (USAID, France, Germany, Islamic Bank of Development). The Western Region EMPRES program, whose planning and budgeting were the subject of dynamic and constructive debates between all the participants, has become a reality.

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OPERATIONS AND LOGISTICS

Problems and Progress Emerge from the Acridid Outbreak in Kazakhstan.

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Locusts and grasshoppers are serious pests of agriculture in Kazakhstan, the 9th largest country in the world. Situated in the heart of Asia, 2/3 of its area (180 million ha) is covered by native, mostly arid grasslands. The areas and intensity of the acridid infestations were augmented during recent years by recurrent droughts, abandonment of >10 million ha of formerly cultivated lands, and insufficient control. In 1999, the hopper bands and swarms of the most important species, the Italian locust *Calliptamus italicus* L. destroyed 220,000 ha of cereal crops with an estimated damage of 15 million USD.

Following the official request of the Government of Kazakhstan for emergency assistance in locust management, the FAO allocated funds for TCP project FAO/TCP/KAZ 0065(E) "*Emergency Program for the Control of Locust Outbreaks*." The objective of the project was to increase the capability of the newly established Department of Plant Protection and Quarantine (DPPQ) of the Ministry of Agriculture of Kazakhstan and to prepare a medium- to long-term locust program. Various associated measures aimed at ensuring sustainability and at taking into account immediate technical needs for the campaign 2000.

In 2000, the Government of Kazakhstan allocated 20.1 million USD for anti-locust management. The campaign was directed by the DPPQ, working in close collaboration with the Republican State Enterprise "Phytosanitariya." According to the official statistics, the nymphal survey was carried out on 34 million ha, and the chemical control was implemented by spraying 947,000 liters of 14 insecticides over an area of 8,106,000 ha. Insecticide procured using the governmental budget included: several pyrethroid formulations (46% of the area), Diflubenzuron (35%), Fipronil (10%) and Chlorpyrifos (9%). Spraying equipment: the treatments were done using heavy Antonov-2 aircraft (15%), ultra-light aircraft (10%), tractor-driven sprayers, vehicle-mounted ULV sprayers (altogether 42%), and vehicle-mounted mistblowers (33%).

Collection and processing of reliable locust information is a cornerstone of any management program. This is particularly relevant to Kazakhstan, in the context of its immense territories of locust habitats. The project inputs allowed the first steps towards standardization of locust information (introduction of the special forms) and its conversion to a digital format by supplying a number of GPS units and associated training.

The project contributed to further development of ULV applications as the most efficient, most economical, and environmentally less hazardous strategy of locust control by supplying a number of units of different ULV spraying equipment, complemented by practice sessions and demonstrations. During training seminars and field visits, the irregular blanket applications of insecticides for chemical locust control were advocated as the most pragmatic and least environmentally hazardous strategies. Efficacy of several of the most frequently used acridicides has been evaluated by independent experts contracted through the project. Translation into Russian of the last Pesticide Referee Group report (1999) and other FAO documents contributed to the promotion of good insecticide use practices advocated by the FAO. Large-scale blanket applications of broad-spectrum insecticides represent a serious threat to the environment, in particular to non-target fauna. The project implemented the first ever ecotoxicological study of acridicide side-effects on non-target terrestrial arthropods in Kazakhstan, and thereby started to build the relevant database.

The distribution areas of the Italian locust and the swarm movements across political boundaries requires the development of a regional early warning system which could be supported by different donors. This and other problems of regional coordination of anti-locust activities were discussed at the Round Table meeting in August attended by over 60 delegates from 5 neighboring countries: Kazakhstan, Kyrgyzstan, Russia, Tajikistan, and Uzbekistan. Representatives of the MOAs of the above-mentioned countries unanimously signed the resolution requesting the FAO to urgently study the possibility of creating a regional Locust Commission for Central Asia.

Recommendations for the medium- and long-term program of locust management in Kazakhstan have been made. The ultimate goal of the program is the transition from a purely curative strategy using predominantly chemical methods of locust control to the development of a preventative, ecosystem approach to the management of locust populations.

Locust and Grasshopper Outbreaks Become Increasingly Serious in Uzbekistan.

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Locusts and grasshoppers are the most important economic pests of agriculture in Uzbekistan. Among >100 species of the acridids, the most damaging are 3 locusts (Asiatic Migratory, Moroccan and Italian) and such grasshopper species as *Dociostaurus kraussi*, *Calliptamus barbarus*,and *Oedaleus decorus*.

Since gaining independence in 1991, the area of grain production in Uzbekistan has increased from 280,000 ha to 1,400,000 ha, i.e. 5 times. As a result, many permanent breeding areas of *Calliptamus italicus* and *C. barbarus* are now situated very close to the areas of grain crops, and these acridids represented a serious threat.

Areas of anti-locust control in Uzbekistan in 1999-2000.

Species	1999	2000
Dociostaurus maroccanus	250,000 ha (80%)	195,000 ha (67%)
Calliptamus italicus	40,000 ha (13%)	72,000 ha (25%)
Calliptamus barbarus	-	24,000 ha (8%)
Locusta migratoria migratoria	20,000 ha (7%)	2,000 ha (<1%)
Total	**310,000 ha**	**293,000 ha**

Forecast for 2001: 400,000 ha to treat, including about 200,000 ha in the regions adjacent to other countries (Kazakhstan, Turkmenistan, Tadjikistan, Afghanistan and Kyrgyzstan).

Most anti-acridid control in Uzbekistan is applied to the Moroccan locust *Dociostaurus maroccanus* (see Table). Insecticides (pyrethroids, OPs, phenyl-pyrazoles) are sprayed in LV regimes, mostly from ultra-light aircraft. Uzbekistan regularly participates in anti-locust treatments in southern Kazakhstan (1999: 20,000 ha). Uzbekistan is the only post-Soviet country which maintains a centralized system of specialized anti-locust operational teams which are responsible for survey and timely insecticide applications.

A serious problem is the permanent breeding area of the Moroccan locust half of which is situated in northern Afghanistan with the other half in southern Uzbekistan. Swarm flights into Uzbek territory are frequent and devastating. Another problem is located in the zone of the ecological catastrophe of the Aral Sea [for details, see Gapparov & Latchininsky, 2000. What are the consequences of ecosystem disruption on acridid diversity and abundance? pp. 31-59 *in:* Lockwood, Latchininsky and Sergeev (eds.) *Grasshoppers and Grassland Health. Managing Grasshopper Outbreaks without Risking Environmental Disaster.* Kluwer: Dordrecht-Boston-London].

Emerging Grasshopper Problems in South America.

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In Peru, recent outbreaks of *Schistocerca piceifrons peruviana* (North Region) and *S. interrita* (South Region) were observed. Consultants from Embrapa, the Brazilian Organization for Agricultural Research, were invited to visit the area to assist with the planning for emergency control with chemical insecticide and for preventive control with a bioinsecticide based on *Metarhizium anisopliae* var. *acridum*. Two biologists from the Ministry of Agriculture were trained in fungal production at Embrapa Genetic Resources and Biotechnology, Brasília. In addition, there is an international meeting being organized by the Ministry of Agriculture from Peru with the help of UN/IICA. Another outbreak was recorded in the Republic of Guyana, and it seems that *Schistocerca* sp. was causing the problem. In Argentina, according to Lange (1997), at least 15 species can become pests, including *Dichroplus* spp., *Staurorhectus longicornis*, *Rhammatocerus pictus*, *Schistocerca cancellata*, and *Tropidacris* sp. and *Rhammatocerus schistocercoides* occur in Colombia and Venezuela, but recent information on the status of these pests is lacking.

In Brazil, the first records of *R. schistocercoides* attacking crops in Mato Groso State are from 1984. In 1991/1992 there was a severe outbreak, in which the distribution area was close to 2 million hectares. In 1993 the project "Biological Control of Grasshoppers" was started with the support of FAO. In 1994, research activities aimed at the development of a mycoinsecticide based on the fungus *Metarhizium anisopliae* var. *acridum* were initiated. After 6 years of funding support by the Brazilian government through Embrapa Genetic Resources and Biotechnology, control levels of 85% under field conditions have been achieved (Magalhães *et al.* 2000). Although more expensive than chemical insecticides, its narrower environmental impact, including safety toward mammals, may encourage the use of mycoinsecticides in future outbreaks. Populations of *R. schistocercoides* are under control as a result of the chemical campaigns in Mato Grosso from the beginning of last decade. *R. schistocercoides* also occurs in other states (Minas Gerais, São Paulo and Goiás), but the populations seldom build up to threaten agriculture.

Presently, the most severe grasshopper problems in Brazil are taking place in Minas Gerais State. Pastures and irrigated banana are being attacked by a complex of species, such as *Schistocerca pallens, Dichroplus bergii*, *Staurorhectus longicornis*, and *Tropidacris collaris*. The North of this state has about 12,000 hectares of banana orchards and over 50,000 hectares of pastures under grasshopper pressure. Likewise, in the northeastern region, localized attacks of diverse grasshoppers species on banana orchards, the proscopid *Stiphra robusta* on cashew trees, and *S. pallens* attacking sugar-cane, corn, and beans, have been observed.

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International community will help the new National Anti-Locust Center in Madagascar

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In Madagascar, the recent invasion of the Migratory locust (*Locusta migratoria capito* Saussure) could have been avoided. This species is well-known there, beginning with research by some pioneers from the French school of acridology in the late 1920s. The first anti-locust center was created shortly after the last world war. At the beginning of the 1970s, a research project financed by the PNUD (Program of the United Nations for Development) and FAO, proposed a simple system for early warning and preventive control. This system relied on the regular study of the rainfall records, a network of ground observation, and early and rapid interventions against the first concentrations of gregarious insects as the prelude to swarm formation. The only area to be monitored on a regular basis was the southwest portion of the island, in particular the regions of Mahafaly and Antandroy. This localized where gregarious locusts develop and represents the source for the initiation of invasions. All the resources for a simple, effective, and inexpensive system of preventive control exist in Madagascar. In the past, this system functioned for a few years, then with a calming of the locust situation and developing economic difficulties, the resources were dispersed and the system became nonoperational. With the country stripped of any system of prevention and early control, all of the conditions were primed to allow an invasion to develop unrelentingly, and this is precisely what occurred from 1997 to 2000.

In order to help the new National Anti-Locust Center to assume its tasks and to re-establish, on a sustainable basis, a new and efficient early warning system for locust control (the only guarantee of a preventive control approach that is economically and ecologically acceptable), two assistance projects have recently developed.

The first, financed by France and carried out by the CIRAD, is envisaged over a duration of 3 years. This project will assist with the organization of the warning section of the anti-locust center. Specifically, it must: 1) update scientific knowledge necessary to implement an early warning system for locust preventive control; 2) produce a decision-making tool to monitor and assess the locust situation and the ecological conditions; 3) undertake studies of the Red locust, *Nomadacris septemfasciata* (Serville), in order to specify the factors leading to gregarization and outbreaks of this species, as well determining its role in reinforcing the process of gregarization in the Migratory locust.

The second project is a 5 year project of the African Bank of Development. The Board of Directors of the African Funds for Development (FAD) has just approved a loan of 5.76 million Units of Account (1 CPU = 1.29248 $US as of 1/03/01) and a gift of the Funds for Technical Assistance (FAT) of 1.16 million CPU, for a total of about 6.92 million CPU (approximately 8.94 million $US), intended to finance a project of preventive locust control in Madagascar. The objective of the project is to contribute to the reinforcement of the food security in the country. It more specifically aims at preventing the future locust invasions by maintaining, on a durable basis, the locust population below the gregarization threshold. The project pertains to survey and early locust control, as well as sensitizing, training, and organizing the recipients. It also envisages experimentation with and the diffusion of alternative methods (biological control) of locust control in response to the requirements for environmental protection, and the reinforcement of the national capacities.

FEATURE ARTICLE

Synopsis of the 1997-1998 Desert Locust Campaign in the Red Sea Region.

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** Served as the Regional Coordinator for the FAO/Emergency Prevention System Central Region Program from early 1997 until late 1999, and worked extensively on Desert locust control while at the U.S. Agency for International Development from 1988 through 1996.*

Groups of transiens phase adult Desert locusts mixed with African Migratory locusts were first reported on the Red Sea coast near Port Sudan, Eritrea, in November 1997. Aircraft were immediately dispatched from Wadi Madani to Port Sudan and treatment commenced within 24 h. Several days later, Eritrean scouts found hopper bands and some adult groups of both species scattered along the coastal plains from Hasmet to Hirgigo (later during the outbreak, hopper bands were reported further south around Thio and areas north of Assab). Eritrean ground operations began within 24 h and some aerial operations were carried out by the Desert Locust Control Organization for Eastern Africa (DLCO-EA) weeks later. No swarms were reported in Eritrea throughout the campaign despite the presence of hundreds of hopper bands. The Ministry of Agriculture was sufficiently in control of the situation that it allowed several areas with hopper bands to be temporarily left untreated for mycopesticide field research.

Sudan was more problematic. The northern coast, vast and sparse, was difficult to survey systematically, especially for a country whose development was not being funded by many western donor countries. Like other parts of the country, the Red Sea coast from the Tokar Delta to the border with Eritrea was held by the Beja Congress, a rebel guerrilla army. I received updates from the Beja Congress, enabled by radio, which revealed that the southern coast was heavily infested with hopper bands developing into swarms. Conditions along the western Red Sea coast in particular were unusually favorable for breeding and the FAO warned that locust numbers could increase significantly (FAO, Nov. & Dec.1997).

In January and February 1998, I received reports from the Beja Congress that swarms had developed and crops were being, lost but insufficient spray equipment and insecticides made effective control impossible. Swarms, presumably from uncontrolled areas of Sudan, began arriving along the Red Sea coasts of Saudi Arabia and southern Egypt. In consequence, more than 330,000 ha in Egypt and Saudi Arabia were sprayed.

Limited breeding on Yemen's Tihama coastal area was controlled, apparently before any swarms crossed national borders. Somaliland (formerly northern Somalia) had no national locust control unit, hence breeding populations produced several swarms that flew into the Ogaden region of eastern Ethiopia, where they were eliminated before reaching the highlands. The FAO supported and coordinated aerial spray operations in Somaliland and the breeding areas dried, so that Ethiopia's Desert locust campaign lasted less than one month. The outbreak did not spread beyond the Red Sea coastal areas, but without early control in Eritrea and parts of Sudan, it might have developed into a plague (Showler 2001).

From the first signs of gregarious locust activity until May 1998 when control operations ended, ~ 430,000 ha were treated in seven countries (FAO Nov. 1997 – May 1998) and cost US $30,000 from the FAO's budget for vehicle repairs (FAO/EMPRES 1999). Some countries, however, incurred substantial costs to support their control campaigns which, arguably, might have been averted had early Desert locust control been conducted along Sudan's southern coastal lowlands.

Some perspective might be gained through comparison. In 1986, an outbreak along the Red Sea coast of northern Ethiopia (now Eritrea, since 1992) and Sudan was left uncontrolled largely because of widespread armed conflict in both countries. The outbreak magnified to plague status that lasted until the late spring of 1989. About 25 million ha were treated with insecticides among 23 infested countries at a cost to the international donor community (national governments' foreign aid agencies, multilateral organizations, and nongovernmental organizations that make funds available for international development and disaster assistance) of ~ US $310 million aimed at supporting control campaigns. Initiated too late, meager crop protection service equipment was deployed to protect croplands, having defaulted to a reactive strategy (Showler 1997). Lack of preparedness in the affected regions of Africa and Asia resulted in infestations that overwhelmed the capacities of the various national crop protection units, and many situations were classified by international aid agencies as disasters (crop loss, however, was apparently light). Drying conditions in breeding areas were mostly responsible for the end of the plague in 1989 (Showler & Potter 1991).

An outbreak began in the same Red Sea coastal area in 1992. Armed conflict and weak national locust control capabilities delayed interventions until gregarious Desert locust populations had built up substantially. Nevertheless, control operations began at an earlier stage than during the 1986-1989 plague, and they focused largely upon breeding areas. Four million ha were sprayed in 18 countries, supported in part by US $18.75 million from international aid agencies (Showler 1995). While climatic factors were significant in suppressing the outbreak at the regional scale, model simulations suggest that control operations may have helped to contain it (FAO 1999).

There has never been an experiment that somehow compares different Desert locust control strategies during the same outbreak because each outbreak has been dealt with in earnest under notably challenging conditions. As long as Desert locust outbreaks are viewed as being potentially catastrophic at the trans-regional scale once plague status is reached, lack of experimental opportunities will remain challenging. On the other hand, some might argue that the best intelligence is gained by making observations under real world conditions. The former appears to be unfeasible for the foreseeable future but the latter suggests that early intervention in breeding areas is connected with better outbreak containment when the 1997-1998 campaign is contrasted to campaigns in the ten years previous to it.

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FEATURE ARTICLE

Armed Conflict in the Central Region of the Desert Locust's Distribution, 1997-1999.

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** Served as the Regional Coordinator for the FAO/Emergency Prevention System Central Region Program from early 1997 until late 1999, and worked extensively on Desert locust control while at the U.S. Agency for International Development from 1988 through 1996.*

During my fourteen years of involvement in Desert locust control, armed conflict in the affected countries has been one of the most challenging obstacles to survey and proactive control operations. The 1986-1989 plague, for example, originated in what is now Eritrea, then fully embroiled in a protracted and bloody war of independence from Ethiopia, and in Sudan where guerilla armies and government forces chronically clash in the country's most productive breeding areas (Showler & Potter 1991). Aside from many other instances of armed conflict in the infested countries, military escorts for locust survey teams were killed in firefights with Tuareg rebels; a U.S. C-130 spray plane was shot down by Polisario guerrillas over Western Sahara killing the American crew (the accompanying C-130 was hit by a shoulder-fired surface-to-air missile); and a locust control helicopter crashed in the Ethiopian desert near the border with Somalia where bandits or quasi-military clans could have shot it down (the dead and wounded were robbed before help could arrive).

Nearly ten years later, 1997-1999, while posted in Asmara, Eritrea, as the Coordinator for the Food and Agriculture Organization (FAO) of the United Nations' Emergency Prevention System (EMPRES)/Central Region Program, I was able to take close measure of armed conflicts occurring in Djibouti, Egypt, Eritrea, Ethiopia, Oman, Saudi Arabia, Somalia, Sudan, and Yemen. At one point, eight of the nine countries were either at war or fully mobilized for it. Following are the instances and the way in which each most obviously affected locust control.

The government of Sudan was fighting several long-term civil wars, the military costs of which were debilitating other government sectors, including the ministry of agriculture. Shortages of vehicles, equipment, and funds for salaries hamstrung survey and control. Sudan's capacity to embrace an effective early control strategy was further hindered by its isolation from international aid agency assistance for harboring terrorist cells. This was underscored by the 1997 U.S. missile strike on a pharmaceutical plant in Khartoum suspected of manufacturing chemical weapons for terrorist financier Osama bin Ladin.

Yemen and Eritrea had recently clashed over the Hanish Islands in the Red Sea, and tensions between them were high until the matter was resolved at an international court. Travel and communication between the two countries were disrupted for months.

Islamic fundamentalist terrorists massacred tour groups in Egypt, which heightened travel advisory cautions there. Kidnapping of foreigners by highland Yemeni clans resulted in fatal gun battles, and an influential Yemeni imam exhorted Moslems to kill infidels; both contributed toward cessation of travel to the countryside by U.N. and other aid organization personnel. Insurgents, reputedly from Sudan, shot Eritreans and Belgians on Eritrea's Filfil escarpment road, and that access to the coastal plains' Shelshela Desert locust breeding area was closed for months.

Somaliland, Puntaland, and other secessionist factions in Somalia had many limited armed engagements, armed clans controlled passage through large areas, banditry remained a serious concern, and Ethiopian troops reportedly invaded two small towns located in Somalia. Lack of a national locust control unit and insecure countryside reduced survey to a UN Volunteer and a Somali counterpart, and occasional FAO-funded aerial missions for the Desert Locust Control Organization for Eastern Africa. During the 1997-1998 campaign, old stocks of insecticides had to be trucked from Djibouti to Hargeisa, Somaliland.

In Ethiopia, Oromo, ethnic Somali, and other groups skirmished with government troops. Kenya claimed that Ethiopian soldiers had crossed the border on several occasions, killing civilians and police, and stealing cattle. Travel in areas of Ethiopia, including parts of the Ogaden desert, was considered unsafe. The same was true of much of Djibouti because of Afar uprisings.

Ground survey in limited areas of Eritrea's Red Sea coast was not possible because of mines buried during the 1962-1992 war for independence. There are tracks through these relatively small areas, and survey can be accomplished by air.

Egypt and Sudan were in conflict over coastal borderlands, and Saudi Arabia and Yemen clashed on their border. These disputes interrupted communication and travel between the countries, and the contested border areas were off limits to locust survey teams.

Ethiopia launched two air strikes against Asmara in June 1998, Eritrea responded with one air strike against Mekele, and a tense border situation became a sporadic but full blown war until June 2000, when Ethiopia invaded large portions of southwestern Eritrea, the combatants stalemated, and United Nations peace keepers were requested by both governments. Though poorly reported, this conflict was the largest military confrontation in the world at the time. More than 100,000 soldiers were killed and greater than 120 tanks, 15 MiG jets, and several attack helicopters were destroyed (most of the human and material losses were to Ethiopia). This war diverted resources, including crop protection personnel, to active military duty and closed travel and communication between the two countries. Many development projects funded by international aid agencies were frozen.

The years 1997-1999 demonstrate the many and varied perils of violence in the central region. Wars, rebellions, insurgencies, and terrorism present the most intractable of problems to locust control - even if some situations might be successfully addressed or circumvented. As long as insecurity remains a significant constant, particularly in breeding areas, armed conflicts will continue to shape the ways in which Desert locust outbreaks are tackled, and reduce the potential of outbreak prevention strategies.

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COMMUNICATIONS: TRAINING, WORKSHOPS AND MEETINGS

Regional Locust Control Workshop for Central Asia.

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A regional workshop was organized to discuss the Italian locust problem in West Siberia and East Kazakhstan. This Workshop was in Klutchi (Altai Region) in April, 2000. The workshop was sponsored by the Russian Federal Government, the Altai Regional Government, and Entwicklungsgesellschaft Halbstadt mbH (GTZ). This workshop was attended by more than 100 delegates from Altai, Novosibirsk, and Omsk Regions, Altai Republic (Russia), and Pavlodar and East-Kazakhstan Regions (Kazakhstan). Invited speakers were from the Federal Plant Protection Agency, All-Russian Institute of Plant Protection, Novosibirsk State University, Altai Institute of Agriculture, and regional plant protection agencies. Representatives of certain international chemical companies also attended.

National Grasshopper Management Board of the US Recommends Changes.

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The United States' National Grasshopper Management Board (NGMB) met in Denver, Colorado in early January of 2001. The meeting addressed a wide range of topics, including policy, research updates, funding issues, and control methods. Three matters may be of particular interest to international acridology. First, the US Department of Agriculture (USDA) is undertaking a complete revision of its Environmental Impact Statement concerning grasshopper control on federal lands. This document evaluates various options and derives a recommendation for the type of intervention, if any, that optimizes the complex, competing interests. Second, the USDA Animal and Plant Health Inspection Service (APHIS) has decided to limit its involvement in grasshopper control in the coming year (and foreseeable future until and unless additional funding is acquired) to the protection of croplands (i.e., the treatment of federal rangelands that represent a risk of infestation to adjacent, private crops). Third, the NGMB is in the process of revising its position statement on grasshopper and Mormon cricket management. This non-binding policy statement provides lawmakers, agriculturalists, state/federal agencies, and others a plan of action intended to "promote responsible grasshopper and Mormon cricket management through economically and environmentally viable stewardship of the land." In brief, the recommendations include a three-tier management strategy: 1) preventative management via strategic grazing of livestock, 2) crisis avoidance via hot-spot treatments of localized infestations to prevent expansion of grasshopper populations into large areas of rangeland or cropland, and 3) outbreak management via utilization of pest management software (HOPPER or CARMA) and implementation of Reduced Agent-Area Treatments (RAATs).

Locust Infestations in Perú Stimulate Upcoming Technical Meeting.

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As a consequence of the recent locust problems (*Schistocerca piceifrons peruviana*, *S. interrita*) in Perú, a locust technical meeting is being planned in that country. Although at present dates are not available, the meeting would be held sometime in the near future as a joint effort by the "Instituto Interamericano de Cooperación para la Agricultura (IICA)" and the Peruvian "Ministerio de Agricultura." Contacts at: jesparza@iicacrea.org.pe

COMMUNICATIONS: PUBLICATIONS

A New Book on Acridid Pest Management Published from AAAI Co-Sponsored Workshop.

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A book entitled *Grasshoppers and Grassland Health* was published by Kluwer (Lockwood, J. A., A. V. Latchininsky, and M. G. Sergeev [eds.]. 2000. *Grasshoppers and Grassland Health: Managing Grasshopper Outbreaks without Risking Environmental Disaster*. Kluwer Academic Publishers, New York, 221 pp.). This book is based on the NATO Advanced Research Workshop (co-sponsored by AAAI and The Orthopterists Society) on "Acridogenic and Anthropogenic Hazards to the Grassland Biome." The book reflects an entirely novel approach to creative and collective problem-solving in a scientific/management workshop. The text includes consensus recommendations emerging from intensive discussions, along with state-of-the-art chapters on grasshopper and locust ecology and management (including six chapters from AAAI associates/affiliates).

Principles and Practices of Acridid Pest Management.

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Acridid Biology and Ecology: The Foundations of Sound Pest Management.

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APPENDIX OF ACRONYMS

BAD	- Banque Africaine de Développement
BBC	- British Broadcasting Service
CIDST	- Centre d'Information et de Documentation Scientifique et Technique
CCA	- Cellule de Crise Antiacridienne
CNA	- Centre National Antiacridien
CNLA	- Comité National de Lutte Antiacridienne
DGPS	- Differential global positioning system
DPV	- Direction de la Protection des Végétaux
EC	- European Commission.
FAO	- Food and Agricultural Organisation of the United Nations, Rome
FITAFA	- Malagasy NGO operating in Zone 5 in SW Madagascar
GPS	- Global positioning system
GTZ	- German Gesellschaft für Technische Zusammenarbeit
NGO	- Non-Governmental organisation
NRI	- Natural Resources Institute, Chatham UK.
ONE	- Office national pour l'Environnement
OTA	- Office of Technology Assessment of the Congress of the US, Washington DC.
PLAAG	- Projet de Lutte Antiacriddienne dans l'Aire Grégarigène
PPRI	- Plant Protection Research Institute, Pretoria
PVA	- Projet Veille Acridienne
UL	- ultra low volume (formulation)
ULV	- ultra low volume (application)
USAID	- United States Agency for International Development, Washington

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As pest management techniques, perspectives, and products have become increasingly sophisticated in the last 20 years, our capacity to adapt and transfer the methods and knowledge has declined. Formerly effective programs have dramatically diminished their roles in assisting afflicted regions. While the ability for any single nation to sustain a critical mass of expertise in acridid (grasshopper and locust) pest management has diminished, the quality of geographically dispersed experience and knowledge is extremely high.

The ***Association for Applied Acridology International*** has brought together the world's leading practitioners in this field to develop and provide unbiased analyses along with culturally, technologically, economically, and environmentally appropriate methods for managing locust and grasshopper outbreaks. The ***Association*** is the first and only humanitarian-based, NGO of entomologists in the world, providing expert advice, training, and applied research to people and nations in need. The demonstrable capacity of grasshopper and locust outbreaks to reduce the standard of living, displace human populations, induce famine, and erode environmental quality demands the highest level of practical expertise and experience in order to rapidly build the capacity of agricultural communities to implement safe and effective prevention and control programs. The ***Association*** consists of 30 Associates/Affiliates from 21 nations, representing more than 300 years of collective experience and 13 Institutional Partners/Participants comprising the world's best organizations dedicated to the study and management of acridids (see inside, back cover).

The purpose of the ***Association for Applied Acridology International*** is to form a coordinated, operational pool of world experts, thereby creating opportunities for collaboration and enhancing access to this expertise by governments, agencies, and companies. This goal is captured in our motto:

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