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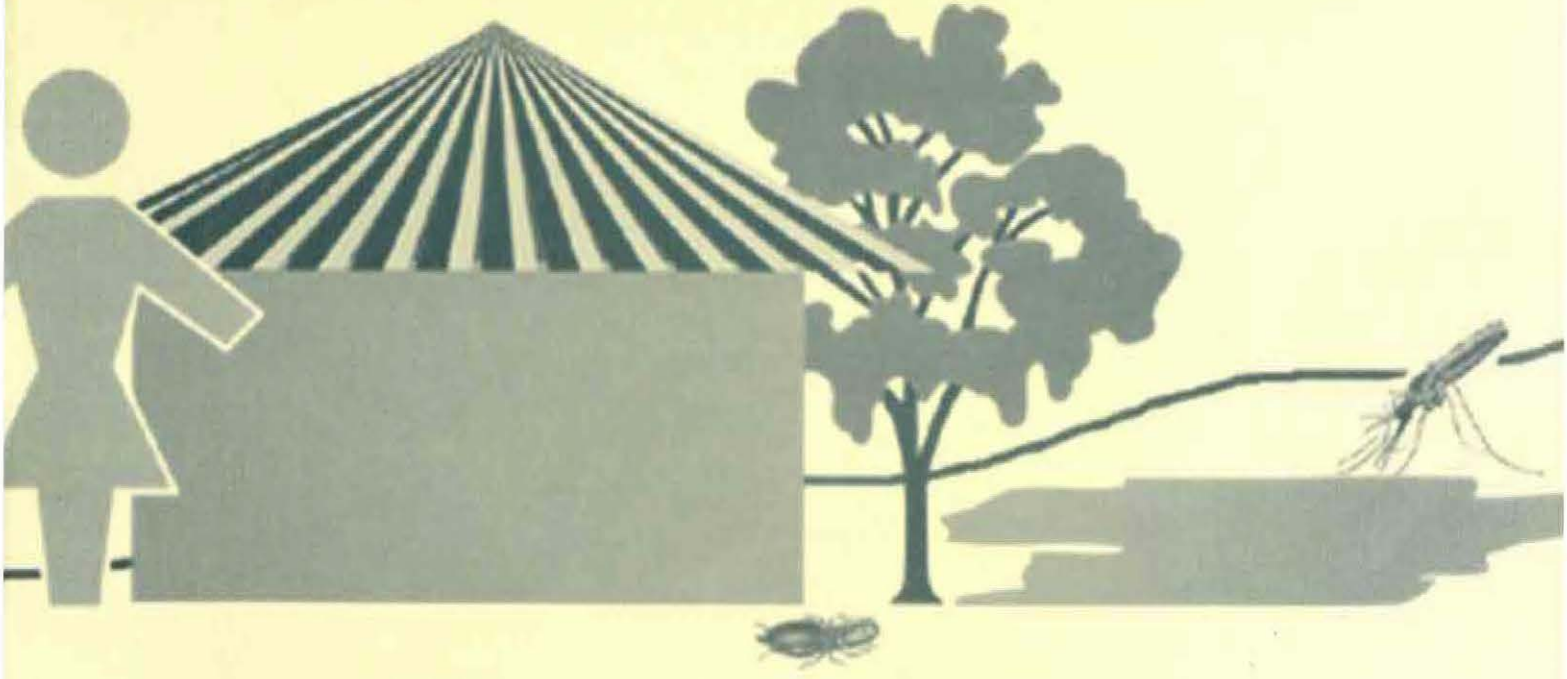
Annual Scientific Report Summaries 2000–2001

International Centre of Insect Physiology and Ecology
Nairobi, Kenya



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Mosquito drawings under Chapter 1 heading by P. J. Kostense © Laboratory of Entomology, Wageningen Agricultural University, The Netherlands.

Contents

Foreword

This latest record of our research covers the last two years and encompasses most of the activities that have been continued or finalised since the last reporting period, as well as newly initiated ones. A few other activities, which are still in their early stages, will be included in the next edition of our now biennial scientific report. As an institution that functions with taxpayers' funding and on a basis of confidence between donors, managers and researchers, we make every effort to fully report on our work to all stakeholders. In addition to these printed and CD-ROM versions of the ICIPE Scientific Report, we are also keeping databases from our research results for the record and also for future use, such as data mining—a method often used on large data sets that span many years—to uncover and analyse long term trends. Such data sets will be made available over the ICIPE web site in the near future.

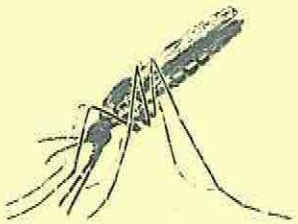
The last two years have been used to consolidate older projects, introduce new phases for ongoing projects and also to start some new areas of research. We have remained committed to our 4-Hs paradigm, and so report our work under these main Divisional headings for the applied and adaptive research. Activities relating to our core competencies and innovative research are reported under Departments and Units, or sometimes embedded into the Divisional reports, as may be best suited. In addition to carrying out research, the preparation of new research proposals, partnership with colleagues in the national, regional and international research and education arena, our scientists have also been very much involved in many stakeholder consultations and in the redrafting of our Strategic Vision document. This highly involving and broadly encompassing process forms part of the scientists' job description, as they have a stake as well as first hand experience with the stakeholders on how best to target the research and capacity building efforts to achieve set institutional goals.

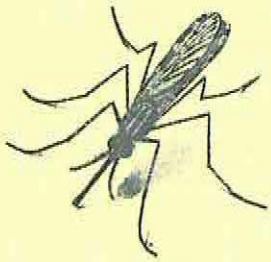
I am proud to be able to report on so many key activities targeting smallscale farmers, and the rural and urban poor, who stand to benefit greatly from the outputs of our research and technical level training in their daily lives. Sustainable and environmentally sound pest and vector management tools and strategies, and insect- and forest margin-based income generation options, are only a few of the technologies that can substantially improve the lives of our target communities—the women and children in particular—while assuring a better future. ICIPE's capacity building efforts at the degree level will contribute substantially to institution strengthening and allow governments, NGOs and other implementing agencies, from where our students are sourced, to become more effective in the planning and execution of development projects.

I would also like to take this opportunity to introduce to many of the readers of this report our newly appointed Director of Research and Partnerships, Prof. Onesmo ole-MoiYoi, who joined ICIPE in October 2001. Prof. ole-MoiYoi comes to ICIPE from the Molecular Biology Institute-Africa (MBI-A), which he founded and based at ILRI under the UNESCO umbrella, in Nairobi. The MBI-A is now being integrated into our Molecular Biology and Genomics department, expanding and modernising our work in that area. Prof. Ole-MoiYoi, a Harvard-trained MD, brings to ICIPE an impressive portfolio of research achievements, research and capacity building management experience, and many fresh ideas to expand our research and training activities with partner institutions.

Hans R. Herren
Director-General

1. Human Health Division





INTRODUCTION

ICIPE's Human Health Division concerns itself with research into anopheline mosquitoes, which transmit the malaria parasite. Malaria causes about 2.7 million deaths worldwide each year with 90 % of them occurring in sub-Saharan Africa.

The Human Health Division consists of two main programmes, one dealing with the ecology and behaviour of anopheline mosquitoes and the other with botanicals for mosquito/malaria control.

The objectives of the **African Malaria Vectors Research Programme** are to conduct research on the ecology and behaviour of mosquitoes, so as to contribute to the efforts of the national malaria control programmes in Africa; strengthen linkages and networks with national research and teaching institutions in Africa; and develop integrated vector management strategies for use in different ecological settings in Africa in collaboration with the World Health Organisation/Africa Regional Office (WHO/AFRO).

Botanicals for Malaria Control is a transdisciplinary and community-participatory malaria control programme that operates in Kisii and Gucha Districts of western Kenya, and which integrates conventional malaria control methods with the use of ethnobotanicals, including neem.

The programme's activities include evaluation of both the biological activity and cost-effectiveness of plant-based products for mosquito and malaria management in a malaria-endemic region of Kenya. Studies include exploration for mosquitocides, larvicides, ovicides and mosquito repellents from locally available plants, and their development and optimisation into affordable products for use by the community.

Work is also being done on the identification and assessment of breeding habitats for the malaria vector *Anopheles gambiae* and on environmentally benign and cheaper botanicals for bednet impregnation. The latter activities complement the clinical/diagnostic approaches of Merlin (a UK-based NGO), in collaboration with the Ministry of Health in Kisii/Gucha.

In addition, a few of the activities initiated by the now-completed ICIPE Neem Awareness Project are being pursued by the Botanicals for Malaria Control programme.

RESEARCH HIGHLIGHTS

A. African Malaria Vectors Research

1. Larval ecology of mosquitoes at the Kenya coast

The main objective of this project is to investigate the temporal and spatial distribution patterns of mosquito larval breeding habitats and adult production in relation to adult distribution. This involves mapping and characterisation of mosquito breeding habitats and determination of survival mechanisms of eggs during the dry season. It has emerged that certain sites are preferred by anopheline mosquitoes and form the main source of adult production. The eggs have been found to be capable of surviving in dry soils for periods of more than three weeks.

2. Biological control of larvae

Semi-field trials of larval control in Mbita, western Kenya, showed that the soil bacteria *Bacillus thuringiensis israelensis* and *Bacillus sphaericus* (*Bti* and *Bs*) were highly efficient at killing mosquito larvae and could find application on a large scale.

3. Behavioural and chemical ecology of mosquito vectors

With the main objective of characterising the human odours that attract mosquitoes, this project also includes studies of swarming and oviposition

behaviour. Some odours from individuals found to be highly attractive to mosquitoes are currently being analysed, with the ultimate aim of developing odour-baited traps.

Work is continuing to elucidate why gravid female mosquitoes prefer certain habitats for egg laying. Soil microbial organisms that are thought to be responsible for the production of mosquito-attractive volatiles are currently being analysed. It is now possible to simulate mosquito life history behaviours in the 'Malariasphere' at ICIPE-Mbita. Tree-hole-breeding anopheline mosquitoes were discovered in Suba, Kisii and Kisumu districts. This has implications on urban malaria transmission or dry-season transmission.

4. Bednet traps

Work on the development of bednet traps as a tool for monitoring disease transmission at the village level continues. An exposure-free bednet that is more efficient than human-landing catches and the CDC light trap have been developed and are being tested in the field in areas of varying transmission intensity.

5. Vector competence of mosquitoes

This study is currently being conducted in Mbita to determine the effect of biotic and abiotic factors on the development of malaria parasites in the mosquito gut. This is done by infecting mosquitoes with gametocytes and subjecting them to different climatic and environmental factors.

6. Urban malaria in Kisumu and Malindi

The adaptation of anopheline mosquitoes in polluted environments is being studied in Kisumu and Malindi, located in malaria-endemic areas of western and coastal Kenya respectively. Anopheline mosquitoes were found even in polluted waters in the urban areas.

SAMPLING FOR MOSQUITO LARVAE. It is found that man-made and polluted urban environments are major breeding sites for Anopheles *spp.*

7. Livestock and agroecosystems management for community-based integrated malaria control

This project in the Mwea Rice Irrigation Scheme aims at improving the health and well-being of the community through the development of sustainable strategies for reduction of malaria on the basis of improved agroecosystem management. This is linked with the Systemwide Initiative on Malaria and Agriculture (SIMA), an activity of the International Water Management Institute (IWMI).

8. Tree hole habitats for mosquitoes

Considering four ecologically different and geographically separated areas of western Kenya (Mbita Point, Rusinga Island, Kisii and Kisumu), a total of 96 tree holes have been identified as either permanent, semi-permanent or seasonal mosquito breeding habitats. These tree holes are present in various tree species, of which eight can be distinguished. Preliminary studies in Mbita in February 2001 have led to the observation that the most important malaria-transmitting vector, *Anopheles gambiae sensu stricto* breeds in these microhabitats, an observation that has not been previously reported in the literature. Further experiments were done in other ecologies to validate this observation.

Depending on the tree's age and the species, the capacity of these tree holes can reach more than 10 litres. We have attempted to estimate the mosquito population size in these tree holes in a longitudinal study over the wet and dry seasons (10 months).

A rich mosquito species diversity was found in the tree holes including *Culex*, *Aedes* and *Anopheles gambiae* complex; all developmental stages were consistently noticed at much higher population

Tree holes have been discovered to support a great diversity of mosquito species

densities (up to 20-fold), than in conventional ground water ponds. This suggests ideal living and survival conditions for these mosquitoes, and could be explained by the presence of enriched organic matter originating from fallen decomposing leaves, flowers, top soil dust, supplemented by stem flow water and stem bark constituents.

The taxonomic/PCR identifications of the mosquitoes collected from the tree holes in the various locations revealed approximately 10–15% *An. gambiae* of the Mbita ponds, 30% in Kisumu and about 50% in Kisii. All identified *An. gambiae* turned out to belong to *An. gambiae sensu stricto*, as revealed by the PCR analysis.

9. Lectin expression associated with *Plasmodium* infections in *Anopheles* spp.

A mannose-specific lectin in the mosquito *Anopheles stephensi* has been shown to be associated with the transmission of *Plasmodium*. Blocking of the lectin reduces transmission of the parasite. The goal of this study is to assess the role of lectin during malaria infections of the mosquito and the variation of the lectin gene sequence in *Anopheles gambiae* populations. Research activities will continue to:

- investigate the heterogeneity of the mannose-specific lectin in *An. gambiae s. s.*;
- elucidate the expression of the gene in the midgut of mosquitoes infected to the oocyst stage of *P. falciparum*; and
- study the regulation of lectin gene expression in mosquitoes midguts following infected bloodmeals.

10. Rapid assessment tool for mosquito bloodmeal sources

This project aimed to develop a bloodmeal analysis technique that can rapidly identify mosquito bloodmeal sources. In 2000–2001, a faster and more efficient technique (dip-stick ELISA) has been developed. Over 1200 samples have been identified using both the dip-stick ELISA and antigen ELISA. The techniques have been compared both for efficiency and cost effectiveness.

Follow-up activities will include validation of the dip-stick ELISA technique, testing of the technique for identification of tsetse bloodmeals and data analysis.

11. Capacity building

Fourteen PhD and 15 MSc students are currently undergoing postgraduate training. These are drawn from Kenya, Uganda, Tanzania, Ethiopia and Mali.

Vector control capability is being strengthened in Eritrea and training of MoH staff is being done by ICIPE and KEMRI.

The first Malaria Training Workshop was organised for 16 participants from Kenya, Uganda, Tanzania, D.R. Congo and Ethiopia.

B. Botanicals for Malaria Control

1. Bioprospecting for natural products in East Africa

This is a regional project on exploration of botanicals for mosquito control. About 150 plants were screened for mosquito repellency and insecticidal activity and several found to be effective. Two of these have been developed into commercial products *(see under Bioprospecting in Environmental Health Division report).*

2. Neem and other botanicals in malaria control

The Neem Project received continued support to study the potential for utilisation of botanicals for malaria control in a trans-disciplinary and community-participatory approach in Kisii and Gucha districts of Kenya. ICIPE will work closely with local NGOs in this venture.

3. Neem-based products for mosquito control

A variety of neem based products (oil, cake powder, soap, jelly, shampoo and candles) have been developed. All have been praised by the community for their quality and income-generating value. So far, three of the products have been registered by the Kenya Bureau of Standards.

The mosquito larvicidal activity of neem cake powder water crude extract (NCP-WCE) has been tested under laboratory conditions and then in the field. Under laboratory conditions, concentrations as low as 0.0001 and 0.001% induced developmental malformations and delayed pupation. In the field, a single 1 and 3% NCP-WCE application, respectively, halted mosquito pupation over a period of 3 weeks. In addition, mosquito eggs deposited after application either failed to hatch or had delayed/abnormal hatching.

4. Neem awareness activities

In the community of Kuja River (Homa Bay District), a group of new community activities was initiated. Two thousand neem seedlings were planted on 6.3 acres of land and a neem nursery was established. The underlying idea is to engage the communities in four different activities simultaneously, all with income-generating potential: a neem plantation for raw material supply (e.g. neem seeds for processing); a neem nursery for establishing further trees; neem product development; and marketing. All these activities will be handled by the community itself, through Special Interest, Women's and Youth groups.

5. Community development and capacity building

ICIPE scientists participated and contributed at three workshops organised by Merlin (UK), an NGO active in the Kisii highlands, and the Kenya MoH, to establish work-plans and capacity building at the community levels. One workshop and an Open/Field Day were organised by BioVision (an ICIPE programme), aimed at bringing together the various players to discuss and define new and sustainable community participatory, income-generating activities.

C. Future Outlook

1. Malaria Vectors Research

- Proposals on neem products for malaria control and biocomplexity pending.
- Bioprospecting for and exploratory use of anti-vector botanicals (WHO-MIM) will continue with 3 PhD and 16 MSc students from 5 universities. A letter of intent for the second phase has been submitted to MIM/TDR and was selected by the reviewers. A detailed proposal was submitted in November, 2001. The project will provide a useful model for ICIPE–University networking for enhancing postgraduate training capacity in the participating universities.
- Investigate the chemical ecology of oviposition selection by *An. gambiae*: a detailed hypothesis has been developed.
- Project on the identification of *An. gambiae* attractant blend from foot odours. The project was approved and is due to start in 2002 with funding from UNDP/WB/WHO/TDR.
- WHO/AFRO Collaborating Centre for Integrated Vector Management will be established.
- Integrate research activities with industries through the development of natural products.
- Involve more national institutions in research and capacity building, e.g. Eritrea, Ethiopia, Tanzania.
- Hire a vector control specialist who can implement the interventions and tools that are available.
- Increase the focus more on upstream research, particularly molecular biology.

2. Botanicals for Malaria Control

- Establish the community-driven mosquito breeding habitat surveillance and control scheme in selected villages in Kisii/Gucha.
- Design, test and evaluate various ethnobotanical blends for large-scale mosquito larval control.
- Provide possible links of tree hole vector dynamics for malaria disease transmission.
- Identify vector-specific volatiles which may be responsible for the selection of tree holes by gravid malaria mosquitoes.
- Define the genetic pattern of malaria mosquitoes residing in tree holes.

COMPLETED STUDIES (Abstracts of papers in refereed journals. For full list see Publications List)

Call No.: 01-1630

Minakawa N., *Githure J.I.*, Beier J.C. and *Yan G.* (2001) **Anopheline mosquito survival strategies during the dry period in western Kenya.** ***Journal of Medical Entomology.*** **38(3), 388–392.**

ABSTRACT: The dry season survival mechanism of *Anopheles gambiae* Giles is one of the most vexing deficiencies in our understanding of the biology of the major malaria vectors. In this study, we examined the dynamics of anopheline adult mosquitoes, their larval habitats, and egg survival potential during the dry season in the basin region of Lake Victoria, western Kenya. Through field surveys, we demonstrated two survival strategies of *An. gambiae* sensu stricto during the dry season: continuous reproduction throughout the year and embryo dormancy in moist soil for at least several days. We further demonstrated that *An. gambiae* shows a strong preference for moist soil as an oviposition substrate rather than dry soil substrate under the insectary conditions. The observation that anopheline eggs remain a dormant stage to resist desiccation clearly contrasts the conventional wisdom that anopheline eggs hatch shortly after they are laid. Our results from western Kenya are consistent with the suggestion that anopheline mosquitoes do not necessarily suffer a severe population bottleneck during the dry season and thus maintain a large effective population size.

Call No.: 00-1539

Mutero C.M., Blank H., Konradsen F. and van der Hoek W. (2000) **Water management for controlling the breeding of *Anopheles* mosquitoes in rice irrigation schemes in Kenya.** ***Acta Tropica*** **76, 253–263.**

ABSTRACT: An experiment to assess the impact of intermittent irrigation on *Anopheles* larval populations, rice yields and water use was conducted in the Mwea rice irrigation scheme in Kenya. Four water regimes including intermittent irrigation were tested in a complete randomized block experimental design. Intermittent irrigation was carried out on a weekly schedule, with flooded conditions from Saturday through Tuesday morning. Larval sampling at each plot was conducted every Monday and

prior to draining of intermittently irrigated subplots on Tuesday. All the adult anopheline mosquitoes emerging from larvae collected in the experimental plots were identified as being *An. arabiensis*. By far the highest numbers of an *An. arabiensis* 1st instar larvae were found in the intermittently irrigated subplots, indicating that the water regime provided the most attractive environment for egg laying. However, the ratio between the 4th and 1st instar larvae in the subplots was only 0.08, indicating very low survival rates. In contrast, the 4th / 1st instar ratio for subplots with other water management regimes ranged between 0.27 and 0.68, suggesting a correspondingly higher survival than observed with intermittent irrigation. The total number of 4th instars was almost the same in the intermittently irrigated subplots and the irrigation system normally practised by the farmers. The failure to eliminate larval development up to the 4th instar in the former method was attributed to residual pools of water. Larval abundance fluctuated throughout the 12-week sampling period. The highest larval densities were recorded in the 3 weeks after transplanting the rice seedlings. Afterwards, larval numbers dropped dramatically as the height of rice plants increased. Rice yields at harvest did not show statistically significant differences among subplots with different water regimes. The average yield per hectare ranged from 4.8–5.3 metric tonnes. The average daily water percolation/seepage rate was 3.6 mm and did not significantly differ among different water management regimes. Further research is necessary to, among other things, determine whether rice yields could be increased by having flooded and drained intervals that were different from those used in this study. It would likewise be important to assess on a wider scale the feasibility of implementing intermittent irrigation with respect to farmer acceptance and required changes in irrigation system design and management.

Participating scientists: J. Githure (Division Head), B. Knols, J. Beier, G. Yan, C. Mbogo, J. Shililu, L. Gouagna, R. Jackson, G. Killeen, J. Kealing, A. Hassanali, E. Osir, J. Ssennyonga, W. Lwande, F. Omlin, J. Moturu, A. Githeko, G. Rukunga, G. Mokoji, R. Novak.

Collaborators: IWMI; KEMRI; MoH, Kenya; UoN; JKUAT; Municipal Council of Kisumu; Municipal Council of Malindi (Kenya); Malaria Research and Training Centre, Mali; National Institute of Medical Research, Tanzania; Addis Ababa University, Ethiopia; Ministry of Health, Eritrea; Makerere University, Uganda; Institut Pasteur, Madagascar; Tulane University; University of Illinois; University of Washington; Harvard University; State University of New York; Michigan State University; University of Wageningen, Netherlands; University of Nijmegen, Netherlands; University of Sweden; Merlin (UK); BioVision; NIH, USA.

Donors: NIH, USA; WHO/MIM; IDRC; NSF, USA; Government of Finland; University of Aberdeen (UK); BiONET-Africa; ICIPE Core Fund donors (Danish International Development Agency, Swedish International Development Agency, Swiss Agency for Development and Cooperation, Government of Norway, Government of Finland, Government of France, Japanese Society for the Promotion of Science (JSPS), Government of Kenya).

2. Animal Health Division

INTRODUCTION

The Animal Health Division continues to develop and promote appropriate technologies for the sustainable management of disease vectors within sustainable farming systems in order to improve livestock health and productivity. Since over two-thirds of the population in the developing world are smallscale farmers, many of whom are dependant on livestock for their everyday survival, improvement of livestock health and productivity provides a significant opportunity to improve the livelihoods of these poor people and to allow them to escape the poverty trap. It is important to improve livestock productivity if the demands for increased livestock products are to be met and also to enhance traction power of oxen for improved agricultural productivity.

For over three decades, ICIPE has targeted its work on the management of blood-bleeding insects and other arthropods, many of which transmit debilitating or fatal diseases in livestock and in some cases, even in humans. For example, human sleeping sickness, with over 500,000 current cases, is transmitted by tsetse flies. Research is continuing on a range of activities from strategic to adaptive research, to generate technologies which will enable farmers to undertake better ecological management of major livestock disease vectors and help in intensifying and diversifying smallholders farming systems to generate more cash income and enhanced food security.

The emphasis has been on developing environmentally safe methods that can be applied together in a tailor-made, site-specific package. Components of such a package might include trapping enhanced by odour baits, biological control, and the use of repellents. For long-term sustainability, communities are involved at every stage of control operations, for example from planning to construction of traps, to monitoring and evaluation. It must be mentioned that ICIPE is one of the few organisations, despite constraints in funding, that continues to conduct research into the control of ticks and tick-borne diseases, in order to develop IPVM approaches which rely on environmentally friendly methods such as biological control; use of botanicals and anti-tick pasture plants; repellents; and behavioural modification of the cues ticks use to find hosts and mates.

The report below provides some highlights of our research into tsetse and ticks with the above objectives in mind.

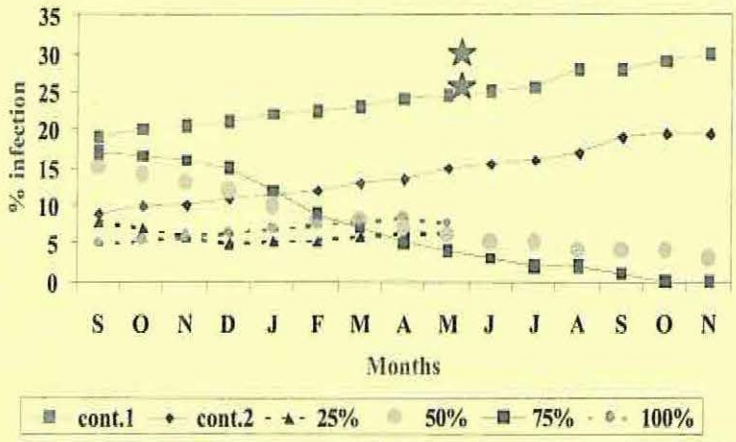
RESEARCH HIGHLIGHTS

A. Tsetse Research

1. Repellents for integrated control of tsetse

The Animal Health Division has identified a potent repellent for the tsetse fly species *Glossina pallidipes* and *G. morsitans morsitans*. The repellent has been shown to significantly reduce the tsetse challenge (> 80 %) and feeding efficiency (> 90 %) on cattle. It could be used in conjunction with other tsetse control tactics to protect livestock and reduce reliance on synthetic pesticides and the associated resistance development. Particularly promising is a 'push-pull' strategy that uses the repellent to 'push' the flies away from their hosts, in conjunction with baited traps/targets, which 'pull' and kill them. A variant of this technology might involve the use of a proportion of cattle herds with pour-on insecticide, to act as the 'pull' component. Tsetse repellents may also find application in the development of barriers that prevent flies from re-invading tsetse-free areas. A patent application for the repellent has been filed.

Under the IFAD-funded ILRI/ICIPE project titled 'Integrated approach to the assessment of trypanosomosis control technologies and impacts in tsetse-affected areas in Africa', a dispenser for the repellent has been developed and optimised and is ready for mass production.



* 25 and 100% of protected herds moved to Tanzania because of drought conditions

Fig. 1. Percentage infection in communal herds treated with tsetse repellent compared to untreated herds

It has been demonstrated that farmers can achieve maximum protection if the repellent dispensers are placed on the body of cattle near the forelegs. This has been accomplished by tying the dispensers with the help of a waistband of appropriate length around the neck of the cattle.

Preliminary results from field trials in Nguruman, Kenya, to evaluate the level of protection of cattle in communal herds treated with the repellent and to assess the level of augmentative suppression and protection of cattle with 'push-pull' tactic indicate that repellents can provide effective protection to cattle. The costs of chemotherapy can also be considerably reduced in protected herds (Fig. 1). Our experiments also suggest that not all cattle in a herd need to be protected. This is due to the diffusion properties of the volatile repellent, as a result of which untreated cattle in proximity to treated ones are also protected.

The 'push-pull' tactic is now ready for large-scale validation trials to adapt it to the needs and circumstances of the target livestock keepers including pastoralists. Appropriate strategies for the inclusion of the repellent technology as an important component of integrated control of trypanosomosis need to be formulated. The above forms the bases of a new ICIPE/ILRI/KETRI project to be funded by IFAD.

2. Entomopathogens for tsetse control

The possibility of using entomopathogens in the control of tsetse was investigated under the ADC-funded project 'Sustainable management of trypanosomosis and tsetse flies through a new concept: The lethal insect technique (LIT)'.

Based on earlier laboratory studies that showed that strains of *Metarhizium anisopliae* were promising candidates for the pathogenic control of tsetse, field trials were conducted on Chamarungo island in Lake Victoria with the following findings:

- Effective transfer of lethal doses of *M. anisopliae* conidiospores from contaminated donor flies to wild flies occurs in the field, but at low levels.
- In a preliminary trial, releases of marked *G. f. fuscipes* contaminated with *M. anisopliae* did not result in a significant decrease in wild *G. f. fuscipes* populations six weeks after releases stopped. However, a marked increase in flies on the control island during the final week was not matched by an increase on the test island.
- Mass-trapping of tsetse flies to monitor the incidence of *M. anisopliae* spores on flies in the field was unsuitable.
- Simple detection of fungus on the cuticle of individually trapped flies is not an indication of their eventual infection and death. However, detection of the fungus on individually collected tsetse does give an indication of contaminated fly activity and therefore, together with the colour marking technique, remains a useful investigative tool.
- The expected superiority of LIT over the sterile insect technique (SIT) was that, in the former technique, both sexes could be released, based on the assumption that all contaminated females would die before reproducing. However, some contaminated females appear to survive long enough to reproduce, and some individuals of both sexes may survive long enough to become disease vectors.

3. Tsetse repellents from un-preferred hosts

Gas chromatograph-electroantennogram detector (GC-EAD) comparisons of volatiles collected from [the tsetse-refractory] waterbuck, and buffalo and ox (tsetse hosts) were completed. Field studies with different blends of the compounds present in the volatiles are underway.

4. Characterisation of factors that influence vectorial capacity in tsetse flies

The Project's goals are the isolation and characterisation of the lectin-trypsin complex and

trypanolysin from the midgut of tsetse flies, and elucidation of the roles of these compounds in trypanosome differentiation and lysis. Characterisation of the genes encoding these molecules will also be done.

In 2000–2001, the following was achieved:

- Elucidation of the role of the lectin-trypsin complex in inducing transformation of bloodstream-form trypanosomes into procyclic (midgut) forms using procyclin immuno-flourescence assay.
- Trypanolysin shown to bind the variable surface glycoprotein (VSG) located on the surface of bloodstream-form trypanosomes.
- Screening of the tsetse midgut cDNA library using antibodies to the complex and cDNA probes undertaken, and is being studied further.

5. Use of ELISA for identification of bloodmeals in arthropods

The Project goal is to establish a bloodmeal identification service for arthropods at ICIPE. A reliable bloodmeal testing system (based on ELISA) was developed and validated for tsetse flies. Services are being offered to a number of outside collaborators.

6. The role of small ruminants and pigs in the epidemiology of nagana and sleeping sickness in western Kenya

The objective of this project is to investigate the involvement of sheep, goats and pigs in the epidemiology of trypanosomosis (human and animal) in western Kenya. Four hundred and eight animals from three villages with documented cases of sleeping sickness were sampled. The main pathogenic species of economic (*Trypanosoma congolense*, *T. vivax* and *T. simiae*) and medical (*T. brucei*) importance have been detected using PCR.

7. Strengthening community capacity for self reliance for financing and managing tsetse and trypanosomosis in Lambwe Valley

Tsetse and trypanosomosis, which affect both humans and livestock in the Lambwe Valley of Suba District in western Kenya, have resisted all conventional control methods in the past. However, the KISABE community, relying on its own financial and management resources with technical support from ICIPE and Kenya Government ministries used a low-cost, NGU tsetse trap developed by ICIPE to suppress the tsetse population by 99.9% in an area of 100 km² straddling the southern end of Ruma National Game Park. This led to the reduction of the trypanosomosis challenge from 200 in 1993 to nil in 1997. Two key issues remained largely unresolved: First, the community had raised funds through household capitation, registration and self-help (*harambee*). There was doubt whether fundraising through solicitation would be sustainable in the long term. Second, free-riders who did not invest in the tsetse control could not be excluded from enjoying its benefits.

In an effort to solve these twin problems, KISABE developed a project that integrates tsetse control into three income-generating activities (IGAs), which enable the community to finance tsetse control and other household needs on a sustainable basis. 'Free riders' are given incentives to participate in both tsetse control and three IGAs: (a) apiculture, (b) processing edible oil from sunflower seeds grown locally, and (c) sericulture.

The UNDP provided funding and subcontracted ILO to implement the project. ILO also subcontracted ICIPE to train KISABE farmers in apiculture and sericulture. Appropriate Technologies for Enterprise Creation (ApproTec), an NGO, would sell two manually operated oil seed processing presses to KISABE and train its members to operate and maintain them.

The specific objectives were:

- KISABE would implement the IGAs and would allocate part of the income from IGAs to tsetse and trypanosomosis control.
- Farmers would improve the nutritional status of their livestock by feeding them the left-over cake from sunflower seed processing.
- Participation would enable the community to acquire entrepreneurial skills, enabling it to directly increase income from value-added products.
- ICIPE would evaluate the technical, economic and social performance of the technologies under end-users' management.

In the period 2000–2001, the following was achieved:

- A month-long training of four farmers was delivered by ICIPE. The trained farmers have subsequently trained 31 farmers in apiculture and sericulture. ApproTec has trained 18 farmers in the management of oilseed processing.
- The farmers are producing sunflower seeds, and processing and marketing edible oil from them. Implementation of sericulture and apiculture is still slow.
- Tsetse control. The delay by ILO to remit donor funds to KISABE forced the community to use their own resources to start the IGAs, virtually halting all trapping activities between May 2000 and April 2001, leading to a resurgence of tsetse flies. Trapping resumed in May 2001 with the acquisition of 165 traps (115 from own resources, 50 from the Government) of which 107 were distributed to 13 blocks (2 blocks were excluded). But, by December 2001 only 67 traps had been laid. Wrangles related to the complaints about the way sunflower oil processing (SOP) is managed have also led to the decline in labour allocation to trapping. Remarkably, KISABE has allocated very little money earned from SOP to tsetse control.

- What is more, due to the total collapse of tsetse control in Ruma National Game Park (RNGP) since 1996 by the Kenya Wildlife Service (KWS), a massive build-up in tsetse population has been reported and alleged to cause loss of livestock. Corroborating evidence is the report by KISABE of a catch of over 200 tsetse flies per trap per day along the boundary with RNGP. ICIPE ceased monitoring tsetse and trypanosomosis in January 2000 at the completion of the IFAD-funded project. However, ICIPE, through this present project, is encouraging KISABE to put more resources into tsetse control.
- Evaluations done:
  - organisational and management structures have been evaluated;
  - labour and land allocation has been monitored;
  - economic analysis of oilseed processing has been carried out.

8. Evaluation of community participation in the management of tsetse, trypanosomosis and related rural development projects in tsetse-controlled areas of Africa

In recognition of the lack of a methodology for monitoring and evaluation of community participation in the development and transfer of technology in general and tsetse/trypanosomosis control (TTC) in particular, FITCA management subcontracted ICIPE to train country project implementers (CPIs) in the use of a methodology for monitoring and evaluating community participation in tsetse control and related rural development projects. The CPIs would in turn train farmers in the application of the methodology. Due to delays in implementing FITCA programmes in Uganda, this work has been carried out in the Kenya country programme only. Active involvement of farmers started in June 2001 in Teso and Busia Districts and has since progressively reached the other three districts in the workplan.

The objectives are to:
- quantify the activities that end-users perform;
- determine what difference participation makes to the achievement of FITCA objectives;
- estimate the cost of participation to end-users and the project;
- provide information for planning the gradual transfer of the technology to end-users and responsibility for managing and financing them.

Research is in progress to:
- determine the seven major project components (interventions) and the activities farmers are expected to perform and the frequency with which they are performed;
- determine the geographical areas (districts, divisions and villages) where the various activities are being implemented and the characteristics of participants by age, gender, socioeconomic strata, etc.;
- determine farmers' contribution in terms of money, labour/time and materials;
- determine expected and actual material and social benefits from the various interventions;
- assess the performance of the various participants (households, individuals, gender, villages etc.) by CPIs and, later, by end-users;
- identify the constraints to participation at the various levels by CPIs and, later, by end-users;
- enter and analyse data and dissemination of results.

9. Capacity building

An international group training course on tsetse management was held from 11 September to 6 October, 2000. This course, sponsored by the Netherlands DSO project, was attended by 18 participants from 12 African countries. The resource persons were derived from ICIPE, ILRI, KETRI and FITCA.

A PhD was awarded in 2001 on the topic 'Semiochemical basis of feeding preferences on waterbuck *Kobus defassa*, buffalo *Syncerus caffer* and ox by some *morsitans* group of tsetse' and another student is working on integrated use of synthetic and natural repellents for tsetse management. Two papers were published on tsetse research and a series of invited lectures delivered at the invitation of WHO.

B. Ticks Research

1. Field evaluation of botanical extracts for tick control

The ability of *Ocimum suave* to control a number of tick species has been previously demonstrated. The aim of this study was to establish the application regime of *O. suave* oil under field conditions. The study, involving 64 animals, was carried out at Kuja River field site (South Nyanza). Two concentrations of the oil (10 and 20%) were sprayed either weekly or after every 2 weeks. In the one control, the animals were not sprayed, while in the other, they received weekly applications of the acaricide, Triatix® (0.2%).

The following was found:
- The 10% oil concentration killed 100% of on-host ticks at the time of application and protected the animals from further infestation for 4 to 5 days. The 20% oil gave similar results as the 10%, but caused severe irritation to the animals' skin.
- The chemical acaricide Triatix® killed all the on-host ticks and protected the animals for 7 days.

2. Natural enemies

As part of the JIRCAS project, work on the ecology and behaviour, and especially the signals associated with the foraging behaviour of the hymenopteran

wasp *Ixodiphagus hookeri*, which parasitises the tick *Amblyomma variegatum*, has been initiated. The work will continue during 2002.

3. Use of entomopathogenic nematodes for tick control

Four nematode isolates were obtained from soil samples from various locations in Kenya. The pathogenicity of these isolates against fed and unfed *Rhipicephalus appendiculatus* and *Amblyomma variegatum* was tested in the laboratory and under semi-field conditions.

Two of the isolates (Kiumba and Shauri Yako) were found to be highly pathogenic to both tick species. The effects of different soil types (red soil, loam, manure and sandy soil) on infectivity of the nematodes was examined. With the exception of sandy soil, the other soils did not affect the infectivity of the nematodes. In sandy soil, infectivity was reduced by 20%. However, this is probably due to rapid loss of moisture from sandy soil, which in turn affects the viability of the nematodes.

The effects of two common chemical acaricides (Triatix® and Stelladone®) on the nematodes were examined at two dosages: normal and twice the recommended concentrations. The nematodes were not affected by the acaricides even after exposure for 24 and 48 h.

In a preliminary study carried out under semi-field conditions, the nematodes were found to be capable of infecting both tick species and causing up to 80% mortality. However, soil moisture level determines the success of infection.

4. Capacity building

An ARPPIS student is being trained on on-host and off-host behavioural manipulation studies of *Amblyomma variegatum*. One research paper on ticks has been published.

FUTURE OUTLOOK

1. Tsetse research

New projects on tsetse starting in 2002 include the following:

- Collaborative work with ILRI and KETRI to:
  - further refine the tsetse repellent technology, including evaluating other repellents and designing better deployment techniques for long-term use;
  - evaluate repellents as a component of integrated control strategies, particularly in conjunction with trypanocidal drugs and traps/targets or 'live baits' as part of a 'push-pull' tactic;
  - assess the potential adoption of repellent-based technologies among pastoralists and agro-pastoralists in Kenya through on-farm trials and economic impact assessments;
  - identify and evaluate options for viable commercial production of the repellent and its delivery to livestock keepers;
  - create awareness and train NARS personnel, livestock health service staff and farmer groups in selected countries to support uptake of the repellent technology.
- Large-scale validation trials for the 'push-pull' tactic for tsetse control in Mozambique, Tanzania and possibly Rwanda and Ethiopia.
- Biochemistry and biotechnology research will be conducted on tsetse, including work on:
  - expression of recombinant lectin and trypsin genes in permissive eukaryotic hosts;
  - screening midgut cDNA library for trypanolysin gene and studying its expression;
  - comparison of expression levels of these molecules in susceptible and refractory tsetse fly species;
  - analysis of tsetse blood meal samples from the University of Addis Ababa, Ethiopia;
  - identification of alternative bloodmeal sources for tsetse in selected game ranches, where cattle are treated with pyrethroid based pour-ons for tsetse control (collaboration with KETRI);
  - genotyping *T. brucei* isolates to evaluate similarity with human infective strains (using microsatellites and minisatellites and the serum resistance associated gene (SRA): Thesis preparation.

2. Ticks research

Research on ticks will seek to:

- Evaluate the efficacy of different formulations of the *O. suave* oil against ticks in the field;
- Evaluate the efficacy of a mixture of oils from *O. suave* and *O. kilimandscharicum* in the field;
- Characterise nematode isolates that have shown potential for tick control;
- Evaluate the efficacy of these nematodes under field conditions;
- Survey plant products in Bungoma district used for traditional on-host control of *R. appendiculatus*. On-host studies will integrate selected botanicals (tick repellents, acaricides) with feeding site location behaviour of the adult tick in 'push' and 'push-pull' tactics (an ARPPIS PhD project);
- Continue work on the foraging behaviour of *Ixodiphagus hookeri* on *Amblyomma variegatum*.

Livestock ticks projects in Senegal and Burkina Faso will be carried out. Supported by ADB, the goal of the projects is to improve food security by increasing animal production. Proposed activities for projects in both countries include:

- A survey in the project areas of ticks species, distribution, animal hosts and tick-borne diseases;
- Evaluation of the effectiveness of current methods

used for tick control;
- A survey of local anti-tick botanicals;
- Testing the efficacy of different formulations of these botanicals (application regimes, dispensation methods) under laboratory and field conditions;
- Capacity building activities.

A joint project between Instituto Nacional de Investigaçao Veterinaria (INIVE, Mozambique) and ICIPE titled 'Capacity building, technology optimisation and transfer for animal health improvement in Mozambique'. The project is on management of ticks and tick-borne diseases. A proposal for funding has been submitted.

A Millennium Science Initiative project on 'Developing a node in integrated control of important tropical disease vectors' will be developed.

Tropical vector genomics initiative in collaboration with TIGR will be pursued.

COMPLETED STUDIES (Abstracts of papers in refereed journals. For full list see Publications List)

Call No.: 01-1593

Hariyama T. and Saini R.K. (2001) **Odor bait changes the attractiveness of color for the tsetse fly.** *Tropics* **10(4), 581–589.**

ABSTRACT: The color choice behavior of the tsetse fly with odor bait and without odor bait was investigated in the field in Nguruman, Kenya. Traps were made using a mixture of blue and green pigments in different ratios and then checked for their trapping efficiency. The effects of color in trapping without odor bait was the same as previous reports, i.e. more flies are attracted by blue compared with other colors. Trapping efficiency was generally augmented when odor bait was used. However, trapping efficiency decreased when odor was presented with a pure blue cloth and increased at the blue-green cloth. It is concluded that blue-green cloth is the most useful material from which to make traps in order to control the tsetse fly, and thereby the incidence of sleeping sickness.

Call No.: 01-1588

Ndegwa P.N., Mihok S. and Oyieke F.A. (2001) **Habitat preferences and activity patterns of *Glossina swynnertoni* Austen (Diptera: Glossinidae) in Aitong, Masai Mara, Kenya.** ***Insect Science and Its Application*** **21(2), 113–122.**

ABSTRACT: The habitat preferences and activity patterns of *Glossina swynnertoni* Austen were studied using Siamese traps, electrified screens and vehicle patrols in Aitong, southwestern Kenya in three habitats: large thicket, wooded grassland and an *Acacia* community. Except in the *Acacia* community, *G. swynnertoni* occurred in association with *Glossina pallidipes* Austen. Apparent density varied significantly among the three habitats, being highest in the *Acacia* community, intermediate in wooded grassland and lowest in large thickets. Density also varied seasonally, with higher densities occurring in the rainy season than in the dry season in all three areas. Vehicle patrol was a more effective and rapid method for sampling *Glossina swynnertoni* than either Siamese traps or electrified screens. However, vehicle patrol catches were strongly biased in favour of males (4:1). Diurnal activity in the *Acacia* community was unimodal for both sexes, with peaks of activity occurring at 1100–1200 h for males and at 1400–1500 h for females. Both sexes remained active in the afternoon but activity declined rapidly towards dusk (1700–1800 h).

Call No.: 01-1592

Odulaja A. and Mohamed-Ahmed M.M. (2001) **Modelling the trappability of tsetse, *Glossina fuscipes fuscipes*, in relation to distance from their natural habitats.** ***Ecological Modelling*** **143, 183–189.**

ABSTRACT: The log–logistic probability distribution function was employed to model trappability of *Glossina fuscipes fuscipes*, with respect to distance from the edge of two types of habitat. The parameters of the model were obtained using the nonlinear maximum likelihood approach. Asymptotic standard errors of the maximum likelihood estimates were computed for the parameters, and the χ^2 goodness-of-fit test used to assess the predicted trap catches. Simulation technique was used to estimate the radius of attraction of the unbaited biconical trap for the fly, taking the efficiency of the trap into consideration. The log–logistic model fitted well to a series of observed field data. The model enabled the estimation of optimum trapping distances from the different habitat types for *G. f. fuscipes*. There is an indication that flies were attracted to, and got trapped optimally with, unbaited biconical traps, at distances that are characteristic of both sex of the fly and the type of habitat.

Call No.: 01-1571

Odulaja A., Baumgärtner J., Mihok S. and Abu-Zinid I.M. (2001) **Spatial and temporal distribution of tsetse fly trap catches at Nguruman, southwest Kenya.** ***Bulletin of Entomological Research*** **91, 213–220.**

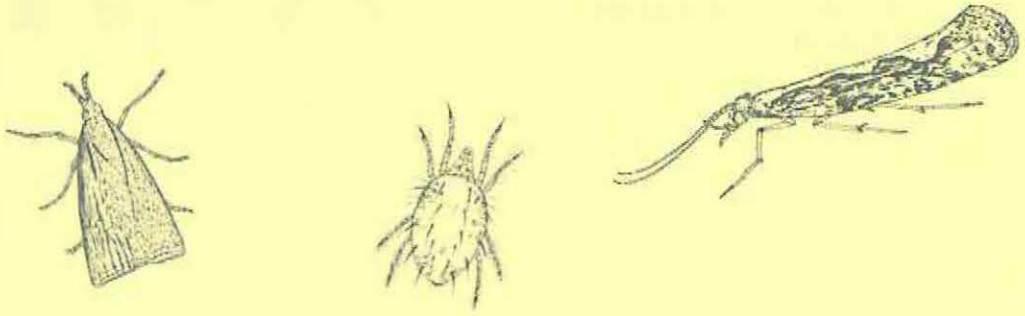
ABSTRACT: Spatial and temporal dynamics of rapidly growing populations of tsetse flies at Nguruman, southwest Kenya during 1993–1995, were investigated, following six years of intensive population suppression with traps over a *c.* 100 km^2 area. The two tsetse species present were randomly distributed in the short rainy season, but were aggregated in the dry and long rainy seasons. Maximum temperature was the dominant weather factor associated with the degree of aggregation. Trends in catches at 20 fixed sites along an 18 km north–south axis were weakly correlated between locations, possibly representing population sub-structuring. In particular, trends in population change were poorly correlated between the area with a long history of trapping suppression in the south and the area with a more recent history of suppression in the north. On a micro-geographic scale, correlations among paired trap catches were clearly related to geographical proximity for *Glossina pallidipes* Austen (r^2 = 0.55); whereas this relationship was quite weak for *Glossina longipennis* Corti (r^2 = 0.12). Positive correlations among trap catches were significant for sites separated by less than *c.* 3.8 km (*G. pallidipes*) or 4.8 km (*G. longipennis*). These results suggest the existence of different population substructures in the two species on a relatively small geographic scale.

Participating scientists: R. K. Saini (Division Head), J. W. Ssennyonga, J. C. Mulindo, E. Osir, N. Maniania, D. Nadel, A. Odulaja.

Collaborators: Inter-African Bureau for Animal Resources (IBAR); Ministry of Agriculture, Livestock Development and Marketing (Kenya); Ministry of Agriculture, Livestock Development and Fisheries (Uganda); ILO; ApproTec; KISABE Community; ILRI; KETRI; KWS; FAO; WHO; Kimron Veterinary Institute (KVI), Israel; KARI National Veterinary Research Centre (NVRC), Kenya; Instituto Nacional de Investigaçao Veterinaria (INIVE, Mozambique); Senegalese Institute for Agricultural Research (ISRA); Directorate of Veterinary Services (Burkina Faso); BiONET-Africa.

Donors: UNDP/ILO; IFS; IFAD; Austrian Development Corporation; TDR/BiONET-Africa; European Commission/FITCA/OAU/IBAR; ADB; CDR/AID; JIRCAS; European Union (EU); ICIPE Core Fund donors (Danish International Development Agency, Swedish International Development Agency, Swiss Agency for Development and Cooperation, Government of Norway, Government of Finland, Government of France, Japanese Society for the Promotion of Science (JSPS), Government of Kenya).

3. Plant Health Division



I. STAPLE FOOD CROP PESTS SUB-DIVISION

INTRODUCTION

Stemborers are the major insect pests of cereals in many areas of eastern and southern Africa. At least four species infest maize in the region, with yield losses reported to vary from 20–40% depending on agroecological conditions, crop cultivar, agronomic practices and intensity of infestation.

Parasitic weeds in the genus *Striga* infest 40% of the arable land in the savanna region, causing an annual crop loss of 7 to 13 billion dollars. Around the Lake Victoria basin, infestation by *Striga hermonthica* causes 30 to 100% loss in maize yield. Striga infestation is associated with increased cropping intensity and declining soil fertility. Infestations by *Striga* spp. have resulted in the abandonment of much arable land by farmers in Africa, and the problem is more serious in areas with low soil fertility and rainfall.

Spraying for stemborer control with pesticides is not only expensive and harmful to the environment, but also is usually ineffective, as the chemicals cannot reach the larval stages that reside inside the stem. On the other hand, weeding—the conventional method for striga control—is both time-consuming and labour-intensive.

It is estimated that preventing crop losses from stemborers and striga weeds could boost maize harvests enough to feed an additional 30 million people in the region.

The 'push-pull' habitat management approach—developed by ICIPE in partnership with several institutions including the Kenya Agricultural Research Institute (KARI), the Kenya Ministry of Agriculture, and the Institute of Arable Crops Research, Rothamsted, UK—exploits chemical ecology and biodiversity in a novel manner to limit crop losses to stemborers and striga weeds. At the same time, it conserves soil and water while preserving biodiversity.

The approach involves trapping stemborers on highly susceptible trap plants (the pull) and driving them away from the maize crop using repellent intercrops (the push). Plants which repel stemborers as well as inhibit striga have also been identified. On-farm trials with farmers in Kenya have confirmed that these approaches, conducted separately and together, result in significant yield increases.

A major accomplishment of **Biological Control of Cereal Stemborers in Subsistence Agriculture in Africa** project during the 2000–2001 period was the evaluation of the impact of a parasitic wasp, *Cotesia flavipes*, introduced by ICIPE in 1993 on stemborer populations in southeastern Kenya. Our analysis indicates that the parasitoid has decreased the stemborer population by 30–50%, which, coupled with work conducted on crop losses caused by stemborers, suggests a maize yield increase of about 8–10%. Additionally, we now have evidence that *Co. flavipes* is established in several countries beyond Kenya, including Tanzania, Uganda, Malawi, Mozambique, Zanzibar and Ethiopia. An important activity over the coming years will be to conduct impact assessment in these countries as well.

A second parasitoid of *Chilo partellus*, one of the most important borers in the eastern and southern African region, has been imported into Kenya, and we believe that it will result in additional mortality to stemborers. Host-range testing of this new parasitoid, *Xanthopimpla stemmator*, has shown that it can successfully parasitise four of the major stemborer species found in eastern and southern Africa. The project was evaluated by an external team in early 2001, and the team recommended that the Netherlands Government continue providing support. As such, a new 4-year project was approved for 2002 to the end of 2005.

Other projects in this sub-division are looking at the impacts of genetically modified maize, and control of pests of banana (*Musa* spp.).

RESEARCH HIGHLIGHTS

A. 'Push-Pull' Strategies for the Management of Stemborers and Striga Weed in Maize-Based Farming Systems in Eastern and Southern Africa

The plants that are used as trap or repellent plants in a push-pull strategy are Napier grass (*Pennisetum purpureum*), Sudan grass (*Sorghum vulgare sudanense*), molasses grass (*Melinis minutiflora*) and silver leaf desmodium (*Desmodium uncinatum*). Napier grass and Sudan grass have shown potential for use as trap plants, whereas molasses grass and silverleaf desmodium repel ovipositing stemborers. Molasses grass, when intercropped with maize, not only reduces infestation of the maize by stemborers, but also increases stemborer parasitism by a natural enemy, *Cotesia sesamiae*. In addition, *Desmodium*, when intercropped with maize, inhibits striga. All four plants are of economic importance to farmers in eastern Africa as livestock fodder and have shown great potential in stemborer and striga management in farmer participatory on-farm trials.

In addition, the habitat management approach reduces soil erosion (via the cover crop of *Desmodium*) and increases soil fertility (via its nitrogen-fixing properties). The full integration of several crop protection approaches in the push-pull management system (i.e. trap crops and increased parasitism of pests), prevents high selection pressure on any single approach, thereby creating a sustainable system by preventing the rapid development of resistance or adaptation by pests; this is a common problem with single control measure, such as the use of pesticides or genetically-based resistance.

The farmers' feedback is highly positive, particularly among those who maintain improved

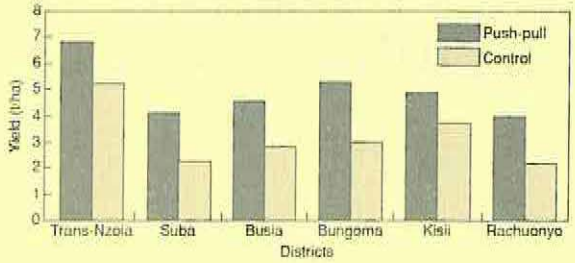


Fig. 1. Average increase in maize yields in 'push-pull' fields in six districts of western Kenya in 2001

dairy cattle, as they readily see the advantages of combining maize and forage production systems. Transfer of the push-pull technology is being expanded into Uganda, Ethiopia and Malawi.

1. Level of participation

The 'push pull' approach is being tested by more than 600 farmers in Trans-Nzoia, Suba, Busia, Bungoma, Kisii and Rachuonyo districts of western Kenya. The numbers of farmers participating in field trials has increased steadily in the past two years.

2. Food security

Intercropping or mixed cropping of maize, grasses and fodder legumes has enabled farmers in the study areas to increase crop yields and has thus contributed to improved food security (Fig. 1).This feature is in keeping with the mixed farming systems prevalent in eastern and southern Africa.

3. Dairy and livestock production

'Push-pull' strategies have contributed significantly —especially on small farms—to increased livestock production (milk and meat) by availing more fodder

This Kenyan farmer has been able to double her maize yield and grow forage for her improved cattle by using the 'push-pull' strategy.

and crop residues. For example, in Suba District of western Kenya, which produces 6 million litres of milk against an estimated annual demand of 13 million litres, the majority of cattle are indigenous (Zebu). In this district, a major constraint to keeping improved dairy cattle for milk production is the inadequate supply and seasonality of feed, often of low quality. 'Push-pull' strategies, adopted by 150 farmers in this district, have increased livestock feed supply and milk production measurably.

4. Exploiting biodiversity

The 'push-pull' approach embodies maintenance of species diversity through intercropping with different plants as a means of avoiding the pest problems usually associated with monocultures. It is well established that wild host plants on uncultivated land adjacent to crop fields are important refugia for natural enemies as well as sources of nectar, pollen, and host/alternate prey.

Although the effectiveness of the 'push-pull' strategy in controlling stemborers had been demonstrated, there was lack of information on its impact on stemborer predators. Our studies show that [mainly generalist] predators are significantly more abundant in push-pull intercrops than in maize monocrops. The predator complex included ants, spiders, earwigs and cockroaches. Other taxa were also recovered, although in relatively lower numbers. They included coccinellids, staphylinids, reduviids, nabiids and gryliids. These predators are crucial pest population regulators. Stemborer populations were conspicuously lower in 'push-pull' fields than in maize monocrops. The pest management potentials of 'push-pull' through enhancement of stemborer predator numbers was demonstrated in this study (Fig. 2).

5. Income generation and gender empowerment

The 'push-pull' strategy has contributed towards raising smallholder farmers' incomes through sale of farm grain surpluses, fodder and *Desmodium* seed, and to the empowerment of the Women, Farmers' and Youth groups.

6. Ethiopia, Malawi and Uganda

The 'push-pull' technology is being introduced in Ethiopia, Malawi and Uganda. Planning workshops, exchange of scientists and technical staff, and establishment of field experiments were initiated with selected farmers in close collaboration with national scientists and extension staff.

Ethiopia

A planning workshop in Makelle, Ethiopia was organised on 28 and 29 August 2001 to review the stemborer and striga problems in cereal-based farming systems in Ethiopia. More than 45 scientists

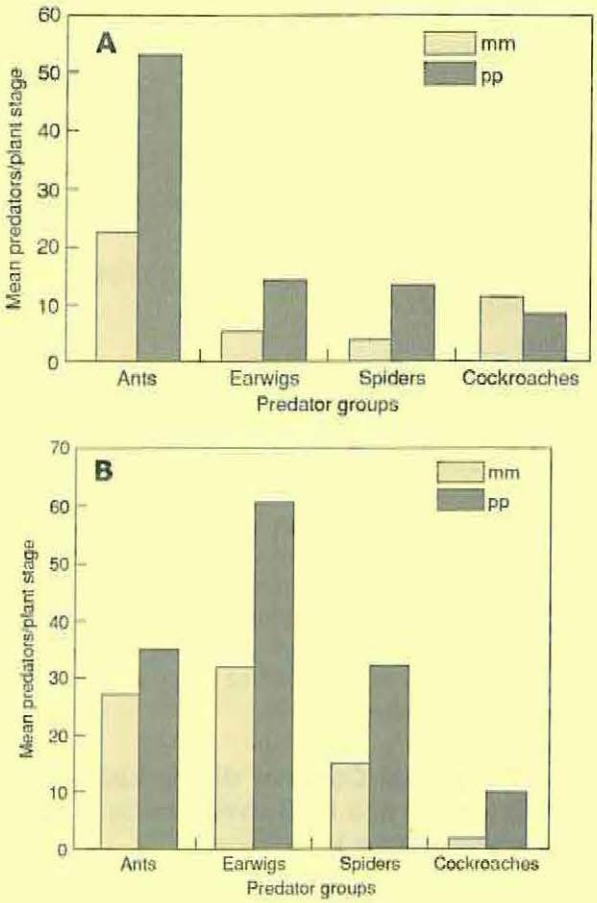


Fig. 2. Average number of stemborer predators at the (A) vegetative, and (B) mature stage of maize plants in maize monocrops (mm) and 'push-pull' (pp) fields in Lambwe

and extensionists from different parts of Ethiopia held a 2-day discussion with representatives of ICIPE, Kenya Agricultural Research Institute and the Ministry of Agriculture and Rural Development (Kenya). The Ethiopian delegation agreed that the technology could find an important place in the management of striga and stemborers in their country, with appropriate adaptations. It was agreed that a substantive research project will be developed and field trials will start in early 2002. A proposal is now ready for discussion and finalisation. Two Ethiopian scientists also visited ICIPE in July 2001 to familiarise themselves with the strategy.

Malawi

A planning workshop of 15 scientists from Malawi, ICIPE, and IACR-Rothamsted was held on 4–5 October 2001 at Bvumbwe Research Station, Limbe, Malawi to discuss plans to undertake 'push-pull' research and validation of trials under Malawian conditions. It was agreed that field trials should start in late 2001 in Limbe area. With the help of ICIPE technical staff, 10 farmers in Limbe were selected and field trials were initiated in November 2001. On-station trials for training and demonstration are also planned at both Bvumbwe Research Station, Limbe and Chitedze Research Station, Lilongwe.

Uganda

On-station trials were conducted in 2001 in collaboration with scientists from the National Agricultural Research Organisation (NARO). The Ugandan Project is selecting appropriate trap and repellent plants for stemborer control and conducting on-farm trials with 30 farmers in three locations.

7. Mechanism of *Striga* suppression by *Desmodium*

An allelochemical mechanism (seed germination with haustorium inhibition) was shown to play a significant role in *Striga* suppression by *Desmodium*. Five to six compounds of a complex blend from *Desmodium* root exudate were identified, some with germination-stimulation and some with haustorium-inhibition activities. Other haustorium-inhibiting components present in the polar fraction of the exudates are being isolated for characterisation and bioassays. This will constitute a basis for introducing *Desmodium* traits responsible for *Striga* suppression into food legumes and maize.

B. Biological Control of Cereal Stemborers in Subsistence Agriculture in Africa

1. Impact assessment of an exotic parasitoid on stemborer (Lepidoptera) population dynamics in Kenya

A ratio-dependent host-parasite interaction model with a linear trend was developed to analyse the impact of the exotic parasitoid, *Cotesia flavipes*, on stemborer population dynamics in the southern coastal area of Kenya. The time-dependence of the host, and between the host and the parasitoid, were tested by using autocorrelation and cross-correlation functions. The results indicated that the suppressive impact of the parasitoid on stemborer densities began in the short rains season of 1997–1998 in the northern part of the coast zone, but was only seen in the southern part of the coast from the long rains season of 1999. The reduction in density of the exotic stemborer, *Chilo partellus* by *Co. flavipes* was about 1 larvae per plant, or a 52% decrease.

Cotesia flavipes, a tiny wasp parasitoid introduced to control Chilo partellus, *is now reducing the density of these stemborers by 50 % in some locales.*

2. Relationship of maize yields to stemborer damage and plant physical condition

A field survey of stemborers, stemborer damage, maize plant physical condition, and maize yield was conducted in eastern Kenya under natural conditions. The results indicated that stemborer damage directly reduced maize yield, with tunnel length of greater than 20 cm causing a 40% reduction of potential yield. More than one stemborer exit hole caused 33% loss of potential yield. Multiple regression results implied a 13.3 ± 1.5 g yield loss (8–10% of potential yield) due to the damage of a single stemborer.

3. Spatio-temporal population dynamics of *Cotesia flavipes* (Hymenoptera: Braconidae) in Kenya

The spatial-temporal population dynamics of the imported parasitoid, *Cotesia flavipes* were analysed. A two-step spatial interpolation method was developed for interpolating the distribution of *Co. flavipes* in Kenya. The results indicated that *Co. flavipes* has spread from the coast to the whole southern part of Kenya and northern part of Tanzania, and parasitism by *Co. flavipes* in maize fields is still increasing. The maximum site-specific stemborer parasitism by *Co. flavipes* reached 68% in the long rains of 1999. The mean stemborer parasitism varied from region to region, with the highest parasitism (16%) in the southeastern area during the long rains of 1999, and the lowest parasitism in central Kenya (2%). The distribution of *Co. flavipes* expanded tremendously after the long rains of 1997.

4. Ecological effects of the introduction of the exotic parasitoid *Co. flavipes* on non-target Lepidoptera in Kenya

The aim of this study was to generate information on the potential ecological impacts of the introduction of *Co. flavipes* in Kenya on non-target Lepidoptera. The attraction of the exotic parasitoid, and the acceptance and suitability of selected Lepidoptera species for its development were investigated in the laboratory, and field-collected Lepidoptera larvae were examined for parasitisation by *Co. flavipes*. The non-target lepidopteran larvae used for the laboratory study included *Galleria mellonella, Charaxes cithaeron, Bombyx mori,* and *Eldana saccharina*. The target hosts, *Chilo orichalcociliellus* and *Ch. partellus*, were used as controls. Results show that when maize is infested with *Ch. partellus*, the target host, it is significantly more attractive than the other food sources infested with their hosts. Only small butterfly

larvae were accepted for oviposition, but no parasitoids developed in these larvae.

Field surveys were conducted from June to December 2000 in coastal Kenya where *Co. flavipes* is established. A variety of non-target Lepidoptera larvae were collected, brought to the laboratory and reared until adult emergence or host death. Parasitoids emerging from these larvae were kept for identification. Results indicated that out of more than 4000 larvae collected, none produced *Co. flavipes*. These studies provide strong evidence that *Co. flavipes* does not have a negative impact on non-target Lepidoptera.

5. Variation in encapsulation sensitivity of *Cotesia sesamiae* biotypes to *Busseola fusca*

Previous studies have revealed that in Kenya there are two biotypes of *Cotesia sesamiae* that differ in their ability to develop in the stemborer *Busseola fusca*. The biotype of coastal Kenya (M) is not able to develop in larvae of *B. fusca*, whereas the inland biotype (K) can develop in *B. fusca*. The genetic transmission of the wasp's ability to suppress the immune system of *B. fusca* was investigated using two inbred lines from the immune-suppressive and non-suppressive populations. Hybrid wasps with parents from the two populations did not develop in *B. fusca*. In a second backcross with the hybrid mother of KMK to K, encapsulation was reduced compared to F_1 hybrid mothers. Subsequent hybrid mothers with KMKKK showed further reduction of encapsulation. Continuous introgression of the K genome into the M background eventually cancelled the M factor that contributes to encapsulation in this host. If the encapsulation response of the host were completely mediated through only the activity of the polydnavirus, then we would have expected that the females' genotype would completely determine the level of encapsulation. (Her genotype does not change in response to the male she mates with). However, if the genetic makeup of the eggs of the wasp is also important, then we would expect the offspring of those females mated with K males to experience lower levels of encapsulation. In those cases where both type of crosses were done, the results showed that the offspring of females mated to K males did indeed survive better. It is therefore suggested that some egg characteristics, such as surface proteins, could play a role in the encapsulation response of the host, even in the presence of a functional polydnavirus.

6. Development of *Xanthopimpla stemmator* in various cereal stemborers

Xanthopimpla stemmator is an exotic pupal parasitoid of cereal stemborers that was recently imported into Kenya for evaluation. Host range tests were conducted with four important cereal stemborers: *Busseola fusca, Chilo partellus, Sesamia calamistis* and *Eldana saccharina*. Acceptability was evaluated by counting the number of probe wounds made by the parasitoid. Results indicate that all stemborers are equally acceptable hosts. The different age groups tested also were acceptable. *Xanthopimpla stemmator* was also able to develop in all host age groups except for day 6 for *E. saccharina*. Wasps emerging from *B. fusca* were significantly larger than the rest. In summary, these results indicate that *B. fusca* is the best host for the development of *X. stemmator*, even better than its old association host *Ch. partellus*. Thus, *Xanthopimpla* appears to be a good candidate for the control of three species of stemborers, particularly *B. fusca*, a major pest in some areas but which is not controlled by *Cotesia flavipes*.

7. Impact of vegetation on stemborers and their natural enemies

A field study was conducted in 1998/99 to examine the influence of vegetational diversity around maize fields on the abundance of stemborers and stemborer natural enemies in maize. This data was reanalysed during the first half of 2001. The results indicate that the number of neighbouring maize fields around the experimental field positively affect the maize infestation rate by stemborers and also increase stemborer densities in the experimental field. The intensity of this effect is dependent upon the phenological stage of the maize. Forested areas around maize fields significantly reduce stemborers and stemborer larval parasitism.

Specific grass species were classified into four groups based on their effect on the borers and their parasitoids. One cluster contained grasses which reduce stemborer densities in maize fields and included *Echinochloa haploclata, Sorghum verticilliflorum*, and *Hyparrhenia rufa*. A second group increases stemborer densities and consisted of *E. pyramidalis, H. nyassae, S. aethiopicum, Pannicum maximum*, and *S. arundinaceum*. A third group includes *Pennisetum purpureum, H. dissolula* and *Rottboellia exalta*, which have a positive effect on both stemborer abundance and parasitism. The last group of grasses have little or no effect on both stemborers and their parasitoids. Our results on the relationships between grass abundance and stemborers occurrence can be used in the development of habitat management programmes for stemborer control. (*See also the previous report on Habitat Management*).

8. Biodiversity, abundance and bitrophic interactions between stemborers and parasitoids in coastal Kenya

Field data on parasitioid diversity collected in southern coastal Kenya from 1992–1999 were summarised. The stemborers included three native species, *Sesamia calamistis, Busseola fusca, Chilo*

orichalcociliellus, and one exotic borer, *Chilo partellus*. A total of 174,663 individuals were collected, of which 12,645 were found to be parasitised. The parasitoids belonged to 40 species in 11 families and two orders. Among the 40 species, 20 were larval, 10 pupal, four egg, one egg/larval, two larval/pupal, and three were hyperparasitoids. The highest number (26) of parasitoid species were reared from the exotic borer, *Ch. partellus*, indicating a rapid accumulation of native parasitoids on the alien borer. The four most abundant parasitoids were the larval parasitoids *Cotesia sesamiae* and *Co. flavipes* and the pupal parasitoids *Pediobius furvus* and *Dentichasmias busseolae*. These four species all used an 'ingress and sting' method of attack, which suggests this was the most successful 'refuge breaking' attack strategy. Koinobiosis was more common among larval and larval/pupal parasitoids than idiobiosis. *Cotesia flavipes* is an exotic species that was introduced into Kenya in 1993, and has been found in all seasons since 1997, becoming the most abundant stemborer larval parasitoid in the area. A native congener, *Co. sesamiae*, appeared in all seasons sampled from 1992 to 1999. Together these two parasitoids accounted for 83.3% of the parasitised borers. *Pediobius furvus* was by far the most abundant pupal parasitoid.

9. Stemborer distribution in Kenya: Update

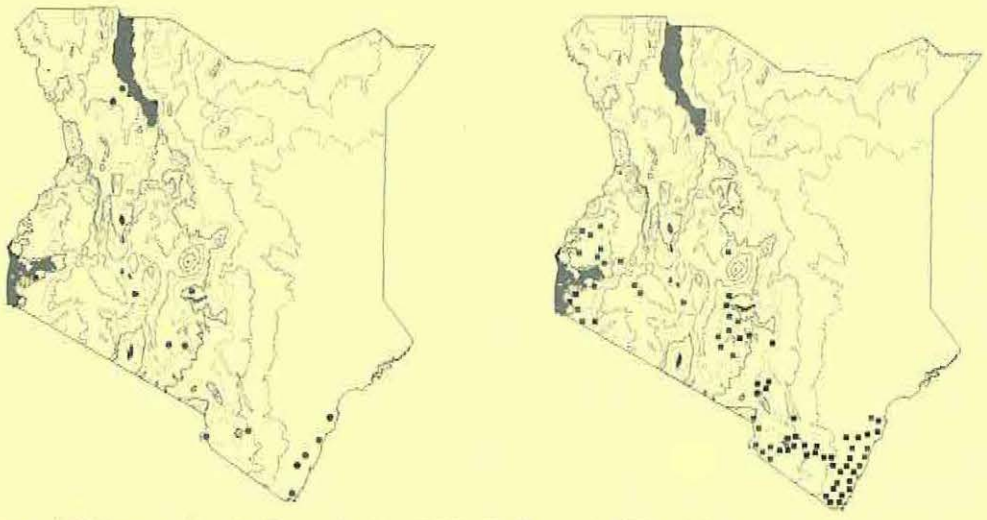
Distribution of stemborers in the late 1990s (1996–2000) in Kenya was compared with the data from late 1950s. The results indicate that the exotic borer *Chilo partellus* has overtaken the indigenous *Busseola fusca* as the most abundant stemborer in Kenya. The exotic borer was found to be distributed throughout southern Kenya and was recovered from highland western Kenya at an altitude of 2000 m a.s.l. The native western Africa stemborer species, *Eldana saccharina*, has successfully invaded western Kenya in the Lake Victoria area.

10. Modelling multihost–multiparasite interactions and its potential for successful biological control

A multihost–multiparasite model was constructed which incorporates a negative binomial survival probability of stemborers and an exponential function of both intraspecific and interspecific competition between different stemborer species. All parameters were selected from either field data or from the literature. The initial population density was retrieved from previous field surveys of different regions in Kenya. The simulation results indicate that without competition, *Chilo partellus* would die out in areas where *Cotesia flavipes* is established. Competition could maintain the stemborer population at a low level such that no damage occurs. Thus, competition can help to realise sustainable biological control. In the highland area where *Busseola fusca* is dominant, numbers of *Co. flavipes* and *Co. sesamiae* were not adequate to control stemborers. The results also show that 'competitive exclusion' will not happen in this system, i.e. the introduction of *Co. flavipes* provides added or supplementary control of stemborers rather than a competitive elimination of *Co. sesamiae*.

11. Predicting the distribution of *Chilo partellus* and *Cotesia flavipes* in Ethiopia using step-wise regression and GIS

The recent development of geographic information systems (GIS) provides new avenues for analysing spatial patterns in insect populations. GIS and statistical models were used to predict the distribution of *Ch. partellus* and *Co. flavipes* in Ethiopia. The results suggest that the distribution of *Ch. partellus* and *Co. flavipes* were affected by rainfall and temperature. The predicted distributions of *Ch. partellus* and *Co. flavipes* were similar.



Distribution of Chilo partellus *in Kenya in the 1950s (left) and 1990s (right) [Source: Zhou et al. (2001) Insect Sci. Applic. 21, 395–402]*

12. Comparative studies on the influence of relative humidity and temperature on the developmental time of two populations of *Cotesia flavipes*

The interactive effect of temperature and relative humidity on developmental time of two populations of *Co. flavipes* originating from India and North Pakistan was studied. The results indicate that developmental time was significantly influenced by the interaction of temperature, relative humidity and population, suggesting the possibility of selecting populations for release depending on climatic conditions. The Indian population was slightly better adapted to high temperatures, while the Pakistani population performed better at lower temperatures.

13. Host suitablity of *Chilo partellus*, *Sesamia calamistis* and *Busseola fusca* for *Cotesia flavipes* in Ethiopia

The objective of this study was to confirm the existence of two populations of *B. fusca* in Ethiopia in terms of host suitability for *Co. flavipes* and also to determine the suitability level of the major cereal stemborers for the parasitoid. Ten populations of *B. fusca* were collected in Ethiopia and reared for one generation in the laboratory on natural diet. Cultures of *Ch. partellus* and *S. calamistis* were also established by rearing them for one generation. Fourth instar larvae of these stemborers were stung by four populations of *Co. flavipes* collected from different localities in Ethiopia and kept under ambient laboratory conditions. Unparasitised fourth instar larvae of each of the borers were kept under similar conditions to correct for natural mortality. The results obtained indicate that two populations of *B. fusca* are suitable hosts for all populations of *Co. flavipes*. After the data were corrected for natural mortality, no significant differences were observed between *Ch. partellus* and *Sesamia calamistis*, but both populations of *B. fusca* were inferior in terms of suitability.

14. Country reports on stemborers and their natural enemies

Mozambique

In surveys conducted in 2000/2001, three stemborer species were found attacking maize and sorghum in Mozambique: *Chilo partellus*, *Busseola fusca* and *Sesamia calamistis*. The exotic stemborer *Ch. partellus* was the most abundant species at all locations below 800 m altitude, followed by *B. fusca* in Boane/Namaacha (500–800 m altitude) and *S. calamistis*. The highest stemborer density was recorded in the areas where *Ch. partellus* was the dominant species. *Chilo partellus* was the dominant stemborer species at all locations, constituting more than 90% of borers at Xai-Xai, Chokwe and Gurue and more than 80% of borers at Moamba and Matutuine. *Busseola fusca* was recorded in high numbers at medium- to high elevation zones. The three stemborer species were found overlapping in the areas and/or plants at medium- to high elevation areas in Boane/Namaacha and Gurue. *Sesamia calamistis* was recorded from all locations and elevations but it was not a dominant species in any area. Fields with 100% of plants infested were observed at several locations in the southern region, with *Ch. partellus* being the dominant species.

All stemborer species found at each location were parasitised by *Cotesia* parasitoids. In general, *Cotesia sesamiae* and *Co. flavipes* were significantly more abundant at Xai-Xai than other locations. *Cotesia flavipes* was recovered from *Ch. partellus* larvae at the majority of locations where releases had been made and from adjacent fields, but was not recovered from the native stemborer species *B. fusca* and *S. calamistis*. However, the native larval parasitoid *Co. sesamiae* was the most abundant at all locations and it was reared from all three stemborer species.

Several other indigenous parasitoids were reared from the stemborer larvae and pupae collected from fields at the study areas. These include the larval parasitoids *Stenobracon rufa* Szepligeti (Hymenoptera: Braconidae), *Goniozus* sp., *Chelonus curvimaculatus* Cameron (Hymenoptera: Braconidae), *Sturmiopsis* sp. (Diptera: Tachinidae) and the pupal parasitoids *Pediobius* furvus (Gahan) (Hymenoptera: Eulophidae) and *Dentichasmias busseolae* Heinrinch (Hymenoptera: Ichneumonidae). The hyperparasitoid *Aphanogmus fijiensis* (Ferriere) (Hymenoptera: Ceraphronidae) was reared from cocoons of *Cotesia* species.

Uganda

Surveys and release of *Co. flavipes* continued in Uganda and was concentrated in the eastern and central zones. *Cotesia flavipes* was found to be the predominant parasitoid and parasitism was 20–30% at most locations. In farmer interviews, several farmers indicated that stemborer populations had decreased since the introduction of *Co. flavipes*, but this will need to be confirmed through impact assessment studies.

Malawi

Surveys for stemborers and their natural enemies were conducted in 18 districts of the 27 districts in Malawi during the months of January, February, May and June 2001. The surveys were conducted in both summer and winter crops. The most abundant larval parasitoid recovered was *Co. flavipes* at some sites, and parasitism was as high as 12%.

A questionnaire on farmers' perceptions on the constraints to cereal production was conducted in three different agroecological zones. The results reveal that stemborers are the major insect pests of maize and sorghum. Most farmers do not use any stemborer management techniques, and only those growing maize and sorghum for commercial purposes use chemicals to control these pests. Some of the farming practices used by farmers to control

stemborers are burning and ploughing under crop residues. The survey clearly indicates that biological control and other tactics such as habitat management fit in well with farming practices in Malawi.

Ethiopia

In a survey conducted in the year 2000, four species of lepidopteran stemborers were recorded in maize and sorghum: *Chilo partellus, Busseola fusca, Sesamia calamistis* and *S. nonagrioides botanephaga*. Based on earlier surveys, *Ch. partellus* was believed to only occur below 1700 m, whereas in our survey this species was found at 1930 m. The level of infestation ranged between 30 to 100%, with 5–27 borers per infested plant. Grain yield losses were estimated at 12 to 60%. Stemborers were found in three cultivated and 12 wild host plants. More than 14 species of parasitoids, six species of predators and five different pathogens were found attacking different stages of stemborers. The exotic larval parasitoid *Co. flavipes* was found at several locations. *Cotesia flavipes* was never released in Ethiopia and was not reported in earlier surveys (i.e. before 1998). The most likely source may be Somalia, where *Co. flavipes* was released in 1997 along the Shebele River near the Ethiopian border.

Zimbabwe

Surveys were conducted at five locations: Harare and its immediate surroundings (highveld), Henderson Research Station (highveld), Bindura, 88 km northeast of Harare (middleveld), Principe Irrigation Scheme, approx. 130 km northeast of Harare (middleveld), and Chisumbanje Experiment Station (lowveld). Three stemborer species, *Busseola fusca, Chilo partellus* and *Sesamia calamistis*, were found damaging crops. *Chilo partellus* was the dominant species but as demonstrated in previous work, the species composition was dependent on agroecological region. While *B. fusca* occurred almost exclusively within the highveld, *Ch. partellus* was recorded in all three regions. At the two middleveld sites of Bindura and Shamva (Principe Irrigation Scheme), at least 95% of the stemborer larvae sampled were *Ch. partellus*, making these two locations ideal as *Cotesia flavipes* release sites.

Stemborer larval parasitism recorded during the season was due to *Cotesia sesamiae, Sturmiopsis parasitica* and the parasitic nematode, *Hexamermis* sp. However, *Co. sesamiae* parasitism in the highveld was very low (not more than 6 %) while *S. parasitica* parasitism in the Harare area attained a peak of 64.8% in January. In general, although some useful data was garnered during the 2000–2001 season, surveys were severely hampered by the serious on-going nationwide fuel crisis.

Following the surveys conducted in the middleveld, *Co. flavipes* was released at Principe Irrigation Scheme. Compared to the lowveld sites of Musikavanhu and Muzarabani where releases have already been conducted, Principe appears to be the most ideal non-lowveld location to conduct uninterrupted *Co. flavipes* releases and post-release surveys due to its proximity to Harare, nearly year-round cultivation of maize and the predominance of *Ch. partellus* hosts. During the 2000–2001 season, approximately 54,000 parasitoids were received from ICIPE and liberated at the irrigation scheme. A further 1500 cocoons obtained from hand-stung *Ch. partellus* larvae were released about three weeks later. In the lowveld, releases were conducted at Birchenough Bridge where about 13,500 cocoons were liberated. This later release was made with the aim of eventually linking up with the first release that was made at Musikavanhu Irrigation Scheme in July 1999.

In is now nearly two years since the first releases of *Co. flavipes* were conducted in Zimbabwe but its establishment has yet to be assessed. The unending fuel crisis has hampered the planned post-release surveys. Hopefully, the first post-release surveys will finally be conducted during the 2001–2002 season.

Zanzibar

Monitoring of *Cotesia flavipes* Cameron establishment continued in Zanzibar (Unguja and Pemba Islands). The parasitoid was recovered from 8 (out of 16) sites on Unguja one year after its release. This indicates that the parasitoid has firmly established on the island, although its population is still low. Recoveries were made only on Unguja. A survey showed that three stemborer species, *Chilo partellus, Ch. orichalcociliellus* and *Sesamia calamistis* were found attacking maize and sorghum.

Tanzania

Surveys were conducted in the maize- and sorghum-producing districts of Biharamulo and Ngara of Kagera region. Sampling was carried out from the Lake Victoria shore to the highest altitude at the border with Rwanda and Burundi. *Busseola fusca* was found to be the predominant stemborer in the region. Only three *Chilo partellus* larvae were recovered from two sites near the Lake. The local parasitoid, *Cotesia sesamiae* was the only larval parasitoid recovered. Since *Buseola fusca* was found to be the dominant stemborer in Kagera region and *Cotesia sesamiae* was the only parasitoid identified, it was concluded that *Co. flavipes* should not be released in Kagera region because it is unlikely that it will establish. A pupal parasitoid, *Xanthopimpla stemmator*, might be a suitable parasitoid for release in the region. *(See highlight 6 above)*.

In the southern highland zones, a survey was conducted between June and July 2001. *Busseola fusca* was found to be the predominant stemborer, and accounted for 53% of borers followed by *Chilo partellus* (37%) and *Sesamia calamistis* (9%). *Eldana saccharina* was found in only three fields. The highest occurrence of *B. fusca* was recorded in Singida region. However, high numbers of *Chilo partellus* were found in the same region. *Cotesia sesamiae* was the predominant parasitoid in central and southern highland zones, while *Cotesia flavipes* was recorded in only one site.

15. Response of *Chilo partellus* populations in Kenya to *Bacillus thuringiensis*

The objectives of this activity are to assess whether various *Chilo partellus* populations respond differently to *Bacillus thuringiensis* formulations, and to evaluate whether there are any genetic differences in these populations.

Three *Ch. partellus* populations were successfully reared in the laboratory. Bioassay studies showed that the three populations have different LC_{50} values to both local and commercial *Bt* formulations.

Activities for 2002 will include optimisation of RAPD for use in analysis of the populations and data analysis and thesis preparation.

C. Research on Genetically Modified Organisms (GMOs)

1. Assessment of potential impacts of introducing genetically-engineered crops into Africa

This is a new project that began in late 2001. The objectives are to assess the potential ecological impacts of maize expressing *Bacillus thuringiensis* toxins (*Bt* maize). The activities will include assessment of the effects of *Bt* maize on non- target beneficial species (e.g. fungi, bacteria, nematodes); evaluation of various management strategies; estimation of gene flow; and capacity building.

Analysis of the background populations of *Rhizobium* and *Mycorrhizae* is underway. The effect of *Bt* toxin on biological activities of these organisms will be assessed. Studies on the effects of *Bt* toxin on the biodiversity and pathogenicity of root-knot nematodes in soil planted with tomatoes is also underway. Soil samples are being collected and physico-chemical analyses performed.

2. Assessing the risk of transgene dissemination associated with the introduction of GM crops in Africa using cowpea as a model

The objectives of this 2-year project are to:

- assess genetic diversity within and among cowpea populations;
- study out-crossing events and trace the origin of introgression with chloroplast (cp) DNA markers;
- study pollen competition between cultivars and their wild relatives;
- assess the fitness of F_1 hybrids and of their progenies;
- catalogue potential pollinators as a means of assessing gene flow;
- map genes of the 524B cultivated line in order to assess amount of introgression from the line.

The main cowpea pollinators have been identified. Although the wild plant has an out-crossing breeding system, and the pollinators are large carpenter bees, gene flow between populations is low. Probably due to heterosis, F_1 hybrids between wild and cultivated plants appear to be very fit since they produce a large number of seeds. However, due to lack of dormancy and high predation, seeds of F_1 plants may be less fit in the wild. To follow the direction of cultivated genes introgressed into wild plants, we have set a cpDNA PCR-based marker from a previous RFLP marker.

Future activities for 2002 include genetic studies of wild and cultivated populations; setting up of AFLP and microsatellite techniques; pollen competition and fitness studies; and assessment of the bee foraging range.

D. Research on Banana and Its Pests

1. Socioeconomic evaluation of technologies for the improvement of banana productivity with special reference to the control of pests and diseases of banana in Uganda

Banana is the world's fourth most important staple food crop after rice, wheat and maize and is the most important food staple in Uganda. For instance, 75% of farmers allocate 40% of cropped land to banana production. However, productivity is decreasing due to pests and diseases, declining soil fertility and socio-economic factors such as inadequate labour and marketing problems. In response to these trends and constraints, a research and development agenda was developed with the Uganda National Banana Research Programme (UNBRP) of the National Agricultural Research Organisation (NARO), in collaboration with

Banana pests and diseases can seriously lower the production of this important food staple for many in the tropics. Allelochemicals of different varieties have been shown to contribute to resistance or susceptibility.

Table 1. Estimation of the average costs and benefits obtained from growing different banana and other crops in Bamunanika Sub-county, Uganda over four years

	Average cost ('000 U.Shs per ha)				Average benefit ('000 U.Shs per ha)			
Crop	Y1	Y2	Y3	Y4	Y1	Y2	Y3	Y4
Cooking banana	664.5	190.9	190.9	190.9	0.0	303.7	607.4	404.9
Brewing banana	95.4	95.4	95.4	95.4	209.4	209.4	209.4	209.4
Coffee	177.7	177.7	177.7	177.7	1024.2	1024.2	1024.2	1024.2
Maize	551.0	551.0	551.0	551.0	592.8	592.8	592.8	592.8
Sweet potato	548.8	548.8	548.8	548.8	1188.4	1188.4	1188.4	1188.4
Beans	337.5	337.5	337.5	337.5	445.1	445.1	445.1	445.1
Cassava	300.5	300.5	300.5	300.5	440.5	440.5	440.5	440.5

U. Shs 1780=US$ 1.00 (yr 2000).

the International Institute of Tropical Agriculture (IITA) and the African Highland Initiative. In 1997, collaborators invited ICIPE to provide input into the socioeconomic component of the banana R&D agenda.

Banana production systems were characterised with special reference to the control of pests and diseases at three benchmark sites representing two types of regions: those showing a severe decline in production and productivity decline (Luweero District, year 2000), and those with relatively high production and productivity with incipient decline (Ntungamo District, year 2001).

Farmers' knowledge and control of pests and diseases of banana were determined. The role of institutional factors (including gender, markets and extension) on banana production were also determined. An economic analysis showed that banana has the highest production costs compared to other crops in areas of both high and low farm productivity. In Luweero, the benefit of growing cooking banana is highest in the third year but declines thereafter, confirming farmers' earlier reports (Table 1). Overall, banana production in Luweero is as competitive as the other leading food crops, due to its higher costs and diminishing benefits after the third year. But results from Ntungamo are likely to show the opposite trends.

2. Monitoring and evaluation of farmer participation in on-farm trials in Luweero District

Worldwide, there is a recognised lack of reliable information on the contribution of community participation in the research, development and management of technologies. In recognition of this gap, we undertook to monitor and evaluate farmer participation in four on-farm trials on 180 farms in Luweero District, Central Uganda. The objectives were to:

- identify and quantify the activities performed by the farmers;
- determine the cost of participation to the research farmers and the programme;
- determine the time/labour budgets of the different activities;
- determine the benefits of participation and how they are shared;
- determine the factors influencing participation;
- assess the overall contribution of farmer participation to the achievement of the on-farm trials (OFT).

Work started in November 2001 and a research protocol was developed. Selection of field enumerators was completed in December and their training is planned. A survey was carried out among the seven scientists implementing the OFTs to determine their expectations of farmer participation. Results analysed and presented to them revealed that not enough had been done to conceptualise and operationalise farmer participation.

3. Chemical ecology of banana resistance to pests

As part of ICIPE's collaboration with IITA (Uganda), allelochemicals of banana varieties have been shown to contribute to resistance or susceptibility. Major feeding stimulants in a susceptible variety were characterised and quantification of these in different varieties suggests that they are partly responsible for the susceptibility seen in some varieties. Similar work on candidate allomones is planned. IITA is developing a major grant proposal on banana, which includes support for a PhD student based at ICIPE to continue these studies.

4. Genetic biodiversity in the banana weevil from different regions of the world

Results of this study conducted in the Molecular Biology and Biotechnology Unit showed low to moderate genetic variability in different banana weevil, *Cosmopolites sordidus* populations worldwide. The populations fall into several district clusters depending on their degrees of genetic similarities. Specific molecular markers for the different clusters have been identified, proving the genetic distinctiveness of the clusters. The results indicate the possible spreading patterns of the weevils (20 localities) from their ancestral home in Asia to other parts of the world.

II. HORTICULTURAL CROP PESTS SUB-DIVISION

INTRODUCTION

Effective chemical control of the diamondback moth (DBM), the key insect pest of crucifers in eastern and southern Africa, has become difficult and uneconomical. DBM has developed resistance to common insecticides, while the insecticides used are deleterious to indigenous natural enemies. Farmers are increasingly using insecticide cocktails and spraying more frequently. This is resulting in rising production costs, environmental contamination, health risks and high residues in produce. The recorded level of parasitism by indigenous parasitoids, including members of the genus *Diadegma*, is low compared to the Southeast Asian and South African situations. The project **Biocontrol-based IPM for the DiamondBack Moth, *Plutella xylostella* L. in Eastern and Southern Africa** is a collaborative regional research effort implemented in various steps: collection of basic information on distribution and efficiency of the indigenous natural enemy complex in the region; study of the taxonomy and bionomics of these in comparison to parasitoids of proven value in Southeast Asia and South Africa; importation, multiplication and release of superior parasitoids from Asia or South Africa. The improvement of biological control in tropical lowlands through exploration for additional parasitoids adapted to high temperature environments is another aim of this project. This will be coordinated by ICIPE's partner institution, AVRDC.

The most important red spider mite (RSM) species found on tomato, *Tetranychus evansi*, is of American origin and was introduced into southern Africa in the 1970s. The pest spread northwards from Zimbabwe, where it was discovered for the first time in 1979, reaching Zambia around 1985 and Malawi in the early 1990s. In March 2001 *T. evansi* was discovered for the first time in Kenya by scientists at the ICIPE project **Integrated Management of Red Spider Mites**. The project is developing integrated and biological management strategies for *T. evansi* and *T. urticae*, the second-most important spider mite pest of tomatoes in the region.

Cabbage and other brassicas are the preferred hosts of the diamondback moth (DBM), a pest that is now resistant to almost all synthetic insecticides.

The **African Fruit Fly Initiative** addresses one of the major constraints to quality fruit production in Africa—fruit flies—and seeks to provide environmentally friendly and affordable technologies and skills for their management. Fruit fly damage reduces the profits and market competitiveness of smallholder growers and traders, about 70% of whom are women, and results in the high cost of fruit in the local urban markets. The recent introduction in Europe of regulations on uniform and strict quarantine and stringent maximum residue levels (MRL) further compounds the problem. For instance, mango production is currently at the level of 35,000 tonnes annually, worth US$ 42 million (FAO). Smallholders supply over 90% of mangoes produced in Africa. But out of 1.9 million tonnes of mangoes produced annually, about 40% is wasted due to fruit flies. AFFI is the only regional fruit fly programme operating in Africa. Operations of the first phase commenced in 1999 and ended in 2001.

The Old World bollworm, also known as the African bollworm, *Helicoverpa armigera* (Hübner), is a key pest of several horticultural crops including tomato and capsicum, among others in Africa (FAO, 1994). It also damages some legume crops (e.g. pigeon pea), cereal crops (e.g. sorghum), oilseed crops (e.g. sunflower) and commercial crops (e.g. cotton and tobacco). Smallholder farmers are unable to manage this pest sustainably since they apply pesticides frequently and at high doses, resulting in problems of pest resurgence, pesticide resistance, increased cost of crop protection and risk of high levels of pesticide residues in marketable produce. There is therefore the need to develop safer and more sustainable pest management options. The objectives of the **African Bollworm Biocontrol** project, which began in 2001, are to undertake complementary research on this pest, by filling in knowledge gaps and promoting the adoption of improved and integrated management practices in Africa. ICIPE, in partnership with concerned IARCs and NARES, is developing biological control-based IPM strategies for this key pest in order to build national and regional capacity.

As agricultural development programmes in the region improve access to irrigation, more smallholder farmers are finding it feasible to grow vegetable crops throughout the year. However, the intensive cultivation of vegetables, often in overlapping seasons, tends to also promote the year-round build-up and rapid multiplication of key pests. Farmers are therefore required to invest more on crop protection, and in the process, tend to overuse or misuse chemical pesticides. There is the need to develop safer alternatives to chemical pesticides if farmers are to comply with guidelines on pesticide use, MRLs and export regulations. Since NARES in the region have almost exclusively depended on the use of synthetic pesticides for pest management, farmers need training on alternative options, as well as appropriate research-extension-farmer linkages to help build IPM awareness. While the Farmers' Field School (FFS) approach is recognised as a useful

strategy, it needs refinement to particular communities. The **IPM Promotion and Awareness in Major Vegetable Crops in Eastern and Southern Africa** project seeks to assist NARES in developing capacity to recommend, deploy and assimilate environmentally safer IPM options, and in developing models for IPM awareness-building among farmers.

The Entomopathology Unit has continued with evaluation of **fungus-based biopesticides** in the field and validation of the results. Data generated so far have confirmed the potential of two isolates of *Metarhizium anisopliae* for the control of thrips in horticultural crops, onions and legumes, and termites in maize cropping systems. With regard to termite control, results have been very positive, to the extent that Uganda is willing to register the fungus as a control agent for termites. An initiative has been made at ICRISAT / Nairobi to include Metathripol (a *Metarhizium*-based product) in pigeon pea IPM.

Spray application is the main method employed for introduction of entomopathogens, including fungi, into the ecosystem. A new strategy is currently being developed, whereby insect pathogens are disseminated among target pest populations by using devices that attract the insect pests into a focus of the pathogens. The Unit has developed and successfully tested contamination devices for fruit fly and tsetse fly control.

RESEARCH HIGHLIGHTS

A. Biocontrol-Based IPM for the Diamondback Moth, *Plutella xylostella* L., in Eastern and Southern Africa

1. Baseline information and collection of the indigenous natural enemies of DBM in collaborating countries

Surveys are being conducted in cooperation with the national research institutions of four eastern African countries: Ethiopia, Kenya, Tanzania and Uganda. Surveys in Ethiopia and Kenya (Western Province, Rift Valley, Northeastern Province, Central Kenya and Taita Hills) are at an advanced stage; the Northern Province of Tanzania has been completed while southern Tanzania and most of Uganda are still to be conducted. Delays are due to organisational problems and unusual rains. The evaluation of the surveys and the analysis of the collected material is still on-going, but the findings of the earlier work done by the GTZ-IPM Horticulture Project are largely confirmed. The main parasitoid species collected are in order of importance: *Oomyzus sokolowskii* (Kurdjumov) (Hymenoptera: Eulophidae); *Diadegma mollipla* (Holmgren) (Hym.: Ichneumonidae) and very few specimens of *Itoplectis* sp. (Hym.: Ichneumonidae) and even fewer *Cotesia plutellae* Kurdjumov (Hym.: Braconidae). Overall parasitism rates were in the range of 10–15%, confirming earlier observations about low parasitism compared to the situation in Asia and South Africa. Unusual material was collected only from Ethiopia and is awaiting identification.

2. Taxonomic status of the genus *Diadegma* in Africa

One of the hypotheses of the project—that the African *Diadegma* species are not identical with *D. semiclausum*—has already been confirmed in two ways. Firstly, in the period between proposal writing and Project initiation, all African *Diadegma* parasitoids of DBM were lumped together under the name *D. mollipla*. In addition, molecular taxonomic work conducted by the project using mitochondrial and ribosomal DNA as genetic markers clearly indicates differences between *D. semiclausum* from Taiwan and *D. mollipla* from Kenya and Tanzania. However, DBM parasitoids (genus *Diadegma*) from South Africa and Ethiopia are different, both morphologically and based on DNA studies. More work is required, but it may well be possible that new species will be described as a result of this work.

The Project has also contacted DBM researchers and ichneumonid specialists worldwide and asked for samples of any available fresh material of the genus *Diadegma*. The intention is to construct a cladogramm for the genus using molecular methods. This should resolve some of the disputes about the validity of the species names currently in use.

3. Comparative biological studies of the African and Asian DBM parasitoids and promising strains for a classical biocontrol programme

Studies on the biology of the major local parasitoid species, *D. mollipla*, were initiated. Currently, the performance of this parasitoid is being investigated under different temperature regimes. It is emerging that *D. mollipla* is more highly attracted to DBM larvae on pea, a new host plant in Kenya, than on cabbage. We have also collected *D. mollipla* on potato tuber moth, which also cannot be the original host of the species because the moth was introduced from South America, while *D. mollipla* is definitely indigenous. We therefore assume that *D. mollipla* is only a facultative parasitoid of DBM and the original host is not known.

Our surveys show that *Cotesia plutellae* is not of prominence in any of the countries of eastern Africa. This contrasts sharply to the situation in South Africa, where this species is reported to achieve consistently high parasitation rates under high temperature conditions. A good larval parasitoid in the lowland tropics and for semi-arid areas is still not available, and therefore an agreement was signed with the Plant Protection Research Institute (PPRI) of South Africa to conduct bioecological studies on the South African strain of *C. plutellae*. This species will later be imported into Kenya and released in semi-arid areas during 2002.

4. Classical DBM biocontrol pilot programme for Kenya

In February 2001, the Project requested permission from the Kenya Standing Technical Committee on Imports and Exports (KSTCIE) to import three DBM parasitoid species: *Diadegma semiclausum* Hellen and *Cotesia plutellae* Kurdjumov from Taiwan and *D. mollipla* (Holmgren) and *C. plutellae* from South Africa. Upon request by KSTCIE, a dossier was prepared with details about the parasitoids including an assessment of the risks associated with the introduction. The dossier was delivered in early March and an import permit for all three species was granted on 20 April 2001.

In October, Dr Talekar of AVRDC brought *D. semiclausum* from Taiwan. A second shipment was received on 29 January and the species is now being multiplied in the quarantine rearing facility. A release permit is currently being processed. Four pilot release sites have been selected, three in Kenya and one in Tanzania. Since April 2001, DBM populations are being assessed and samples collected for estimation of parasitism at fortnightly intervals. Weather stations have also been deployed at all sites for the assessment of climatic conditions in relation to DBM populations and parasitism. One year of data collections will be completed before a release is made in early 2002.

Two MSc projects were recently initiated for impact assessment, one on biological impact, the other on economic impact. Baseline data are being collected to facilitate ex-ante and ex-post comparisons of the effects of the introduction on DBM populations and damage.

5. Exploration for additional pupal DBM parasitoids in areas of DBM origin

A Project collaborator from the USDA/ARS Biocontrol Station in Montpellier, France collected a DBM pupal parasitoid in Usbekistan at 42 ºC. The species was identified as *Diadromus collaris* (Kurdjumov), quarantined in France and sent to AVRDC in Taiwan in October 2000. It was quarantined there again for two generations and then released into field cages at AVRDC where studies on temperature adaptability and biological traits of the species are being conducted.

6. Additional activities

A new DBM strain attacking export peas was discovered south of Lake Naivasha in Kenya before the Project started. This is remarkable, as DBM has never been reported as a pest of peas elsewhere in the world. The host range of DBM is considered limited to the Cruciferae family, while peas belong to the Leguminosae. Work was initiated to elucidate the reasons for this host switch and to study the implications this host switch may have for biological control of DBM.

The Project Coordinator visited USDA/ARS Montpellier in April to discuss exploration activities for heat-tolerant parasitoids. All concerned persons in the Project felt it might be a good idea to establish a cooperation with Prof. G. Mustata in Romania to conduct field observations and collections throughout one or two seasons according to a pre-established protocol, including the recording of temperature and humidity data. The highest diversity of DBM parasitoids identified so far has been found in Moldova region. However, no information is available about changes in parasitoid fauna composition throughout the season and especially with rising temperatures during the summer months. This information would be very useful to the Project, as a considerable percentage of crucifer production in East Africa comes from semi-arid areas, where the currently known parasitoids may not perform satisfactorily. It could also give a boost to DBM biocontrol attempts in hot climates worldwide.

7. Capacity building

Currently, there are four PhD and three MSc students involved in the project. Two more PhD projects are under development. The students originate from Zimbabwe, South Africa, Ethiopia, Uganda, Kenya and Germany. Three research articles and two conference papers have been written.

8. Molecular characterisation and phylogenetic studies of parasitoids of *Plutella xylostella*

A new project in the Molecular Biology and Biotechnology Unit to characterise parasitoids of *Plutella xylostella* (*Diadegma* and *Cotesia plutellae*) and to carry out phylogenetic studies is beginning in 2002 with support from BMZ. The activities will include:

- development of a PCR-based methodology for *Diadegma mollipla* identification (COI region of mtDNA, ITS2 of ribosomal DNA. Techniques: PCR-RFLP, sequencing);
- analysis of populations from Kenya, Tanzania, Uganda, Ethiopia, Reunion and South Africa using AFLP technique;
- analysis of endosymbiont (*Wolbachia*) and *Microsporidia* by PCR;
- analysis of the phylogenetic relationships of the genus *Diadegma* worldwide;
- cross-breeding experiments with *D. mollipla* (populations in Kenya, South Africa and Ethiopia) and *D. semiclausum* (from Taiwan, to be introduced for biocontrol of diamondback moth);
- development of PCR-based methodologies for identification of *Cotesia plutellae* (COI region of mtDNA, ITS2 of ribosomal DNA).

The on-going augmentation biocontrol activities for network partnerships will be continued. In

particular, potential demand and scope for integrating *Trichogramma* with other control options will be assessed, principally through in-country stakeholders workshops in the partner countries. Capacity building and partnership activities in collaboration with NARES and IARCs will continue under this network. A pilot production unit will be established to promote and support training of personnel for commercial production of native egg parasitoids. The combined use of egg parasitoids and NPV as complementary augmentation biocontrol components will be studied.

Research and NARES capacity building initiatives will be continued and options for integrating other pest management components including pheromone technology, and harmonising them with pesticide use will be undertaken. Efforts will also be made to link up with IARCs, especially ICRISAT, AVRDC and IWMI for complementary initiatives in their mandated cropping systems in which *H. armigera* is a key pest in eastern and southern Africa.

B. Integrated Management of Red Spider Mites

1. Survey of growing practices, RSM species composition and impact of natural enemies in Kenya, Zambia and Zimbabwe

The results of the surveys clearly show the different impact of the two different RSM species (*Tetranychus evansi* in Zambia and Zimbabwe, *T. urticae* in Kenya). Infestation levels were generally much higher in Zambia and Zimbabwe than in Kenya. It is expected that this situation will change, since *T. evansi* was detected in Kenya for the first time in March 2001. Predatory mites were only found in Kenya in association with *T. urticae*, but never in Zambia and Zimbabwe in association with *T. evansi*.

2. Yield loss caused by *T. evansi* and the influence of time of infestation on mite numbers and yield of tomatoes

Uncontrolled development of *T. evansi* reduced tomato yield up to 90% in Zimbabwe. Preliminary results of experiments on the relation of time of infestation, and population development and yield indicate that the period from set of the first flower to beginning of harvest is the most critical one for mite control. These results are important for the development of critical intervention periods and will help to reduce pesticide use by farmers.

3. Resistance of tomato accessions to *T. urticae* and *T. evansi*

In screenhouse tests, 15 out of 56 tomato accessions supported significantly lower numbers of *T. urticae* than the susceptible control variety (Money Maker).

Tomato is one of the most widely grown crops in Africa, but production is severely curtailed by a wide range of arthropod pests and diseases.

Some of these accessions are commercial varieties available in Kenya and can be recommended to farmers as soon as the results are validated in field trials. Preliminary investigations in Zimbabwe identified 6 out of 20 accessions with resistance/ tolerance to *T. evansi* in screenhouse tests.

4. Spatial and temporal dynamics of *T. urticae* in the field

The distribution of *T. urticae* within the plant canopy was investigated in a field trial. Results clearly showed that mites are more abundant in the lower part of the canopy. However the distribution was more uniform towards the end of the trial. Overall mite density was low throughout the trial with a maximum of only 34 mites per leaf at the end of the trial. The distribution of mites was aggregated within as well as between plants.

The temporal dynamics of *T. urticae* in a tomato field were investigated at Mwea Irrigation Scheme for 3 seasons. The population development followed the same pattern in all three seasons with mite numbers starting to increase from about 7 weeks after transplanting. RSM numbers at the end of the season were highest in Season III with the lowest rainfall and lowest in season I with the highest rainfall.

Similar experiments were conducted with *T. evansi* in Zimbabwe, and data analysis is in progess. Generally, mite numbers were much higher in Zimbabwe than in Kenya. This is also reflected in the distribution data. The mean density of mites was highest in the middle of the canopy.

The results of these experiments are vital in establishing reliable sampling plans for the development of integrated and biological control systems.

5. Effect of pruning and trellising of tomatoes on RSM numbers and tomato yield

The effect of pruning and trellising of tomatoes on RSM numbers and tomato yield was investigated in an on-farm trial in Zimbabwe. Mean mite numbers were lowest in the pruned and trellised tomatoes and highest in the un-pruned and un-trellised control.

The yield was highest in the pruning and trellising treatment and lowest in the control. The lower mite numbers are due to better spray deposit in the pruned and/or trellised tomato plants. However, it is doubtful if the yield increase is caused only by lower mite numbers. Removal of axillary shoots is known to have positive effects on quality and quantity of fruits of tomatoes.

The coverage of tomato plants with spray is a major problem in RSM control. The mites prefer the lower surface of leaves and available acaricides do not have a systemic action. Pruning and trellising considerably improves spray deposit. In Zimbabwe farmers in some areas have practised pruning and trellising for some time, while others did not, claiming that cost and labour were too high and there is no economic return. Our trials were conducted on a farmer's field in an area where pruning and trellising had not been practised. The farmer and his neighbours were so impressed by the outcome of our experiment that they immediately adopted the techniques and started to prune and trellis their tomatoes in the following season.

6. Exploration for biocontrol agents for *T. evansi* in Brazil

Surveys for natural enemies of *T. evansi* in north-eastern Brazil started in September 2000. So far 14 species of predatory mites and one species of predatory Cecidomyiidae were collected in association with *T. evansi*. Currently, efforts are underway to establish laboratory colonies of some of these predators for further investigations on their suitability for introduction into eastern and southern Africa as biological control agents.

7. Identification of *T. urticae* and *T. evansi* with PCR-RFLP

Mites are difficult to identify because of their small size (< 0.5 mm) and identification with classical taxonomic techniques needs a lot of experience. Molecular biological techniques (e.g. polymerase chain reaction — PCR) provide a powerful tool to distinguish between sibling or closely related species. The internal transcribed spacer 2 (ITS2) region of the nuclear ribosomal DNA was analysed by PCR-restriction-fragment length-polymorphism (PCR-RFLP). The technique is a relatively cheap, easy and less time-consuming method compared with the sequencing of the genetic region. The amplicons were digested with restriction enzymes *Rsa I, Dra I* and *Alu I. Rsa I* cuts *T. evansi* into two fragments (310 bp and 350 bp) and *T. urticae* into three fragments (300 bp, 160 bp and 180 bp). *Alu I* cuts *T. urticae* into two fragments of 410 bp and one of 170 bp. *Tetranychus evansi* is also cut once in fragments of 600 bp and 80 bp. *Dra I* could not digest *T. urticae* or *T evansi*.

The results clearly showed differences between *T. urticae* and *T. evansi* obtained by PCR-RFLP. The results were also confirmed by sequencing of the ITS2 fragment at INRA, Montpellier.

8. Capacity building

Two PhD students have been working in the project since 1998 and their theses will be completed by mid-2002. Currently, one MSc student is working on resistance to spider mites in tomato at ICIPE and another student on resistance of mites to acaricides at PPRI, Harare.

C. The African Fruit Fly Initiative (AFFI)

1. AFFI Network

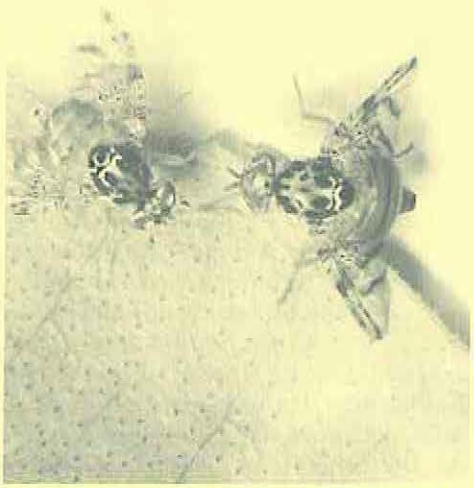
An extensive and productive AFFI network has been established, composed of 12 African countries and 14 technical and regional institutions from the USA, Central America, Europe and Africa, plus the relevant policy and commodity bodies FAO-IGSG-TF, TFNet, IAPSC/OAU. In response to the requests from AFFI stakeholders, ICIPE has utilised its core resources to sustain the basic AFFI operations during the transition from the first phase, to the second phase, expected to begin in mid-2002.

2. Results of the 1st Phase

Some of the highlights of the first phase include:

Assessment of the problem
Fruit infestation and yield losses (ranging from 10–70%) in the participating countries in Africa and socioeconomic aspects of fruit production in target smallholder communities were described.

Pest profile
In all the countries surveyed, *Ceratitis cosyra* has been found to be the major pest of mango, followed by *C. rosa, C. fasciventris* and *C. anonae*.



The Mediterranean fruit fly, Ceratitis capitata, *in a courtship ritual. These and other damaging fruit fly pests remain largely uncontrolled in Africa.*

Fruit fly lures
An effective bait developed by AFFI from local materials, was found to be 30% better than the commercial US-produced (NuLure®), and can be produced at only a fraction (20%) of the cost of the latter.

Baiting stations
Locally made baiting stations employed on smallholder fields at a density of 20–50 per hectare caused a significant reduction in the local fruit fly population.

New fruit fly control agents
Insect pathogens which can substitute for pesticides have been developed and tested for application in the baiting stations.

Distribution of mango pests in Africa
Maps describing the distribution of the fruit flies infesting mango have been prepared.

Identification tools
User-friendly taxonomic keys for easy identification of pest fruit fly species have been developed.

Capacity building
Six African PhD students have been recruited for training in fruit fly biology and management. Technical partners from nine African countries have received training on fruit fly identification, monitoring and control.

Project review
An external review was completed of the project, and it was recommended that the 2nd phase be funded.

3. Molecular identification and population genetic analysis of invasive fruit fly species (*Ceratitis* spp.)

The objectives of this activity are to develop PCR-based methodologies for identification of fruit fly larvae in quarantine; develop tools (single and multi-locus) for analysis of population genetic structures and phylogenetic relationships between different species.

Cross species microsatellite loci, based on sequences identified from medfly *(C. capitata)* have been identified by the Molecular Biology and Biotechnology Unit. A comparative genome-wide scan using AFLP technique has been undertaken.

The evaluation of three candidate probes (one each for *C. rosa*, *C. fasciventris* and *C. anonae*) is underway. Among these, it is difficult to distinguish females using morphological keys. Two enriched microsatellite libraries (one for *C. anonae*, the other for *C. fasciventris*) are being developed. The use of single locus polymorphic microsatellites will form a key strategy in the genetic analysis of populations.

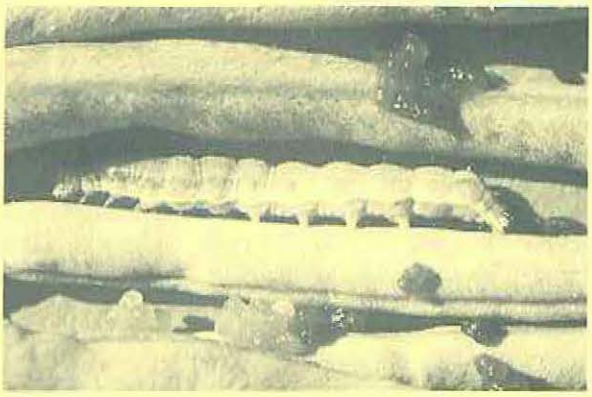
D. African Bollworm Biocontrol and IPM

1. Augmentation biocontrol development for *Helicoverpa armigera*

In Asia, Australia and Europe, considerable progress has been made in utilising natural enemies, especially parasitoids and baculoviruses, as augmentation biocontrol agents for *Helicoverpa armigera*. However, in Africa, the national programmes are in need of scientific back-up for promoting alternatives to pesticide use. At a symposium convened at Ouagadougou, Burkina Faso in 1999, it was recommended that ICIPE lead a consortium of NARES to promote complementary and collaborative research and regional capacity building for strengthening biocontrol technology development.

The national biological control teams of four countries in the region—Ethiopia, Kenya, Tanzania and Uganda—are partners in a new regional network on the use of egg parasitoids for *H. armigera* control. During the first phase (2001–2004), the focus is on assessing the species diversity among native egg parasitoids and on evaluating the potential of trichogrammatid egg parasitoids for adaptation for mass production with regard to climate stresses; methods for standardising impact assessment under field conditions will also be developed. Among this group of natural enemies are the trichogrammatids, which are amenable to easy and cheap mass production and can be introduced in inundative releases, while others such as scelionids that are difficult to rear on substitute hosts, could be conserved *in situ*.

A methodology workshop was held with partners and collaborators, to standardise procedures for surveying and cataloguing of the native parasitoids and their distribution. The agreed-on guidelines were compiled in a manual. This workshop also considered the sequence of field experiments, benchmark monitoring sites for *H. armigera* and assessment of potential demand for egg parasitoids.



Helicoverpa armigera *larva on green beans*

2. Survey of native egg parasitioids in the region

On-farm surveys undertaken by ICIPE and the four national partners in representative vegetable cropping systems have recovered several accessions of native parasitoids. Supplementary collections were also obtained from unsprayed plots of six crops (tomato, okra, capsicum, cotton, sunflower and pigeon pea) grown in benchmark sites. Fourteen collections were made in the first year (2001) from *H. armigera* eggs sampled from different ecologies and altitudes. These include recoveries from all of the above mentioned crops.

The collections of native trichogrammatid parasitoids from different ecologies in Kenya are being evaluated for their adaptation to two climate, temperature and humidity regimes. Identification to species level is being undertaken and consultations have been initiated with experts on identifying and characterising the other important family of scelionid egg parasitoids.

In an effort to improve the quality of mass-produced trichogrammatids, studies have been initiated on fecundity and progeny sex ratio of native strains and the scope for manipulating them. Host egg batch size and the number of cohabiting adult female *Trichogramma* are found to play a role in progeny sex ratio. Tests to identify cheaper sources of feed and additives for mass rearing of the larvae on the hosts (*Corcyra* and *Ephestia*) have been undertaken.

Based on initial consultations with national partners, a methodology was worked out for assessing the in-country demand for egg parasitoids through stakeholder workshops and for the sample surveys to be undertaken. In Kenya, a private enterprise (DuduTech Ltd.) has sought technical assistance from the project to promote *Trichogramma* mass production on a commercial basis.

3. Augmentation biocontrol of *H. armigera* with baculoviruses

Among the baculoviruses, the nuclear polyhedrosis virus (NPV) has shown potential for *H. armigera* control in Asia and Australia. The major steps required for promoting this biocontrol agent in Africa are to identify potent native strains, enhance their deployment in the field and demonstrate their relative benefits in comparison with other control options for *H. armigera* on selected target crops. ICIPE convened a regional symposium in Ethiopia in 2001, on the potential of this biocontrol agent. NARES in the region have expressed keen interest in linking up with ICIPE in a regional collaboration for promoting the utilisation of NPV as an augmentation biocontrol agent for this pest.

Surveys conducted in Kenya during 1998–2000 helped to assemble and map the distribution of several native NPV isolates. Molecular studies involving restriction endonuclease enzyme analysis (REN) have been initiated and the REN profiles of an initial set of NPV isolates have been characterised with the help of a baculovirus expert from TNAU. Electron microscopic study on sections of the polyhedral occlusion bodies (POBs) of one of the isolates showed that it is a single nucleocapsid (SNPV) subtype of the polyhedrosis virus. Characterisation and cataloguing of the isolates is being undertaken in order to establish a regional gene bank of NPV strains with the collaborative input of a KARI expert from Kenya. One of the Kenyan NPV strains is also being compared with NPV strains from Zimbabwe at the University of Zimbabwe.

Two field trials were held at the ICRISAT station, Kiboko, Kenya during 2000–2001 to evaluate the impact of a native NPV on *H. armigera* larval populations, crop damage and grain yield. Infection by NPV among field-collected larvae from plots sprayed with NPV was about 70%. There was a significant reduction in larval populations in NPV-sprayed plots comparable to plots sprayed with a synthetic chemical insecticide (endosulfan). Pod and seed damage by borers (mostly attributable to *H. armigera*) was also found to be reduced by 40–55% and 60–70%, respectively. NPV sprays also resulted in damage-free seeds comparable to endosulfan sprays in one of the trials. Plans to study the interaction between NPV strains and *H. armigera* populations from different ecologies are also being pursued.

Given ICRISAT's vast experience on *H. armigera* management, ICIPE initiated collaboration with that institute on *H. armigera* management as part of IPM development for pigeon pea and chickpea. During 1999–2000, pheromone monitoring was undertaken in two chickpea production benchmark sites in Ethiopia in collaboration with EARO. During 2000–2001, joint evaluation of local botanicals and tolerant chickpea genotypes was also undertaken in Ethiopia. In Kenya, besides joint evaluation of NPV on pigeon pea (described above) a proposal for collaboration for IPM development on biocontrol was initiated with NRI (UK) and Catholic Relief Services, an NGO in Kenya.

Proposals to strengthen the collaboration in the NPV technology through training, pilot production unit establishment and on-farm demonstration testing with involvement of NGOs are being developed at the request of ICRISAT. An experienced baculovirus expert from TNAU, India was invited as a consultant to provide hands-on training in molecular characterisation of NPV strains and quality control monitoring for NPV. Linkages were also built up with NPV experts from UK (NRI) and Germany (BBA) in developing partnership in promoting the technology through regional network initiatives in Africa.

4. Monitoring of field populations of *H. armigera*

To provide a basis for planning experiments for dose rate assessment for parasitoid release, monitoring of the egg load (infestation level) of *H. armigera* was initiated on six target host crops planted at benchmark sites: eight in Kenya, two in Ethiopia and one each in Tanzania and Uganda. Pheromone trap monitoring of adult male moths has also been initiated to estimate target pest populations in the regions where the trial sites are located. This study is expected to provide information on whether there are qualitative differences among the host populations across the benchmark sites, and on population density within and between crop seasons.

ICIPE hosted the training visit of an entomologist from India (TNAU) interested in the use of pheromone trapping for *H. armigera*. A status paper on the scope for improved use of pheromone trap technology is being developed. A proposal for collaboration combining ICIPE's expertise in chemical ecology and applied ecology with the mass scale field demonstration to be undertaken by the University (TNAU) is also being discussed.

5. Development of an integrated systems biology approach for *H. armigera* management

In addition to the practical considerations to linking biocontrol with other IPM components for *H. armigera* control in important crops in Africa, it is also realised that holistic strategies to manage this polyphagous pest across crops and farms need to be developed. The 'systems biology' approach being evolved for this pest on cotton in Australia could be modified to cater for the small-holder multiple cropping systems common in Africa. Linkages with ACIAR and other researchers in Australia are being pursued.

An ecosystem approach (systems biology) for linking management interventions at crop, farm and community level was developed and presented at a symposium during the African Association of Insect Scientists (AAIS) conference at Addis Ababa in June 2001. Scientists from over 15 countries across Africa participated in the discussions and endorsed ICIPE's lead for developing a partnership initiative for validating and fine-tuning and disseminating this holistic management approach for this highly polyphagous and widespread pest.

6. Networking and information exchange

Information sharing on augmentation biocontrol of *H. armigera* is being undertaken via a newsletter and presentations made at different workshops/ conferences. These include International Trichogramma Workshop at University of California, Riverside, USA; African Regional Symposium on Augmentation Biocontrol at the AAIS conference, Addis Ababa, Ethiopia; Helicoverpa Workshop at ICRISAT, Hyderabad, India. Two invited presentations were also made on augmentation biocontrol, one at the National Biocontrol Symposium in Ludhiana, India and the other at the National Entomological Conference of Tanzania in Arusha. Links have also been established for pursuing collaboration with expert scientists in China (CAAS), India (ICAR, TNAU) and Italy (Perugia University).

Two journal articles have been accepted, two submitted and two are under preparation. Six full papers in conference proceedings and three abstracts have been written.

E. Development of Alternative Options for IPM Promotion and Awareness in Major Vegetable Crops in Eastern and Southern Africa

ICIPE has led a network project during 2000–2001 aimed at developing more sustainable farmer-participatory models for building IPM awareness among smallholder vegetable farmers. Another objective has been to fill in gaps in some of the ready-to-use IPM options available for managing the key pests. The national vegetable research teams in four partner countries—Kenya, Ethiopia, Tanzania and Uganda—are the major collaborating partners in implementing the activities. The component on developing IPM awareness building models also includes refining and validating promising IPM options such as botanicals and biocontrol products. Supportive research is linked to NARS capacity building for expanding the array of IPM options, especially in utilising locally available biocontrol agents and habitat management strategies for priority pests. The project has also undertaken the training of some nationals at PhD and MSc levels.

1. Research for developing a wider range of augmentation biological control options

Research was focused on developing suitable options for managing the key pests, *Helicoverpa armigera*, *Plutella xylostella* and *Thrips tabaci*. Based on collaboration with the Entomopathology Unit of ICIPE, surveys of native pathogens of *P. xylostella* identified one promising isolate of *Bt* and four isolates of *Metarhizium anisopliae*. Pot culture tests on the *Bt* isolate and *M. anisopliae* showed good results for control of *P. xylostella*. During a visit by a baculovirus expert from TNAU, India in 2001, several isolates of granulosis virus (GV) were also assembled and characterised using molecular methods and bioassays.

Biological evaluations were carried out in a collaborative study with the ICIPE Molecular Biology

and Biotechnology Unit and KARI on a new *Bt* product based on *Bt* ssp. *kurstaki*, called Greenguard. The product was tested to evaluate its biocontrol efficacy on populations of *P. xylostella* occurring in contrasting ecologies in Kenya. Data from bioassays and field tests have been assembled for the purpose of registration of the product. This is expected to assist in eventual commercial production under ICIPE's TechnoPark Initiative. In these tests, as well as in follow-up bioassays with additional *Bt* strains, indications are that there is a significant interaction (variability in response) between ecological populations of *P. xylostella* and different strains/products of *Bt*. This information has provided the basis for follow-up studies on *P. xylostella* population variations, in relation to their relative susceptibility/resistance to *Bt* strains, and other attributes of importance for promoting augmentation biocontrol of the target pest. The new *Bt* product was obtained from Bt Research and Development Centre (BtRDC), Hubei, China.

A status paper outlining the scope for utilisation of augmentation biocontrol with egg parasitoids in Africa was developed. Surveys were initiated for native parasitoids in Kenya, from which five accessions of egg parasitoids (one of *Trichogramma* and four of *Trichogrammatoidea*) assembled from *H. armigera*, and 72 accessions (one species of *Trichogrammatoidea*) assembled from *P. xylostella* were identified with the help of experts from University of Hohenheim, Germany. They have been retained as isofemale lines in the gene bank at ICIPE. This work provides a basis for submission of a grant proposal for a regional biocontrol initiative with egg parasitoids in eastern Africa.

2. Ecosystem interactions and habitat management

This approach focuses on component interactions that maximise the impact of safer options from an ecosystem perspective, including use of neem and companion crops together with biocontrol.

Laboratory and field studies were undertaken on the tritrophic interactions of neem products applied as sprays for control of *P. xylostella* with the commonly occurring larval parasitoid, *Diadegma mollipla*. It was found that different products (based on formulation and content of active compounds) differ in the extent of their effect on parasitoid behaviour. The results show that the integrated use of neem should take into account differences in its formulations as well as the differences in habits of the important parasitoid species in the ecosystem.

A study to evaluate the potential of companion crops in influencing *P. xylostella* infestation on cabbage and kale was undertaken. The objective was to identify potential attractant ('pull' type) and repellant ('push' type) companion crops for reducing *P. xylostella* infestations on the target brassicas. Initial laboratory tests on oviposition and larval development showed the potential for mustard/or rape as candidate 'pull' crops and coriander and *Cleome* as 'push' crops.

Laboratory tests on the relative preference for oviposition showed that mustard and kale leaves attracted more oviposition by *P. xylostella* than cabbage, coriander and onion leaves. *Cleome* and rape appeared to be intermediate in their attractiveness for oviposition. These studies are continuing.

Field trials on cabbage plots in which different companion crops had been planted recorded less overall larval infestation than unprotected sole cabbage plots (Fig. 3). Among the six companion crops, coriander, *Cleome* and rape resulted in distinctly lower infestation (numbers of larvae per plant) on the associated cabbage crop, with leaf damage being relatively less severe in plots intercropped with onion, coriander and *Cleome*.

Follow-up studies are being undertaken on the effect of companion crops on the activity of natural enemies such as larval parasitoids. If promising attractant and repellent crops are identified through these studies, it may be possible to develop a 'push-pull' strategy for *P. xylostella* management on cabbage and kale in the region.

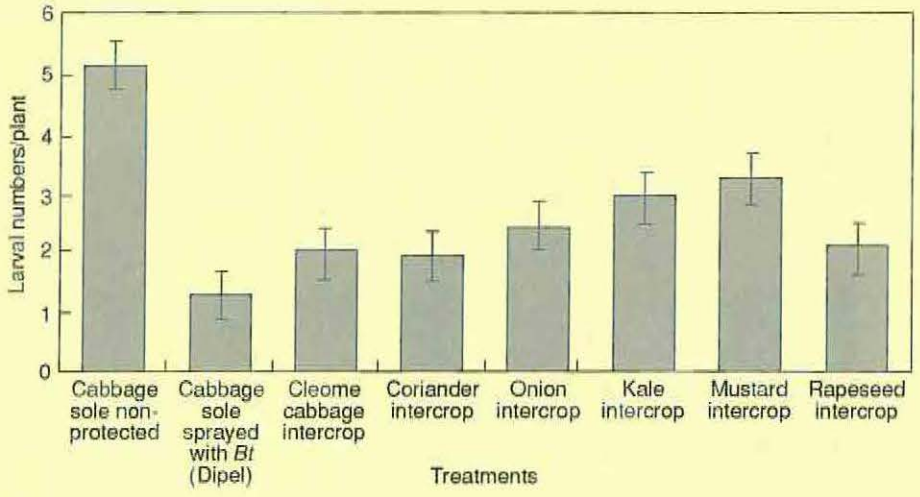


Fig. 3. Effect of companion crops on Plutella xylostella *larval infestation on cabbage, JKUAT, 2000*

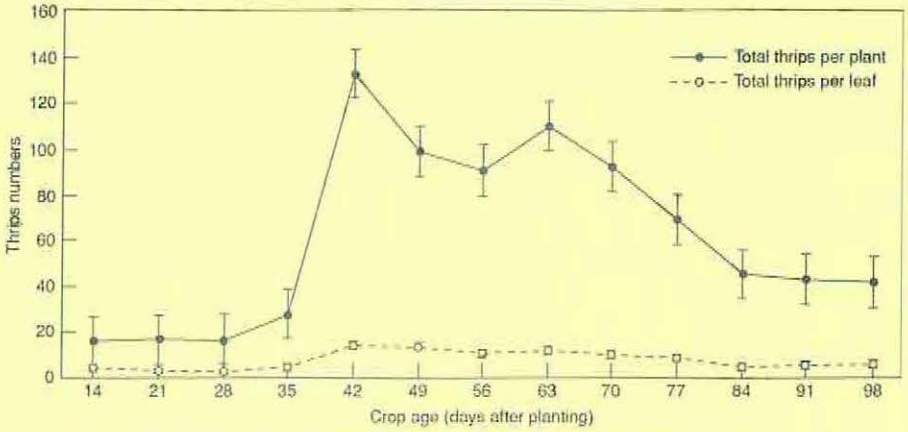


Fig. 4. Infestation pattern of thrips on onion at different crop ages

Further experiments to evaluate the impact of the above companion crops in two ecologies, at low altitudes (with kale) and at high altitudes (with cabbage), is in progress. Tomato has been included as an additional candidate companion crop in these evaluations. This approach to identify beneficial companion crops was discussed and endorsed at a recent symposium on tropical horticultural crops at JKUAT (2001) as a promising approach, which could be fine-tuned to suit the common cropping systems in the region.

3. Development of improved IPM for onion thrips

Onion thrips, *Thrips tabaci*, is emerging as a key constraint to production of onions, in eastern and southern Africa, especially when grown under supplementary irrigation. Studies were undertaken to provide a wider range of IPM options and to develop decision support tools for managing this pest.

The research aspects being addressed under a PhD project include analysing the thrips species distribution in major onion crop production ecologies in Kenya; identifying critical crop growth stages for protection from thrips; relating the thrips numbers per plant at critical stages to the extent of crop loss caused; and evaluating the potential for seedling dips in early stage field protection.

Field monitoring studies have shown that thrips density (on whole plant basis) gradually increased from the second week after transplanting and reached a peak by the sixth week, after which it declined (Fig. 4). Thrips density per leaf also showed the relationship of crop phenology on the pest population build-up. Follow-up experiments to assess the interactions between crop phenology and pest seasonality are being undertaken.

4. Farmer-participatory model activities and impact assessment

These were completed in four countries (Ethiopia, Kenya, Tanzania, Uganda) in collaboration with NARES and NGOs. Over a three-year period of participatory IPM awareness building, major refinements were tested in this model on the deployment of farmer trainers as second-line extensionists to promote group learning at grassroots

ICIPE is developing and assessing IPM methods for control of Thrips tabaci, *an important pest of onion in eastern Africa.*

level. In addition, stepwise awareness-building activities were planned, spread over two to three seasons instead of an intensive single-season programme. Impact assessment showed that the IPM awareness building model activities which are based on modifying some of the components in the Farmers' Fields School approach, are indeed useful for grassroots-level IPM awareness building. Four model groups of vegetable farmers in Thika district of Kenya participated and gained confidence in identifying the pests by their local names. They developed confidence to test improved pest control options in a common plot for each group. By the final phase (third year), a high percentage of these farmers were adopting improved nursery management (95%), planting of pest tolerant varieties (70%), using botanical products such as neem (65%) and biological control products such as *Bt* (40%).

The changes in the attitude of participating farmers' groups to different improved pest management options were positive and contrasted well with non-participating farmers in the same communities and region. Farmer-to-farmer extension is being promoted to enable the exchange of experiences within and between groups and the participating farmers, extensionists and researchers perceived the model as a viable and affordable 'self-help' strategy to access IPM knowledge at the grassroots level, without depending on external support.

5. Expanding the impact of IPM awareness building

An experience-sharing workshop of the IPM network partners from the four partner countries held in Arusha, Tanzania (June 2001), including farmers' representatives and development projects funded by IFAD/USAID, led to the formulation of a 3-year programme to follow up on the experiences gained and lessons learnt in the present phase (which ended in late 2001), so as to produce a wider impact. The multiplier effect will be achieved by establishing additional model groups in major vegetable-producing zones of the partner countries, as well as institutionalising the Training of Trainers (ToT), backed up by production of training materials in local languages for Farmers' Cadre Trainers. Two additional countries (Eritrea and Zambia) participated at this workshop and expressed their keen interest in joining the IPM network in its next phase.

F. Fungus-Based Biopesticides for Control of Thrips and Termites

1. *Metarhizium anisopliae* as a microbial pesticide

The performance of *Metarhizium anisopliae* as a microbial control product for termites has been confirmed by trials in Uganda and the coast region of Kenya. Socioeconomic studies conducted in coastal Kenya also indicate that the fungus-based biopesticide for termite control was acceptable by farmers and that they can easily adopt the technology. A new formulation of granules/spores for soil application against termites in maize agroecosystems has been developed.

The efficacy of Metathripol® has been demonstrated against thrips in five commercial greenhouses on different crops (chrysanthemum, roses, carnations, French beans, snowpea and runner beans).

Metathripol® has also been found to be effective against some of the insect pests of cowpea (pod borers and sucking bugs) and could be incorporated into pigeon pea IPM. Application of the fungus resulted in an increase in grain yield comparable to that using a chemical insecticide. The anti-fungal properties of a tolerant variety of cowpea that could affect the performance of the fungus have been demonstrated.

The use of a strain of *M. anisopliae* in a newly developed contamination device achieved good control of fruit fly populations in a mango orchard in Nguruman, comparable to the chemical insecticide, malathion.

Large-scale production of Metathripol® under ICIPE licence is being explored with DuduTech.

Three MSc students and three PhD students are being supervised in entomopathological research. *(See under Entomopathology Unit report)*

III. LOCUSTS AND MIGRATORY PESTS SUB-DIVISION

INTRODUCTION

The Locusts and Migratory Pests sub-division's strategy is built around two components: the use of the insect's own pheromones to disrupt communication at specific stages and the development of a quantitative understanding of the events associated with outbreaks to serve as a basis of an early warning system. The effectiveness of the pheromones for control—used in tiny amounts at a fraction of the cost of synthetic insecticides—has now been demonstrated in field trials, and the processes involved in the transformation of the insect from harmless solitary individuals to gregarious masses are now well understood. The stage is set for a truly revolutionary approach to managing the desert locust at very early stages in the development of gregarious outbreaks with cheap and environmentally benign tools. These findings provide a model for other locusts and aggregating grasshoppers, as well as migratory pests of other kinds, such as the African armyworm.

Three PhD and three MSc students from Africa are being trained in the programme.

RESEARCH HIGHLIGHTS

A. Locusts Research

1. *Schistocerca gregaria* pheromone studies

Because of the extreme recession during the last three years, field trials with the adult pheromone on natural hopper bands of the desert locust, *Schistocerca gregaria*, could not be undertaken in Sudan.

A large insectary is being developed at Port Sudan for trials and training of EMPRES representatives on pheromone technology.

Locusts are characterised by a pronounced ability to transform reversibly between solitaria and gregaria phases. Maternal effects mediated by a pheromone primes embryonic development of eggs towards gregarious phase, resulting in gregarious hatchlings from solitaria egg-pods and accumulation of gregarious characters across generations. To gain insight into the biochemical events associated with the onset of phase transition of locust eggs exposed to gregarising primer pheromone, a study is being undertaken, with the objectives to determine the different embryonic proteins expressed at the onset of phase transition and to determine the genes expressed during the process.

Solitary females have been shown to be most attractive to gregarising males. This fact constitutes another recruitment mechanism in a gregarising population and the semiochemical signal responsible for transfer of social traits from mothers that experience crowding to their progeny has been identified and opens up another potentially useful area of research in the phase dynamics of locusts.

The pheromonal signal responsible for maternal transfer of gregarious character to the offspring was identified, as part of a PhD project.

A patent on the use of PAN (the major adult pheromone component) in hopper control was granted.

2. Artificial diet for desert locust

As part of the ICIPE-based JIRCAS project, an artificial diet for the desert locust has been developed. Initial studies show that the insect grows faster and mortality is lower when raised on this than on natural diet. More data on the performance of the locusts on the diet will be collected during 2002. In another initiative, the performance of the insect under constant and variable temperature regimes is being studied.

3. Research on the Madagascar locust

Work on the Madagascar locust (*Locusta m. capito*) in collaboration with CABI and FOFIFA is planned to start in 2002. Four PhD and four MSc students (all Madagascar nationals) and a PDF will be involved. [Funds from ADB available to ICIPE: US$ 400,000 for 5 years].

4. Pathogen screening and studies

Screening for pathogens effective against locusts (and grasshoppers) and enhancing the effects of specific pathogens against the desert locust was done. A Germplasm Centre for isolated pathogens and collections from other sources has been established. This is accessible by workers in other institutions via the ICIPE website. A strain of *Metarhizium anisopliae* from infected locusts collected in Sudan (Sudan isolate), potent against the desert and migratory locusts (*Schistocerca gregaria* Forskal and *Locusta migratoria capito, L. m. migratorioides*, respectively) has been isolated. Treatment of desert locust hoppers with the LUBILOSA isolate of *Metarhizium anisopliae* (var. *acridum*) in the presence of the major component of the adult pheromone causes earlier and higher mortality of the insects. Optimisation of the pheromone effect is in progress. (The adult pheromone was previously shown to inhibit hoppers' perception of their own aggregation pheromone, resulting, among other things, in hyperactivity and predisposition to toxication by reduced doses of pesticides).

COMPLETED STUDIES (Abstracts of papers in refereed journals. For full list see Publications List)

STAPLE FOOD CROP PESTS SUB-DIVISION

Call No.: 01-1617

Bonhof M.J. and *Overholt W.A.* (2001) **Impact of solar radiation, rainfall and cannibalism on disappearance of maize stemborers in Kenya.** ***Insect Science and Its Application*** **21(4), 403–407.**

ABSTRACT: The effect of solar radiation, rainfall and cannibalism on the disappearance of eggs and larvae of the cereal stemborer *Chilo partellus* (Swinhoe) were studied. Disappearance and nonviability of egg batches was higher on plants exposed to solar radiation than on shaded plants. Significantly fewer small larvae were recovered from plants exposed to rainfall than from shielded plants. Cannibalism among larvae of the same size was not common except at high larval densities. Contrary to the common belief that disappearance is the result of predation, these studies show that solar radiation and rainfall might also play an important role in the disappearance of stemborer eggs and small larvae.

Call No.: 01-1584

Bonhof M.J., van Huis A., *Kiros F.G.* and *Dibogo N.* (2001) **Farmers' perceptions of importance, control methods and natural enemies of maize stemborers at the Kenya coast.** ***Insect Science and Its Application*** **21(1), 33–42.**

ABSTRACT: A survey among 240 resource-poor farmers at the Kenya coast indicated that insect pests were considered to be the main production constraint. Over 70% of respondents mentioned stemborers to be the most important insect pest. Unlike the eggs and adults, stemborer larvae and pupae were frequently seen by farmers. Alternative gramineous host plants for pests were common near maize fields and were often not destroyed until after the first rains. Nearly all farmers left dry stems and stubble in the field after harvest. Farmers knew of many methods for controlling stemborers, but only 32 and 56% of farmers in Kilifi and Kwale Districts, respectively, used any of the methods..Chemical control was the most popular control method, being applied regularly by 19 and 38% of farmers in Kilifi and Kwale Districts, respectively. Traditional methods and cultural control methods were seldom used. Approximately 50% of farmers had heard of beneficial insects, with farmers collectively mentioning 17 predators of stemborers. Cocoons of the parasitoids *Cotesia flavipes*, released in a biological control programme in the study area in 1993, and the indigenous *Cotesia sesamiae* had been seen by 33% of respondents, but none knew what these were. The results of the present study stress the need to educate farmers about the biology and ecology of stemborers and the role of natural enemies. Also, after effective control methods suitable for resource-poor farmers have been identified, both groups should be trained in pest management methods, for example through the Farmers Field School approach.

Call No.: 01-1569

Chinwada P. and *Overholt W.A.* (2001) **Natural enemies of maize stemborers on the highveld of Zimbabwe.** ***African Entomology*** **9(1), 67–75.**

ABSTRACT: The species composition of maize stemborers and prevalence of their natural enemies at five highveld (>1200 m) sites were studied by random sampling of borer life stages in maize fields. *Busseola fusca* Fuller (Lepidoptera: Noctuidae) was the dominant species and constituted 99% of all larvae and pupae sampled during the study. *Cotesia sesamiae* Cameron (Hymenoptera: Braconidae) was the most abundant and widely distributed parasitoid reared from *B. fusca* larvae, followed by *Sturmiopsis parasitica* (Curran) (Diptera: Tachinidae). Two hyperparasitoids, *Aphanogmus fijiensis* (Ferriere) (Hymenoptera: Ceraphronidae) (from *C. sesamiae* cocoons) and *Dendrocerus rodhaini* (Bequaert) (Hymenoptera: Megaspilidae) (from *S. parasitica* puparia) were recorded. Preliminary data on the occurrence of *C. sesamiae* and *S. parasitica* suggested that these two parasitoids complement each other by partially partitioning their niche and thus minimizing competition. However, firm conclusions concerning the host range and ecological adaptations of the two parasitoids cannot be drawn until detailed studies have been conducted countrywide, especially at lower altitudes (<900 m a.s.l.) where *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) and *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) predominate.

Call No.: 01-1610

Chinwada P., *Omwega C.O.* and *Overholt W.A.* (2001) **Stemborer research in Zimbabwe: Prospects for the establishment of *Cotesia flavipes* Cameron.** ***Insect Science and Its Application*** **21(4), 327–334.**

ABSTRACT: The stemborers *Busseola fusca* (Fuller) and *Chilo partellus* (Swinhoe) cause the highest economic damage to maize and sorghum in Zimbabwe. A number of studies on stemborer bioecology and management in Zimbabwe have been conducted, but most are still incomplete. The more important of these are studies on life history, incidence and distribution patterns, host plants, yield losses, chemical control, cultural control, host plant resistance, the use of sex pheromones, and biological control. These

are discussed here in detail, and areas where further research is needed are pointed out. As part of an integrated strategy for managing stemborers in Zimbabwe, an exotic braconid larval parasitoid, *C. flavipes* Cameron, has been released in the lowveld area and prospects for its establishment appear to be good. However, this establishment might be curtailed mainly by the inability of *Cotesia flavipes* to adapt to the seasonal carryover mechanisms utilised by the indigenous *Cotesia sesamiae* (Cameron).

Call No.: 01-1602

Cugala D. and *Omwega C.O.* (2001) **Cereal stemborer distribution and abundance, and introduction and establishment of *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) in Mozambique. *Insect Science and Its Application* 21, 281–287.**

ABSTRACT: Field surveys carried out in Mozambique showed that two indigenous cereal stemborers, *Busseola fusca* Fuller (Lepidoptera: Noctuidae), *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) and one exotic stemborer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae), are the main pests of maize and sorghum in the country. *Busseola fusca* was abundant at high altitudes (>800 m) and *Ch. partellus* was abundant at low altitudes (< 800 m). *Sesamia calamistis* occurred at all elevations but in low numbers. Of the three stemborers, *Ch. partellus* was the most widespread and abundant pest of maize followed by *Busseola fusca*. Therefore, a programme was initiated to introduce the exotic parasitoid *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) to increase natural suppression of *Ch. partellus* populations. *Cotesia flavipes* was introduced into southern Mozambique for the first time in November 1996. Additional releases were subsequently carried out in several places in southern and central Mozambique from 1998–2000. The parasitoid was recovered from all localities sampled 1 to 3 years after its introduction, indicating that this exotic parasitoid had established in the southern and central regions of Mozambique.

Call No.: 01-1609

Cugala D., *Overholt W.A.*, Santos L. and Giga D. (2001) **Release of *Cotesia flavipes* Cameron for biological control of cereal stemborers in two ecological zones in Mozambique. *Insect Science and Its Application* 21(4), 303–310.**

ABSTRACT: *Cotesia flavipes* Cameron (Hymenoptera: Braconidae), a gregarious larval endoparasitoid of *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) and other stemborers in the Indo-Australian region, was released in Mozambique for the first time in 1996. Before its release, countrywide surveys on stemborers and their natural enemies were conducted in several places. However, all led to the same conclusion: that *C. partellus* was the most abundant stemborer at the majority of locations, and that the rate of larval parasitism was very low (<5%). To evaluate the effect of stemborer species composition on the establishment of *Co. flavipes*, two releases were made at two agroecologically different sites during the 1998/1999 and 1999/2000 growing seasons. *Cotesia flavipes* was recovered from all the three stemborer species found at each site during the season of release and a year later. However, the rates of parasitism were very low, ranging from 0.6 to 1.9% on *Ch. partellus*, 3.2% on *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) and 2.6% on *Busseola fusca* Fuller (Lepidoptera: Noctuidae). The native natural enemy, *Cotesia sesamiae* (Cameron) (Hymenoptera: Braconidae) was the most common larval parasitoid at the two sites. The recoveries of *Co. flavipes* during the release period and a year later indicate that this exotic parasitoid has become established at the two locations in the southern and central regions of Mozambique, in spite of differences in stemborer species composition. However, it is too early to evaluate the impact of *Co. flavipes* on the stemborer populations.

Call No.: 00-1520

Ekesi S. and *Maniania N.K.* (2000) **Susceptibility of *Megalurothrips sjostedti* developmental stages to *Metarhizium anisopliae* and the effects of infection on feeding, adult fecundity, egg fertility and longevity. *Entomologia Experimentalis et Applicata* 94, 229–236.**

ABSTRACT: The susceptibility of immature stages of the legume flower thrips, *Megalurothrips sjostedti*, to the entomopathogenic fungus *Metarhizium anisopliae*, was investigated under laboratory conditions. The adult stage was found to be more susceptible to infection than the larval and pupal stages. Mortality at all stages was dose-dependent, with the highest concentration of 1×10^8 conidia ml^{-1} producing the highest mortality (26, 46 and 100% for larvae, pupae and adults, respectively) at 8 days post-inoculation. At the same concentration, daily pollen consumption was significantly reduced at 2 days after treatment in infected adults but more slowly in infected larvae. Fecundity, egg fertility and longevity in adults surviving infection as larvae were significantly reduced compared to the control.

Call No.: 01-1572

Ekesi S., Maniania N.K., Ampong-Nyarko K. and Akpa A.D. (2001) **Importance of timing of application of the entomopathogenic fungus, *Metarhizium anisopliae*, for the control of legume flower thrips, *Megalurothrips sjostedti* and its persistence on cowpea. *Arch. Phytopath. Pflanz.* 33, 431–445.**

ABSTRACT: Field experiments were conducted for two seasons to evaluate the timing of application of the entomopathogenic fungus, *Metarhizium anisopliae*, for the control of legume flower thrips, *Megalurothrips sjostedti* on cowpea. One application of *M. anisopliae* timed at flower bud stage and another at flowering stage did not protect cowpea yield against *M. sjostedti* as does chemical insecticide,

Karate (Lambda-cyhalothrin). Instead, one application of the fungus given at flower bud stage and two applications given at flowering were required to keep *M. sjostedti* population in check through these stages, which are very sensitive to thrips damage with a concomitant increase in cowpea yield which was significantly higher than the Karate treatment. Studies of persistence showed that *M. anisopliae* remained active in the field for 3–4 days.

Call No.: 00-1531

Ekesi S., Maniania N.K. and *Lwande W.* (2000) **Susceptibility of the legume flower thrips to *Metarhizium anisopliae* on different varieties of cowpea.** ***BioControl* 45, 79–95.**

ABSTRACT: The susceptibility of *Megalurothrips sjostedti* to *Metarhizium anisopliae* when reared on susceptible, tolerant, and moderately resistant varieties of cowpea at different constant temperatures was evaluated in the laboratory. Insects were exposed either to direct spray of the conidia or to fungus-treated floral tissues. Mortality was significantly higher on the moderately resistant variety at all temperatures compared to the susceptible and tolerant varieties. Correspondingly, lethal time and lethal concentration values were significantly shorter and lower, respectively, on the moderately resistant variety compared to the other varieties, thus indicating that the two control methods are compatible as part of an integrated pest management strategy. Thrips raised on the tolerant variety incurred an exceptionally low level of mortality when the inoculum was sprayed directly on the insects or when the insects were exposed to fungus-treated floral tissues. Observations on the effects of airborne volatiles and crude extracts of this variety revealed an inhibitory effect on fungal germination, colony forming units and growth. This suggests the existence of anti-fungal substances in the tolerant variety.

Call No.: 01-1615

Khan Z.R., Pickett J.A., Wadhams L. and Muyekho F. (2001) **Habitat management strategies for the control of cereal stemborers and striga in maize in Kenya.** ***Insect Science and Its Application* 21(4), 375–380.**

ABSTRACT: Maize is the principal food and cash crop for millions of people in the predominantly mixed crop–livestock farming systems in Kenya. Stemborers and striga (*Striga hermonthica*) are major constraints to increased maize production in eastern Africa. An intercropping and trap crop system has been developed, using a 'push-pull' strategy, for the control of stemborers in smallscale maize farming systems. The 'push-pull' strategy involves trapping stemborers on highly susceptible trap plants (pull) and driving them away from the crop using repellent intercrops (push). Napier grass (*Pennisetum purpureum* Schumach) and Sudan grass (*Sorghum vulgare sudanense* Stapf.) are used as trap plants, whereas molasses grass (*Melinis minutiflora* Beauv.) and two species of desmodium (*Desmodium uncinatum* Jacq. and *Desmodium intortum* Urb.) repel ovipositing stemborers. The integrated 'push-pull' strategies were shown to increase parasitism of stemborers through attraction of parasitoids to one of the intercrops, molasses grass. The leguminous intercrop, silver leaf desmodium, drastically reduced damage to maize by the parasitic weed, striga. This aspect was further investigated and developed for integration with stemborer control. On-farm trials with farmers in Kenya have shown significant yield increases in maize farming.

Call No.: 00-1558

Khan Z.R., Pickett J.A., van den Berg J., Wadhams L.J. and Woodcock C.M. (2000) **Exploiting chemical ecology and species diversity: Stem borer and striga control for maize and sorghum in Africa.** ***Pest Management Science* 56, 957–962.**

ABSTRACT: Stem borers, comprising the larvae of a group of lepidopterous insects, and parasitic witchweeds, particularly *Striga hermonthica* and *S. asiatica*, cause major yield losses in subsistence cereal production throughout sub-Saharan Africa. Studies are described that have led to the development of a 'push-pull' strategy for minimising stem borer damage to maize and sorghum. This involved the selection of plant species that could be employed as trap crops to attract colonisation away from the cereal plants, or as intercrops to repel the pests. The two most successful trap crop plants were Napier grass, *Pennisetum purpureum*, and Sudan grass, *Sorghum sudanensis*. The intercrop giving maximum repellent effect was molasses grass, *Melinis minutiflora*, but two legume species, silverleaf, *Desmodium uncinatum*, and greenleaf, *D. intortum*, gave good results and had the added advantage of suppressing development of *S. hermonthica*. In terms of stem borer control, the plant chemistry responsible involves release of attractant semiochemicals from the trap plants and repellent semiochemicals from the intercrops. With *M. minutiflora*, parasitism of stem borers was also increased by certain chemicals repellent to ovipositing adults. The mechanism of striga control has not been fully elucidated, but allelopathic effects from the *Desmodium* species have been shown to involve stimulation of germination and interference with haustorial development. Significant beneficial effects have been obtained with the individual components of these push-pull strategies. However, the most robust crop-protection package is obtained when these components are combined. The trap crop and intercrop plants also provide valuable forage for cattle, often reared in association with subsistence cereal production. There has been considerable take-up of the system within the communities where farmer-managed trials have been carried out, particularly in the Trans Nzoia and Suba districts of Kenya, and the programme is set to expand throughout and beyond Kenya.

Call No.: 00-1557

Kimani S.M., Chhabra S.C., *Lwande W., Khan Z.R., Hassanali A.* and Pickett J.A. (2000) **Airborne volatiles from *Melinis minutiflora* P. Beauv., a non-host plant of the spotted stem borer.** ***Journal of Essential Oil Research*** **12, 221–224.**

ABSTRACT: Airborne volatiles released by *Melinis minutiflora* P. Beauv., a non-host plant of the spotted stem borer, *Chilo partellus* (Swinhoe), were trapped from the live plant by air entrainment into porous polymer Porapak Q and analyzed by GC and GC/MS. The main hydrocarbons identified and confirmed by co-injection with authentic samples on two columns of different polarities were (3E)-4,8-dimethylnona-1,3,7-triene (28.1% of isolated volatiles) and β-caryophyllene (24.2% of isolated volatiles). Of these, (3E)-4,8-dimethylnona-1,3,7-triene is electroantennographically active (EAG) against *Chilo partellus* (Swinhoe).

Call No.: 01-1619

Matama-Kauma T., Kyamanywa S., Ogwang J.A., *Omwega C.O.* and Willson H.R. (2001) **Cereal stemborer species complex and establishment of *Cotesia flavipes* Cameron in eastern Uganda.** ***Insect Science and Its Application*** **21(4), 317–325.**

ABSTRACT: Studies were conducted in two districts of eastern Uganda from 1997 to 1999 to introduce and monitor the establishment of an exotic parasitoid, *Cotesia flavipes* Cameron (Hymenoptera: Braconidae), for the control of the stemborer *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae), and also to determine the stemborer species complex in maize and sorghum. The study confirmed the presence of four important stemborers, two pyralids *Ch. partellus* and *Eldana saccharina* Walker and two noctuids, *Busseola fusca* Fuller and *Sesamia calamistis* Hampson. *Chilo partellus* was dominant, constituting 53–88% of stemborers found followed by *B. fusca* at 8–37%. The most abundant local parasitoid was the larval parasitoid *Cotesia sesamiae* (Cameron) (Hymenoptera: Braconidae). The pupal parasitoids *Pediobius furvus* Gahan (Hymenoptera: Eulophidae) and *Dentichasmias busseolae* Heinrich (Hymenoptera: Ichneumonidae) were also recorded. Parasitism of *Co. sesamiae* on *Ch. partellus* ranged between 0 and 13.1%. The introduced *Cotesia flavipes* was recovered from all sites in four consecutive seasons (between 1998 and 1999) causing parasitism of between 4 and 32.9% on *Ch. partellus*. *Cotesia flavipes* was also recovered from the indigenous stemborers *B. fusca* and *S. calamistis*. This study indicates that *Co. flavipes* has established in eastern Uganda.

Call No.: 01-1614

Ngi-Song A.J. and *Mochiah M.B.* (2001) **Polymorphism for *Wolbachia* infections in eastern and southern African *Cotesia sesamiae* (Cameron) (Hymenoptera: Braconidae) populations.** ***Insect Science and Its Application*** **21(4), 369–374.**

ABSTRACT: *Cotesia sesamiae* (Cameron) (Hymenoptera: Braconidae) is an indigenous, gregarious, larval endo/parasitoid which is widely distributed in Africa and attacks mid- to late instars of stemborers. There is renewed interest in using *Cotesia sesamiae* for biological control to reduce the problems caused by stemborers. However, *Wolbachia* sp., a bacterial symbiont of some populations of *Co. sesamiae*, poses some threat to the successful use of the parasitoid for stemborer control. This bacterium's common effect is cytoplasmic incompatibility between infected males and uninfected females. Polymerase chain reaction (PCR) tests were carried out on parasitoid samples collected from 5 locations in Kenya and 8 other countries in eastern Africa. *Wolbachia* presence was detected in *Co. sesamiae* populations from Coast and Machakos in Kenya, and from samples collected from 6 other eastern and southern African countries. No infection was detected from western Kenya, Uganda and Malawi. Cross mating among 3 infected populations (North Coast, South Coast and Machakos) and 2 uninfected populations (Kitale and Kuja) was done to establish which populations were reproductively compatible. Biological parameters, such as brood size and percent females were compared among the different crosses. One-way incompatibility, indicative of *Wolbachia* infection, was observed from the crosses between males of either Mombasa or Machakos and females from Kitale. Selection of compatible *Co. sesamiae* populations is critical to successful augmentation biological control programmes.

Call No.: 01-1568

Ngi-Song A.J., Kimani-Njogu S. and *Overholt W.A.* (2001) **Multiple parasitism by *Cotesia sesamiae* and *Cotesia flavipes* (Hymenoptera: Braconidae) on *Busseola fusca* (Lepidoptera: Noctuidae).** ***Biocontrol Science and Technology*** **11, 381–390.**

ABSTRACT: *Busseola fusca* (Fuller) is one of the most important pests of cereals in sub-Saharan Africa. *Cotesia sesamiae* (Cameron) is the predominant parasitoid attacking *B. fusca* larvae in many parts of Africa. An exotic parasitoid, *Cotesia flavipes* Cameron, was introduced into Kenya in 1993 for the control of *Chilo partellus* (Swinhoe). Laboratory studies indicated that although *C. flavipes* would search for, and attack *B. fusca*, it was not able to complete its development in this host. The aim of the present study was to investigate the outcome of multiple parasitism of *Busseola fusca* by the two *Cotesia* species. The study showed that when both parasitoid species stung a *B. fusca* larva at the same time, both parasitoids emerged from more than half of the host larvae, *C. flavipes* alone emerged from 17%, and *C. sesamiae* alone emerged from 9%. When the larvae were parasitized by *C. sesamiae* first, and then 2 h

later by *C. flavipes*, and vice versa, most of the progeny were *C. flavipes*. However, when *B. fusca* larvae were stung by *C. sesamiae* three days before oviposition by *C. flavipes*, significantly more *C. sesamiae* emerged from the larvae. When *C. flavipes* oviposited first, no larvae produced *C. flavipes* only. The interaction of parasitoids and the host immune system, and the implications of these results for the biological control of stem borers in East Africa are discussed.

Call No.: 00-1562

Ngi-Song A.J., Njagi P.G.N., Torto B. and *Overholt W.A.* (2000) **Identification of behaviourally active components from maize volatiles for the stemborer parasitoid *Cotesia flavipes* Cameron (Hymenoptera: Braconidae).** ***Insect Science and Its Application*** **20(3), 181–189.**

ABSTRACT: In the present study, Y-tube olfactometric assays confirmed that volatiles from maize seedlings infested with *Chilo partellus* larvae were more attractive to the borer's larval endoparasitoid *Cotesia flavipes*, than volatiles from uninfested maize. Coupled gas chromatography-electroantennographic detector (GC-EAD) analysis of the volatiles from larvae-infested maize revealed six electrophysiologically active compounds on the antennae of the female parasitoid. These compounds were identified by GC-MS as (*Z*)-3-hexenyl acetate, linalool, (*E*)-4,8-dimethyl-1, 3, 7-nonatriene, heptanal, (*E*)-β-ocimene and a C-5 aliphatic compound. (*E*)-4,8-Dimethyl-1, 3, 7-nonatriene was present in EAG-detectable amounts in the volatiles of uninfested seedlings. In bioassays, a blend comprised of (*Z*)-3-hexenyl acetate, linalool, (*E*)-4,8-dimethyl-1,3,7-nonatriene, (*E*)-β-ocimene and heptanal was significantly attractive to the parasitoid. Of the individual compounds, (*Z*)-3-hexenyl acetate was attractive at the doses tested while (*E*)-4,8-dimethyl-1, 3, 7-nonatriene and heptanal showed varying degree of attractiveness to the parasitoid at different doses. Linalool and (*E*)-β-ocimene were unattractive at the same doses. The significance of these results is discussed.

Call No.: 01-1612

Nsami E., Pallangyo B., Mgoo V. and *Omwega C.O.* (2001) **Distribution and species composition of cereal stemborers in the eastern zone of Tanzania.** ***Insect Science and Its Application*** **21(4), 347–351.**

ABSTRACT: A survey was conducted in the four regions of Tanga, Morogoro, Coast and Dar es Salaam in eastern Tanzania to determine the distribution and species composition of cereal stemborers and their natural enemies. A total of 22 fields were sampled in Tanga, 28 in Morogoro, 17 in Coast and one in Dar es Salaam. *Chilo partellus* was found to be the predominant species, accounting for 80% of all stemborers collected. *Busseola fusca, Sesamia calamistis* and *Chilo orichalcociliellus* made up 15, 4 and less than 1% of the stemborers collected respectively. Infestation levels varied with the age of the plants, whereby younger plants were more severely infested (infestation ranging from 20–40%) than mature plants (infestation ranging from 5–15%). Two larval parasitoids, *Cotesia sesamiae* and *Cotesia flavipes*, were the main natural enemies collected. However, the levels of parasitism of the stemborers were very low. The exotic natural enemy *Co. flavipes* may have spread from the Kenya coast (where it is established) into eastern Tanzania.

Call No.: 01-1560

Sallam M.N., *Overholt W.A.* and Kairu E. (2001) **Dispersal of the exotic parasitoid *Cotesia flavipes* in a new ecosystem.** ***Entomologia Experimentalis et Applicata*** **98, 211–217.**

ABSTRACT: A study on the dispersal of the exotic larval endoparasitoid, *Cotesia flavipes* Cameron (Hymenoptera: Braconidae), was conducted in a maize field in the northern Kilifi District in the coastal area of Kenya. Because *Co. flavipes* did not previously occur in the release area, it was possible to use a unique indirect method to estimate dispersal by examining the distribution of parasitised hosts. Parasitoids released in the centre of the field moved as far as 64 metres during their life span, and dispersal was dependent on wind direction. The level of parasitism was influenced by the location of hosts in plants. The majority of parasitised stemborers (88.4%) were found inside the plant (stems and tassel stems), where 74.3% of the suitable hosts were found, which indicates that female parasitoids were not searching randomly for hosts. Aggregation of parasitoids in response to plants with different host densities was not detected. Implications of the release of *C. flavipes* on stemborers population in the agroecosystem of East Africa are discussed.

Call No.: 01-1608

Sallam M.N., *Overholt W.A.*, Kairu E. and *Zhou G.* (2001) **Will *Cotesia flavipes* drive its African homologue, *Cotesia sesamiae*, to extinction?** ***Insect Science and Its Application*** **21(4), 297–302.**

ABSTRACT: This paper addresses the competitive interaction between *Cotesia sesamiae*, a gregarious larval endoparasitoid that is native to Africa, and *Cotesia flavipes*, an introduced parasitoid from southern Pakistan which has recently been established in East Africa for biological control of the exotic stemborer, *Chilo partellus*. The two parasitoids are morphologically similar, and they both attack medium-sized to large larval stages of gramineous lepidopteran stemborers. Based on previous work which suggested that *Cotesia flavipes* was competitively superior to *Co. sesamiae*, we speculated that *Co. sesamiae* may be locally extirpated in some areas of Africa. However, evidence from the field does not support this

prediction. Recent field surveys in areas where both parasitoids occur, revealed that *Co. sesamiae* was still present, and densities were not declining. The interaction of the two parasitoids, as well as the influence of this interaction on host regulation, are discussed.

Call No.: 01-1597

Songa J.M., *Zhou G.* and *Overholt W.A.* (2001) **Relationships of stemborer damage and plant physical conditions to maize yield in a semi-arid zone of Eastern Kenya.** ***Insect Science and Its Application*** **21(3), 243–249.**

ABSTRACT: A field survey on maize stemborers, stemborer damage, maize plant physical conditions, and maize yield was conducted in eastern Kenya under natural conditions. *Chilo partellus* was the dominant stemborer accounting for 89.5% of all borers. Stemborer damage greatly reduced maize yield, with tunnel lengths greater than 20 cm causing a 40% reduction of potential yield. A 33% yield loss was found in plants with more than one stemborer exit hole. Each stemborer (at harvest time) was correlated with a 8–10% yield loss. Good plant physical characteristics significantly increased grain yield. Principle component analysis showed that stemborer damage, plant height and stem diameter were key factors affecting maize grain yield. Regression analysis indicated that one centimetre of stemborer tunnel reduced yield by 3 g/plant. Multiple regression analysis implied a 13.3 ± 1.5 g yield loss (8–10% of potential yield) due to the damage of a single stemborer. Comparison with average yields in the study area suggested that our results were representative of losses on farmers' fields.

Call No.: 01-1603

Songa J.M., *Overholt W.A.*, Mueke J.M. and Okello R.O. (2001) **Colonisation of *Cotesia flavipes* (Hymenoptera: Braconidae) in stemborers in the semi-arid Eastern Province of Kenya.** ***Insect Science and Its Application*** **21(4), 289–295.**

ABSTRACT: A study was conducted at Katumani, Kiboko and Ithookwe, in the semi-arid Eastern Province of Kenya for four seasons (short rains 1996 – long rains 1998), to confirm the major stemborers of maize, and to introduce and monitor the colonisation of *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) in these stemborers. About 6750 adults of *Cotesia flavipes* were released at each site, from 'release stations', starting one week after plant emergence and repeated fortnightly up to harvest. Pre-release parasitism of the stemborers was determined, for two seasons prior to release of *Co. flavipes*, during the season of release and one season after the release of this parasitoid. Parasitism was assessed from developmental stages of the stemborers recovered through destructive sampling of 100 plants, starting one week after plant emergence. This was repeated weekly at Katumani, and fortnightly at Kiboko and Ithookwe until harvest. The stemborers recovered from maize were *Chilo partellus*, *Sesamia calamistis*, *Cryptophlebia leucotreta* and *Busseola fusca* in descending order of abundance, with *Ch. partellus* being the most widespread stemborer. *Cotesia flavipes* parasitised and successfully colonised *Ch. partellus* and *S. calamistis* in the three sites during the season of release and one season post-release of the parasitoid. Parasitism by *Co. flavipes* ranged from 7.14–25.80%. The colonisation rate of *Co. flavipes* in the two major stemborers in the semi-arid Eastern Province of Kenya suggests the high potential of this parasitoid in regulating populations of stemborers that attack maize in this region.

Call No.: 01-1595

Zhou G. and *Overholt W.A.* (2001) **Spatial-temporal population dynamics of *Cotesia flavipes* (Hymenoptera: Braconidae) in Kenya.** ***Environmental Entomology*** **30(5), 869–876.**

ABSTRACT: The spatial-temporal population dynamics of an imported parasitoid of stemborers, *Cotesia flavipes* Cameron, were analyzed. A two-step spatial interpolation method, spatial splines with Kriging of the residuals, was developed for interpolating the distribution of *Co. flavipes* in Kenya. The results indicate that *Co. flavipes* has become established throughout the whole southern part of Kenya and northern part of Tanzania, and that the population density of *Co. flavipes* in maize fields is still increasing. The maximum *Co. flavipes* density was about one parasitized borer per plant in the first growing season of 1999. The mean *Co. flavipes* densities varied from region to region in 1999, with the highest density (five parasitized borers per 20 plants) in the southeast and the lowest parasitism in central Kenya (one parasitized borer per 20 plants). The percentage of sites occupied by *Co. flavipes* was 90% in the southeastern area during the first growing season of 1999. In coastal Kenya, *Co. flavipes* occupied >70% of the sampling sites, compared with ~50% in both central and western Kenya. Over the whole sampling area, *Co. flavipes* increased its distribution from 60% of sites occupied in 1994– 80% in 1999. Temporally, *Co. flavipes* population density remained low, with an average of less than one parasitized borer per 20 plants, until the second growing season of 1997–1998, when there was a sharp increase. The suppression of stemborer populations by *Co. flavipes* appeared in southeastern and coastal Kenya from 1998. Analyses indicated that *Co. flavipes* was a minor parasitoid before 1995, but had become the predominant parasitoid after 1998. The results of the spatial interpolation showed that the *Co. flavipes* population did not spread much from the release sites before the first growing season of 1996, but expanded tremendously after the first growing season of 1997. The spatial interpolation model was validated with field data from 1999. The model predicted the *Co. flavipes* density well at the zonal level but underestimated *Co. flavipes* density country-wide. The possible displacement of an ecologically similar native congener, *Co. sesamiae*, is discussed.

Call No.: 01-1631

Zhou G., Baumgärtner J. and *Overholt W.A.* (2001) **Impact assessment of an exotic parasitoid on stemborer (Lepidoptera) population dynamics in Kenya.** ***Ecological Applications*** **11(5), 1554–1562.**

ABSTRACT: A ratio-dependent host–parasite interaction model with a linear trend was developed to analyze the impact of the exotic parasitoid *Cotesia flavipes* (Cameron) (Hymenoptera: Braconidae) on stemborer population dynamics in the southern coastal area of Kenya. The time dependence of the host and that between the host and parasitoid were tested using autocorrelation and cross-correlation functions. The criterion for measuring the parasitoid impact was the difference between the model predictions with and without the parasitoid. The results indicated that the suppressive impact of the parasitoid on stemborer densities began in the short rains season of 1997–1998 in the northern part of the coast zone but was only seen in the southern part of the coast beginning with the long rains season of 1999. The density reduction of the total stemborer complex, which includes one alien and two native species, by *C. flavipes* was 1.05 ± 0.25 larvae per plant in the north coast and 0.62 ± 0.58 larvae per plant in the south coast during the long rains season of 1999. The reduction of the exotic stemborer *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) by *C. flavipes* was 0.99 ± 0.25 larvae per plant in the north coast in the long rains season of 1999, or a 52.94 ± 13.37% decrease of the *C. partellus* density. In the south coast, the reduction was 0.83 ± 0.41 larvae per plant or ~ 33.07 ± 16.33% decrease in the *C. partellus* density.

Call No.: 01-1616

Zhou G., Overholt W.A. and *Mochiah M.B.* (2001) **Changes in the distribution of lepidopteran maize stemborers in Kenya from the 1950s to 1990s.** ***Insect Science and Its Application*** **21(4), 395–402.**

ABSTRACT: Three hundred and ninety-two maize fields in the southern arable zone of Kenya were sampled for lepidopteran cereal stemborers from 1996–2000. *Chilo partellus* (Swinhoe) was the most abundant stemborer, and was found at all locations with elevations below 1500 m, and at some locations between 1500 and 2300 m. The highest density of *C. partellus* was in the semi-arid ecological zone of eastern Kenya. *Chilo orichalcociliellus* (Strand) was found in the lowland southern coastal area, and a few inland sites on the border of Tanzania in southeastern Kenya. *Busseola fusca* Fuller was dominant in highland areas. In the Lake Victoria Basin, which has an elevation of about 1100 m, *B. fusca* was dominant at some sites, but overall, *C. partellus* was more abundant. *Sesamia calamistis* Hampson was present at all elevations and all locations, but typically at low densities. *Eldana saccharina* (Walker) was found in two-thirds of the fields sampled in the Lake Victoria Basin. These results are compared with the distributions of the various stemborers in the 1950s to 1960s, as reported in the literature.

HORTICULTURAL CROP PESTS SUB-DIVISION

Call No.: 01-1596

Sithanantham S., Abera T.H., Baumgärtner J., Hassan S.A., Löhr B., Monje J.C., *Overholt W.A.,* Paul A.V.N., Wan F.H. and Zebitz C.P.W. (2001) **MINI REVIEW: Egg parasitoids for augmentative biological control of lepidopteran vegetable pests in Africa: Research status and needs.** ***Insect Science and Its Application*** **21(3), 189–205.**

ABSTRACT: Among the important constraints to vegetable production in Africa are the lepidopteran pests, in particular *Helicoverpa armigera* (Hb.) and *Plutella xylostella* (L.) which cause direct yield loss as well as cosmetic damage. Egg parasitoids, especially *Trichogramma* spp., have shown promise as biocontrol agents against both species in previous studies. In Africa, surveys have so far recorded 18 species of *Trichogramma*, eight of *Trichogrammatoidea* and seven of *Telenomus* besides one species each of *Baryscopus* and *Oencyrtus*. For effective utilisation of egg parasitoids in vegetable ecosystems in Africa, the experience gained elsewhere should be suitably utilised, and complementary research undertaken. This paper examines the scope for use of egg parasitoids in Africa, focusing on five research areas. Firstly, surveys should be undertaken to collect, characterise, and catalogue the different species and strains of egg parasitoids occurring in the region. Secondly, the pest status of target Lepidoptera and the potential demand for use of egg parasitoids in the major ecologies should be assessed. Thirdly, the local and / or exotic species / strains with good potential to control *H. armigera* and *P. xylostella* need to be identified, and fourthly, analyses aimed at selecting appropriate mass production and delivery systems for *Trichogramma* use in major vegetable crops should be undertaken. Finally, optimisation of inundative release strategies should be researched on. The scope for research collaboration within Africa and internationally is discussed.

MIGRATORY PESTS SUB-DIVISION

Call No.: 00-1540

Bashir M.O., Hassanali A., Rai M.M. and *Saini R.K.* (2000) **Changing oviposition preferences of the desert locust, *Schistocerca gregaria*, suggest a strong species predisposition for gregarization.** ***Journal of Chemical Ecology*** **26(7), 1721–1733.**

ABSTRACT: Field surveys at five sites within desert locust breeding habitats around Port Sudan during three successive seasons indicated that early in the rainy season the incoming solitary females oviposited predominantly in the vicinity of *Heliotropium* spp. (~66%) and millet (~32%) seedlings. Solitary nymphs also preferred to feed on these plants. Follow-up cage experiments were conducted in the field in which solitary and gregarious female locusts were presented with choices of selected desert plants and egg pods. When presented with bulrush millet, *Heliotropium* spp., *Zygophyllum simplex*, and untreated moistened sand, solitary females oviposited adjacent to the first two plants (40% and 60%, respectively). However, when offered a choice of either or both of these plants together with egg pods derived from gregarious and/or solitary insects, solitary females showed a significantly higher preference for ovipositing near *gregaria* egg pods than near the plants, with *solitaria* egg pods eliciting the least response. In contrast with solitary females and in the absence of *gregaria* egg pods, gregarious females preferred to oviposit in untreated moist (control) sand (74–77%) away from the plants (6–14%) or *solitaria* egg pods (~4%). However, when present, *gregaria* egg pods elicited significantly more oviposition. These and previous results indicate a hierarchy of phase-dependent oviposition preferences in the desert locust and are interpreted in terms of a strong propensity of the species to exploit opportunities under appropriate conditions to facilitate congregation and the gregarization of the progeny.

Call No.: 00-1537

Mahamat H., Hassanali A. and *Odongo H.* (2000) **The role of different components of the pheromone emission of mature males of the desert locust, *Schistocerca gregaria* (Forskål) (Orthoptera: Acrididae) in accelerating maturation of immature adults.** ***Insect Science and Its Application*** **20(1), 1–5.**

ABSTRACT: Different blends of five chromatographically prominent components of the pheromone emission of gregarious-phase mature desert locust *Schistocerca gregaria* (Forskål) (Orthoptera: Acrididae) males were bioassayed for their maturation-accelerating effects on immature counterparts. The blend of all five components, namely anisole, veratrole, benzaldehyde, phenylacetonitrile and 4-vinylveratrole was as effective as the emission from live mature males in accelerating the onset of mating in immature males. Substraction of anisole had no significant effect but removal of any one of the other four components significantly reduced the acceleration potency of the resulting blends. The maximum reduction occurred in the absence of phenylacetonitrile which appears to be critical to the activity of the blend. The magnitude of reduction in maturation acceleration that resulted from the substraction of the other three components suggests that, although present in lesser relative amounts, these compounds contribute significantly to the activity of the full blend. Some differences were found between the onset of integumental yellowing and mating which indicate that blends of slightly different compositions are involved in promoting these two physiological processes.

Participating scientists: B. Löhr (Division Head), W. A. Overholt, Z. R. Khan, S. Sithanantham, S. Lux, A. Hassanali, E. Osir, J. Baumgärtner, N. Maniania, R. Pasquet, C. Omwega, A. J. Ngi-Song, G. Zhou, B. Torto, P. Njagi, A. Seif, J. W. Ssennyonga, J. Maitima, M. O. El-Bashir, S. Nakamura, K. Gikonyo, J. C. Mulindo, S. Ekesi, M. Knapp, N. Zenz.

Collaborators: IITA; ICRISAT; NARS/Universities in Kenya, Uganda, Ethiopia, Zanzibar, Zambia, Zimbabwe, Malawi, Mozambique and Tanzania; BiONET-Africa; CABI; FOFIFA; JIRCAS; FAO; GTZ; ADB; IFAD; IACR-Rothamsted; Kenya Agricultural Research Institute (KARI); Ministry of Agriculture and Rural Development, Kenya; National Agricultural Research Organisation (NARO), Uganda; Bvumbwe, Limbe and Chitedze Research Stations, Lilongwe, Malawi; Ethiopian Agricultural Research Organisation (EARO); Agricultural Research Corporation (ARC), South Africa; ICRISAT; IWMI; University of Hohenheim and BBA, Germany; NRI, UK; TNAU, India; ICAR and IARI, India; CAAS, China; Melkassa Research Centre, Ethiopia; PPRI, South Africa; German-Tanzanian IPM Project/Plant Health Division; Kibaha Biocontrol Centre, Tanzania; PPRI (Zimbabwe); USDA Agric. Res. Station, Montpellier, France; AVRDC (Taiwan); UNBRP/NARO, USAID/IDEA project, Kampala, Uganda; AVRDC-ARP, Arusha, Tanzania; Kenyatta University, University of Nairobi and JKUAT, Kenya; Fresh Produce Exporters' Association of Kenya (FPEAK); Horticultural Crops Development Authority (HCDA), Kenya; National Vegetable Team, Horti-Tengeru Research and Training Centre, Arusha; National Vegetable Team, Kawanda Agricultural Research Institute (NARO), Kampala; CABI Bioscience, Kenya; SYV, Benin; Makerere University, Uganda; INRA; IAPSC/OAU; IGG-TF of FAO; Commodity and Trade Division, Rome; TFNET, Malaysia; National Museums of Kenya (NMK); CIRAD, France; Natural History Museum (NHM), UK; Royal Museum for Central Africa, Belgium; USDA; Texas A&M University; University of Hawaii; University of Florida; University of Pavia, Italy; University of Madrid, Spain.

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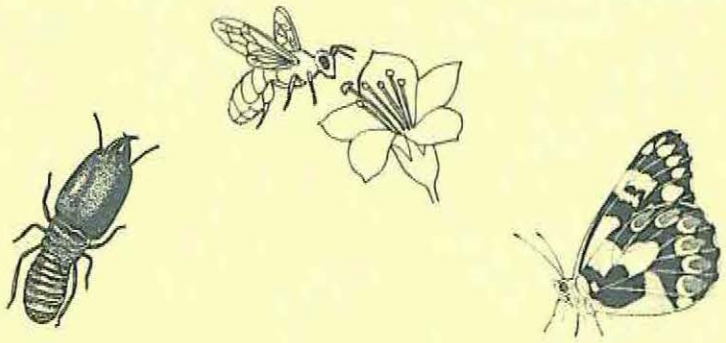
4. Environmental Health Division



INTRODUCTION

Barriers of discrimination and significant inequalities of power, income and opportunity are limiting people's ability to thrive or even survive. With unrelenting over-exploitation, human beings have reduced the natural environment and its biodiversity. Ninety percent of the land surface has been disturbed to some extent and 5% is burnt annually. An annual reduction of this magnitude translates into about 0.5% loss in species. Adequate protection of the most critical areas of biodiversity would ensure the survival of a wide variety of flora and fauna. ICIPE has reached these conclusions by analysis of information on species distribution in Africa. The Centre has several research and training activities that deal with inventory, conservation and utilisation of biodiversity. This fairly new programme started six years ago with the silk and beekeeping projects, and has now been extended to include the environmental impact of genetically modified organisms (GMOs), the contribution of arthropods to ecosystem services ranging from soil biota to pollinators, and bioprospecting for medicinal plants and other income-generating products for insect control and other uses. ICIPE's Environmental Health Division (EHD) strategy corresponds closely to the Global Environmental Facility (GEF) biodiversity and conservation approach.

The early years of these work plans focus on basic foundational R&D activities that will support the more management-oriented later steps. Already bridges are being created to these activities where opportunities currently exist, such as in natural products chemistry and raising of honeybees and conservation of silkmoths as income-generating alternatives to forest destruction. In addition, this Division also has an active programme of education and outreach related to practical biodiversity, including farmers' courses and postgraduate training programmes in collaboration with several universities in Africa and other parts of the world.

The EHD harbours the following areas of research:

- Biodiversity and Conservation
- Bioprospecting
- Commercial Insects
- Biosystematics

The aim of **Biodiversity and Conservation** is to inventory and monitor arthropod and other biodiversity changes in ecosystems, to assess and build awareness about the role of arthropods in the ecosystem and to undertake and promote activities that contribute to conservation of biodiversity.

The objectives of **Bioprospecting programme** are to discover, develop and commercialise products from nature, the financial benefits of which can be used in the protection and management of arthropod and other biodiversity, and to involve rural communities living adjacent to biodiversity-rich areas in research and development activities that are related to conservation of biodiversity.

As population growth stresses the world's agricultural lands and forests, research and extension services need to adapt in order to meet the needs of farmers, while at the same time conserving the environmental and natural resource base.

Since 1995, **ICIPE's Commercial Insects Programme** has been developing the potential for apiculture and sericulture for generating employment and improving the income of rural dwellers in Africa (Phase 1 TAG). As a result of the success in basic research and in introducing improved apiculture and sericulture technologies to farmers in East Africa, ICIPE staff have been requested to introduce the technologies in Ghana, Nigeria, Senegal, Côte d'Ivoire, Zambia, Zimbabwe, Ethiopia, Eritrea, Sudan, Namibia, Madagascar, Libya, Tunisia, Algeria and Morocco. A network of interested partners called SARDNET (Sericulture-Apiculture Research and Development Network) has been established. Training has been provided at ICIPE in Nairobi to representatives (all from government) of most of the above countries.

This project was initiated to validate technologies developed during Phase I in beekeeping, wild and

domesticated silkworm rearing, and conservation and utilisation of these commercial insects and their habitat. The technologies developed in Phase I needed a further period to be validated in the field. In order to develop and validate the full technology packages, the Commercial Insects Programme is undertaking several sub-programmes.

RESEARCH HIGHLIGHTS

A. Biodiversity and Conservation

1. An integrated package for the conservation of the Kakamega forest

An integrated project on the conservation of arthropods and other related biodiversity in the unique Kakamega rainforest in western Kenya was initiated in partnership with relevant institutions aimed at tackling factors that contribute to its destruction and loss. ICIPE is the overall coordinator of the project. Inventory and monitoring of selected taxa in the threatened Kakamega Forest was initiated and annotated checklists for selected arthropod and other species compiled for publication. Eight members of the community living adjacent to the Kakamega forest were trained as parataxonomists in recognition and sampling of different invertebrates for monitoring activities in the forest. Around the Kakamega Forest, land use and land cover maps of the Forest were developed for the years 1975, 1986 and 2000.

A reforestation programme was initiated in 30 hectares of deforested land in the Kakamega Forest with planting of indigenous trees with the help of the community adjacent to the forest. Alternative, non forest-derived income-generating activities for communities around the Kakamega Forest were promoted in apiculture, sericulture and cultivation of medicinal plants through training and demonstrations. The Commercial Insects Programme has installed 212 Langstroth hives in rural households, two silkworm rearing huts and established mulberry farms. Community members were mobilised to grow two indigenous plants for alternative income-generation. One community-owned Financial Services Association (FSA or 'Village Bank') was fully established near the forest to provide savings and credit facilities for the community to assist them with microenterprise development.

Community members were trained and mobilised to install a total of 3799 energy-saving, fuelwood cooking devices and to raise and plant 109,535 seedlings of multipurpose trees in rural homes around Kakamega forest to relieve pressure on the forest from overharvesting of firewood and timber.

THE KAKAMEGA FOREST. This important rainforest is home to numerous endemic species, but is under serious threat from encroachment.

2. Biodiversity and evolution of gramineous noctuid stemborers

Noctuid stemborer abundance, their regulation by antagonists and their economical incidence are very variable according to the environment, phytogeographic characteristics and altitude. A study of the genetical variability of pest populations and their main antagonist (a parasitoid) has been undertaken on a large scale in all of Africa since 2001 and on a small scale in two sub-regions of Africa (Bénin-Togo-Ghana in West Africa and Kenya in East Africa).

Since February 2001, a survey of distribution and abundance of stemborers and their parasitoids has been undertaken throughout Kenya. Collections have been obtained from maize and cultivated sorghum in more than 60 areas ranging in altitude from sea level to 2500 m in all ecological areas of southern Kenya between the Coast Province to the border with Uganda. Currently, 12,000 infested stems have been collected with more than 14,000 stemborers. Collections are also obtained from wild grasses, mainly in the Kakamega area and with light traps in different ecological areas (Coast, Tsavo, Nandi Escarpment, Rift Valley).

The following parameters were covered to understand the biology and ecology of the different populations of stemborers in order to develop sustainable control strategies:

- genetic variability of noctuid stemborers and their parasitoid populations;
- identification of abiotic and biotic factors responsible for this variability;
- genetic structure of pest–parasitoid populations;
- behavioural studies of tritrophic interactions between host plant/pest/parasitoid;
- phylogenetic reconstruction of the noctuid stemborer family;
- survey of the stemborers and their parasitoids in southern Kenya and extending to northern Kenya (Lodwar, Marsabit, etc.);
- distribution patterns of stemborer wild host plants in space and their overall abundance in all of Kenya;
- foraging behavioural variability of *C. sesamiae* and the influence of the different stemborers species on damage and grain yield in maize.

B. Bioprospecting Programme

1. Conservation and sustainable utilisation of biodiversity

The 2000–2001 highlights of the above project within the Bioprospecting programme are as follows:

- A community living next to the endangered Kakamega forest has been mobilised to grow indigenous plants as an alternative source of income. Naturub, a product from one of the plants (*Ocimum kilimandscharicum*) has been formulated and packaged and is now on sale in more than 62 outlets in Kenya. Farmers of medicinal plants are reporting a 10-fold increase in income compared to growing traditional crops. *(See also Biodiversity and Conservation report).*
- Repellent and insecticidal plants and plant-based methodologies and products have been identified and developed for use in the control of malaria vectors by rural communities. *(See also under Human Health).*
- A herbal-based low-cost mosquito repellent that is suitable for rural communities is in the final stages of development and commercialisation.
- An agreement of cooperation was signed between ICIPE and the Kenya Wildlife Service (KWS) for discovery, development and commercialisation of products from Kenyan arthropods, microorganisms and plants in a manner that benefits conservation of biodiversity.
- Capacity building: The project trained 4 PhD and 13 MSc students.

C. Commercial Insects Programme

1. Validation of sericulture and apiculture production modules

The Project has developed a validation strategy that empowers the rural poor to produce and market their own goods by developing a market for their products such as silk, honey, wax, etc. Through this strategy, self-sustainability is attained. In Kenya, groups in Mwingi, Othoro, Nyakasumbi, Lambwe Valley, Sambut, Baringo, Muka Mukuu, Naro Moru and Laikipia are involved in the validation trials. In Uganda, the areas of Kawanda, Jinja and Bushenyi are involved in the silk validation trials and beekeeping models are being tested in Hoima, Kibaale and Masindi, Kiryandongo settlement. In Tanzania, the Sakila group is a model for beekeeping and the Usa River and Mara area groups for mulberry silk and beekeeping.

2. Grainages for production of bivoltine silkworm eggs

A grainage system has been established to produce disease-free silkworm eggs for use by farmers in different parts of Africa.

From field to harvest to product, communities around the Kakamega forest are reaping the benefits of medicinal plant farming.

3. Honeybee line breeding

At Mbita Point and Duduville, several research protocols have been set up to enhance the production of queens.

4. Assessment of location-specific constraints

Unexplored ecological niches have been tapped to enhance both wild and mulberry silk production and an exit strategy for silk fabric manufacture in Africa developed.

5. Assessment of pollination

Floral volatiles of specific Cucurbitaceae species have been investigated for their attraction to foraging worker honey bees and are being used to increase crop pollination and yield.

6. Capacity building

This has been enhanced through training of farmers, NGOs, government officers and MSc and PhD students. The Programme has supported 3 PDFs, 6 PhDs, and 5 graduate students and trained over 300 NARES and 7000 farmers from collaborating and networking partners from 24 African countries.

7. Marketing strategy

A marketplace development action plan and implementation capacity has been programmed for Kenya, Uganda and Tanzania.

8. Regional Programme for the Development of Improved Apiculture Technologies in North Africa

The overall goal is to facilitate the development and transfer of proven apiculture technology to

smallholder bee-keepers in North Africa, specifically Algeria, the Libyan Arab Jamahiriya, Morocco and Tunisia by means of participatory adaptive research, training and demonstrations. As the lead agency, ICIPE has provided technical backstopping and administrative support to the Programme. The responsibility for Programme implementation in each participating country is entrusted to the Livestock and Pasture Development Authority in Tunisia; the Livestock Department of the Ministry of Agriculture in Morocco; the Agriculture Research Centre in the Libyan Arab Jamahiriya; and the Livestock Technical Institute in Algeria. Each national institution has appointed a National Coordinator to liaise closely with a part-time Regional Coordinator based at ICIPE's headquarters in Nairobi.

The objectives of the Programme are being effected through four main activities: queen bee rearing and breeding; honey bee disease control; quality control and marketing of honey bee products; and bee-keeper training, technology diffusion and programme beneficiaries.

The Programme has had a significant impact on the improvement of small bee-keepers' incomes through enhanced productivity as a result of introducing improved races and disease management, and higher producer prices as a result of honey- and honey product marketing based on quality analysis, grading and labelling.

Queen rearing stations are being established for North African regions in four countries and queens of known desirable qualities produced. Disease diagnosis facilities will be made available, and quality control laboratories for honey and other hive products developed and extension officers trained. Overall, the North African capacity for improved apiculture will be significantly improved.

FUTURE OUTLOOK

Activities on conservation of biodiversity in Kakamega Forest will continue. A feasibility study is underway on the Insect Park that is proposed for establishment in one of the ICIPE's plots in Nairobi, Kenya, as a demonstration site for environmental education. Conservation of biodiversity will be promoted in community-based alternative income-generating activities around Budongo Forest in Western Uganda, and partnerships have been established to work on the conservation of biodiversity in Budongo Forest (like the Kakamega Forest, also a remnant of the Guineo-Congolean rain forest) and Ntungamo in western Uganda with the following community groups and agencies: Budongo Forest Community Development Organisation (BUCODO), Ntungamo Women's Effort to Save the Environment (NWESE) and UNDP-GEF Small Grants Program.

Partnerships have been established to work on conservation of biodiversity in the semi-arid regions of Laikipia and Samburu districts of Kenya with the following institutions and community conservation groups: African Wildlife Foundation (AWF), Laikipia Wildlife Forum (LWF), Maralal County Council and Samburu Community Group Ranches around Kirisia Forest.

Bioprospecting activities as a means to conservation of biodiversity are continuing. New initiatives are being developed for community-based bioprospecting in the semi-arid regions of Laikipia and Samburu districts of Kenya.

The following activities will continue in 2002 toward meeting the programme's objectives:

- develop silkmoth and honeybee smallholder/microenterprise production facilities adapted to local conditions;
- collect data and undertake an analysis addressing location-specific production and adoption issues for both apiculture and sericulture on socio-economic, institutional and biophysical aspects;
- define product-quality requirements of the markets;
- provide technical backstopping in sericulture and apiculture in order to develop initiatives involved in the promotion of rural microenterprises for income-generation;
- provide training for farmers and farmers' groups in appropriate technologies for apiculture and sericulture;
- increase scientific capacity by means of postgraduate training and scholarships, in order to provide a solid scientific base for practitioners throughout Africa;
- promote further the dissemination of the apiculture and sericulture technologies developed under phase I of the Programme;
- continue the support for demonstration groups established under Phase I, including development of their marketing strategies, identification of marketing constraints, and identification of relevant market linkages with private traders.

COMPLETED WORK (Abstracts of papers in refereed journals. For full list see Publications List)

Call No.: 00-1553

Kioko E.N., Raina S.K. and Mueke J.M. (2000) **Survey on the diversity of wild silk moth species in East Africa.** ***East African Journal of Science*** **2(1), 1–6.**

ABSTRACT: In East Africa like elsewhere in the world, there is an increasing concern for biodiversity and its sustainable conservation. Since some solution to the depletion of biodiversity lies in introducing

economic incentives that integrate conservation with the economic development of the people, a need exists to document some of the biological resources that can be utilised as models for both conservation and income generation. During this study, 58 wild silk moth species were found to occur in three Lepidoptera families, Saturniidae, Lasiocampidae and Thaumetopoeidae. Species diversity varied in the three families. In Saturniidae, 19 species were recorded in 6 genera, 33 species in 17 genera in Lasiocampidae and 6 species in one genus in Thaumetopoeidae. These results indicate a great potential for wild silk production in East Africa.

Call No.: 01-1599
Miller S.E. and *Rogo L.M.* (2001) **Challenges and opportunities in understanding and utilisation of African insect diversity.** ***Cimbebasia*** **17, 197–218.**

ABSTRACT: Approximately 100 000 species of insects have been described from sub-Saharan Africa. Largely as a result of Africa's colonial history, the region's insect fauna is probably better known than that of other tropical regions, but information is often more difficult to locate. Few centres of expertise on insect diversity and systematics exist in tropical Africa, while most large insect collections are housed in South Africa, Europe and the United States. Recent surveys of in-country resources show that human resources are also thinly distributed in tropical Africa. Yet, there is urgent need for basic information on insect diversity for pest management related to plant, livestock and human health, as well as conservation and environmental management. Invasive (alien) species represent a newly recognised threat that cuts across traditional sectors. Recent work shows the potential of different approaches to these challenges, including compilation and synthesis of pre-existing data and research targeted at strategic needs. Information can also be applied in novel ways to promote 'environmentally friendly' income-generating schemes such as silk and honey production, ecotourism, butterfly farming and bioprospecting. The Global Taxonomy Initiative of the Convention on Biological Diversity provides an opportunity to expand these experiments to better meet the needs.

Call No.: 00-1554
Rogo L. and Oguge N. (2000) **The Taita Hills forest remnants: A disappearing world heritage.** ***Ambio*** **29(8), 522–523.**

ABSTRACT: The causes of fragmentation and conservation needs of the Taita Hills Forest are discussed in this paper.

Call No.: 01-1591
Rogo L. and *Odulaja A.* (2001) **Butterfly populations in two forest fragments at the Kenya coast.** ***African Journal of Ecology*** **(E.A. Wild Life Society) 39, 266–275.**

ABSTRACT: Species richness, diversity and composition of butterflies in two Kenya coastal forest remnants, Muhaka and Mrima hill, were investigated. Sixty-three species were recorded from each forest remnant from a total of 1329 individuals. Species accumulation curves for both forests did not reach an asymptote. High species similarity was recorded between the forest interior and the surrounding matrix, primarily due to invasion of the forest interior clearings by the savanna species. Despite their small sizes, these forest remnants were found to maintain viable populations of true forest butterflies. However, the number of species was less than half that recorded from the larger forest reserve of Arabuko-Sokoke, located in the same geographical area. Records from Muhaka forest show species unique to it, not found in the larger forest reserves, underscoring the importance of small remnants in the preservation of forest biodiversity. The high species similarity between the forest remnants implied that if habitat corridors were created, gene flow between these remnants and other larger forest reserves would be possible. This would reduce the isolation of true forest butterfly populations within the remnants and potential local extinction.

Participating scientists: S. Miller (Division Head), S. Raina, L. Rogo, W. Lwande, V. Adolkar, E. Kioko, P. Le Rü, B. Gemmill.

Collaborators: ICRAF; ITDG; DRSRS; FD; KEFRI; KWS, K-REP; National Museums of Kenya; Kenyatta University; KWS; Diversa Corporation; NARES and NGOs in Kenya, Uganda, Tanzania, Madagascar, Zambia, Senegal, Algeria, Libya, Morocco, Tunisia.

Donors: MacArthur Foundation; Univerity of Natal; Smithsonian Institution, USA; Government of France (Department of Education and Foreign Ministry); World Bank/UNDP/WHO-TDR; UNDP-GEF-Small Grants Programme (Kenya); UNDP-GEF-Small Grants Programme (Uganda); Dupont Corp. (USA); ICSC (Lausanne); IFAD; UNDP; US Ambassador's Fund.

5. Capacity and Institution Building

INTRODUCTION

ICIPE's Capacity Building Programme aims to enhance the capabilities of developing countries in the tropics and subtopics, particularly in Africa, for research and training in insect science, to promote the development and utilisation of sustainable arthropod management technologies. Through its postgraduate and professional development schemes, the programme makes a major contribution to ICIPE's research by sponsoring and facilitating postgraduate training, postdoctoral fellowship and visiting research positions at the Centre.

The main thrust of the Capacity Building programme is geared toward three major areas of activity, directed primarily at African countries and the Third World. These are:

(a) training of African nationals for leadership roles in insect science to enhance interactive technology generation and adaptation;
(b) enhancing national capacities for technology diffusion, adoption and utilisation; and
(c) facilitating dissemination and exchange of information.

This strategy has been translated in the following themes:

(a) **Postgraduate training** at PhD and MSc levels, undertaken through two main programmes:
   - The African Regional Postgraduate Programme in Insect Science (ARPPIS), and
   - The Dissertation Research Internship Programme (DRIP)
(b) **Professional development** schemes for scientists of any nationality
(c) **Non-degree training,** consisting of research methodology courses for scientists, practitioner training courses for pest management practitioners, and industrial attachment for students in technical colleges and universities.

HIGHLIGHTS

A. Postgraduate Training

1. The ARPPIS Programme

The African Regional Postgraduate Programme in Insect Science (ARPPIS) was established in 1978, with the primary objective of training arthropod scientists and pest management specialists within Africa. It is a collaborative training programme between the ICIPE and 27 African universities.

ICIPE provides a thesis project, research facilities and supervision, and a training fellowship to support students—university fees, research costs and a maintenance stipend. A full ARPPIS scholarship amounts to US$ 30,000 per student per year. Students are registered at any of the participating universities, whose responsibility is to provide additional research supervision to ensure that the research meets international academic standards, and to examine the students and award them with degrees. At any time the programme has between 20 and 40 students at various stages of their thesis work, and to date a total of 164 scholars from various African countries have been enrolled in the programme (Fig. 1). The following were the major activities of the ARPPIS programme in the year 2000/2001:

- Five ARPPIS doctoral scholars completed the requirements for and were awarded PhD degrees by their registering universities. This brings the total number of PhDs awarded through the programme since 1983 to 119.
- Seven other scholars of the 1998 class have completed the 3-year doctoral training programme. Most of these candidates have submitted theses to their registering universities and are awaiting their oral examinations, while a few others are in the process of finalising their theses.
- Six new students were admitted to the ARPPIS doctoral programme. After undertaking a 2-

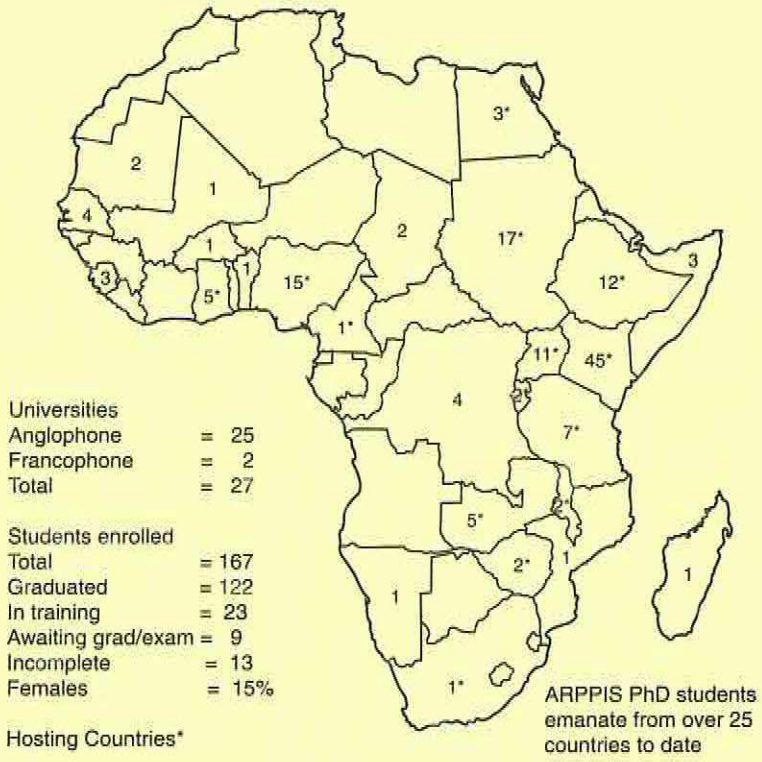


Fig. 1. *The ARPPIS network in Africa 1983–2002*

month remedial coursework regime in graduate biostatistics and research project management, the six immediately embarked on the development of a research proposal with the help of an ICIPE-based supervisor, and in consultation with a supervisor from their registering university.

- As at 2001 the number of ARPPIS participating universities stood at 27.
- The 30th meeting of the ARPPIS Academic Board was held at the University of Pretoria, South Africa, on 23 February 2000.
- ICIPE continued to provide support in the form of Masters degree training scholarships and departmental support, to **ARPPIS Sub-Regional Masters Degree Programmes** hosted by selected universities within three sub-regions of the African continent, namely:
  - Sub-regional Centre for West Africa hosted by the departments of Crop Science and Zoology at the University of Ghana, Legon;
  - Sub-regional Centre for Southern Africa hosted by the Department of Biological Sciences at the University Zimbabwe, Harare;
  - Sub-regional Centre for Eastern and North-Eastern Africa hosted by the Department of Biology at Addis Ababa University.

Sponsorship is derived from ICIPE's Human Resource Development project sponsored by The Royal Netherlands Government as well as a number of Masters scholarships awarded by the German Academic Exchange Service (DAAD). The 2000/2001 intake of the ARPPIS Masters programmes comprised 17 scholars, bringing the total number of Masters' students admitted by the Centres to date, to 106 (Fig. 2).

2. The DRIP programme

The Dissertation Research Internship Programme (DRIP) continued to provide training opportunities for students from Africa and abroad. In 2000/2001, 42 DRIP scholars were admitted into the programme, bringing the total number of scholars under this programme to 69 (25 doctoral and 44 masters).

B. Professional Development Schemes

Three professional development schemes, the Postdoctoral Fellowship Programme, the Visiting Scientist Scheme and the Research Associateship/Internship Scheme, enable ICIPE to attract both young and established scientists and professors from developing and developed countries. In the course of their work at ICIPE, these professionals gain professional growth and at the same time contribute to ICIPE's research activities. ICIPE hosted a total of 29 visiting scientists and six Postdoctoral Fellows during 2000/2001, facilitated by the Capacity Building programme.

C. Technology Dissemination

1. International Group Training Courses and Workshops

Three international training courses and workshops were held as follows:

- International Course on Tsetse Management, 11 September–6 October 2000. This was the fourth

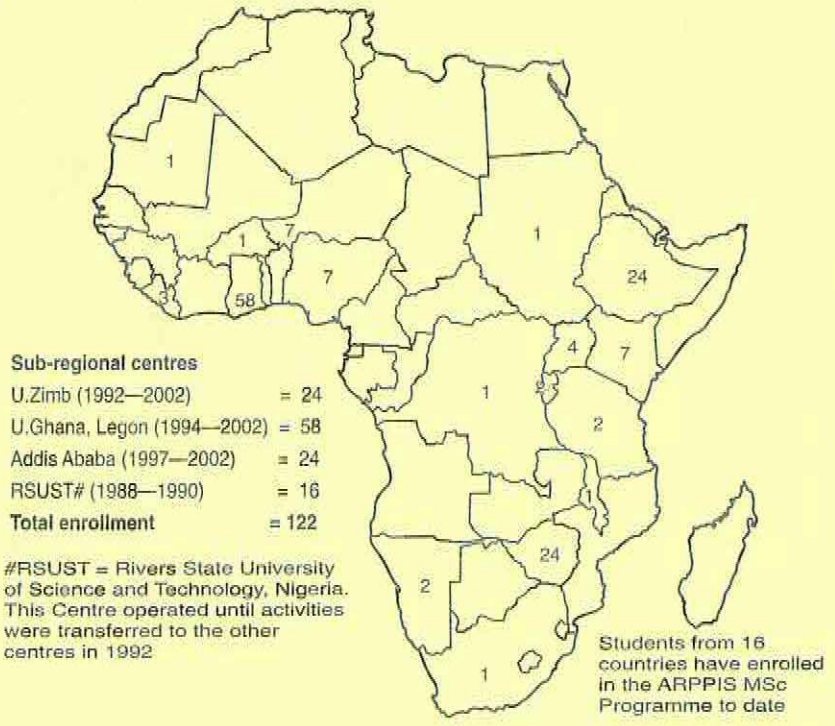


Fig. 2. *The ARPPIS sub-regional Masters programme enrollment 1992–2002*

in a series of five courses sponsored by the Royal Netherlands government. Twenty-three pest management practitioners from 14 countries participated in the course.

- The Fifth Course on Entomological, Parasitological and Managerial Methods for Malaria Surveillance and Control in Africa, 15–26 October 2001. Attended by 12 participants from 5 countries.
- A planning workshop on the establishment of a Network on Capacity Building in Biotechnology and Biosafety, 1–2 March 2001. Attended by 34 participants from the eastern Africa region.

2. Consumer awareness training

A training of trainers (ToT) course and the 3rd International Workshop on the Conservation and Utilisation of Commercial Insects was held at ICIPE from 13th November to 8th December 2000. Thirty-one participants from 19 countries were in attendance. The course culminated in a Farmers' Day at which honey and silk technologies were exhibited. The latter was held on 8th December 2001 and was attended by over 200 farmers and extension officers from Kenya, Uganda and Tanzania.

Participants at the Malaria Surveillance and Control workshop, October 2001

3. Practical training attachment for technical and undergraduate students

This scheme continues to provide practical laboratory training to university undergraduates from Africa and abroad, and trainees from technical training colleges and government ministries. While gaining practical skills which form part of the requirements of their training programmes, the trainees provide valuable research assistance to ICIPE's projects and basic laboratories. In 2000/2001, training opportunity was afforded to over 200 individuals in various departments of ICIPE.

D. Publishing Activities

Experience from the ARPPIS postgraduate coursework and practitioners' training courses at ICIPE has revealed a deficiency of training materials relevant to the African situation. For this reason, one of the main objectives of ICIPE's capacity building programme is to facilitate the preparation of books and training manuals for use in training courses for graduate students and insect pest management practitioners. One teaching manual was published by ICIPE Science Press in the 2000/2001 period, and others are at an advanced stage of preparation.

- *Manual on the Taxonomy of Ticks of Economic Importance in Africa.* Copies of this fully illustrated manual are in print and available at ICIPE.
- *Manual on Integrated Pest Management of Vegetable Pests.* The fully illustrated manual on IPM for french beans production has been printed and others on IPM for tomatoes and brassicas are at an advanced stage of preparation.
- *A Practical Guide for Raising and Utilisation of Silkmoths and Honeybees in Africa.* In print and translated into Kiswahili, Luganda, French and Spanish.
- *Economics of Apiculture and Sericulture Modules for Income Generation in Africa.* In print.

E. Institution Building and Intra-Africa Cooperation

A number of activities were undertaken under the DSO-sponsored project on Human Resource Development in Africa.

- Eight Re-entry Research Grants were awarded to ARPPIS alumni working in NARS. Of these, seven were ongoing while one was granted in 2000.
- Seven internships were awarded in 2000 and one in 2001. One other was ongoing from 1999.
- Two Scientific Exchange Fellowships were awarded in 2000 to ARPPIS alumni to attend a workshop on agricultural research management for research leaders of sub-Saharan Africa, Reduit, Mauritius, 2–14 October 2000.

A selection of the publications supported by the Capacity Building Programme in 2000–2001

Future Outlook

In the coming year, the Capacity Building Programme looks to undertake the following activities:

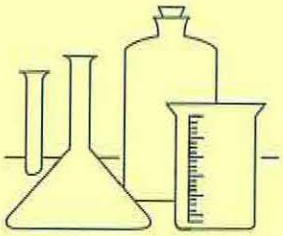
- Award of ARPPIS doctoral scholarships will take place in July 2002.
- Recruitment of masters degree students to the ARPPIS Sub-regional Masters Programme.
- Recruitment of students to the DRIP programme.
- Practical training attachment for technical and undergraduate students.
- Professional development programmes.
- Institutional building and intra-Africa cooperation, specifically exchange visits.

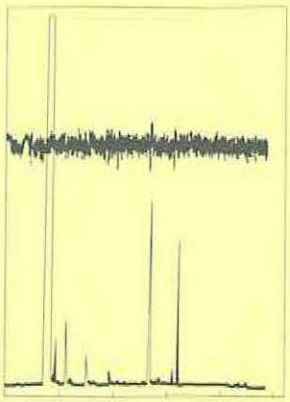
Participating staff: V. Musewe, L. Chongoti.

Collaborators: 27 African universities.

Donors: Royal Netherlands Government, Direct Support to Training Institutions in Developing Countries Programme (DSO), German Academic Exchange Service (DAAD).

6. Science Departments





INTRODUCTION

ICIPE's four major Divisions—Human Health, Animal Health, Plant Health and Environmental Health—work closely with the two Science Departments, whose role is to contribute specialised expertise in the key areas of **population ecology and ecosystems science** and **behavioural and chemical ecology.** Apart from providing support to the Divisions, the well-staffed Departments conduct research and development and carry out capacity building activities in their own right.

In 2000–2001, PE&ESD had two major objectives. First, in agreement with its previously presented research plan, research concluded the work on temporal population dynamics and began investigating the analysis of the spatial dynamics and on ecosystem structure and function. Second, PE&ESD assisted the Ethiopia Regional Office to set up projects within the framework of the empowerment of national institutions.

The BCED contributed to the four Divisions as outlined under Research Highlight below. Further details can be found under the respective thematic areas.

RESEARCH HIGHLIGHTS AND FUTURE OUTLOOK

A. Population Ecology and Ecosystems Science Department (PE&ESD)

1. Temporal population dynamics

A stochastic model on time-distributed ageing and growth processes has been developed, and a publication is being finalised. Stemborer–parasitoid population interactions have been studied via statistical inference methods, and the results have been published in an international journal.

2. Spatial population dynamics

To obtain an adequate knowledge on spatial processes, PE&ESD sought different levels of understanding. A low level of understanding of spatial processes was sought by using statistical inference methods for drawing conclusions regarding the spatial dynamics of plum moth and tsetse populations; the results have been published in international journals. A deeper level of understanding was sought by applying diffusion models to plum moth, tsetse and mosquito populations. The work is in progress. To obtain an even deeper level of understanding, a representation of spatial dynamics on the basis of stochastic process models are in an advanced planning stage.

3. Ecosystem structure and function

The PE&ESD participated at an international workshop on biodiversity conservation and presented the topic 'Mitigating effects of biodiversity on pests'. As a follow-up, guidelines for biodiversity conservation programmes are being formulated. The guidelines will reflect design principles, such as institutional diversity, identified in sustainable systems all over the world. The design principles have been used in a case study on alpine ecosystems, recently published in an international journal.

The project on fodder tree evaluation and establishment was started in September 2001.

4. BioVillage

The PE&ES Department was given the responsibility of concluding the BioVillage project in Ethiopia by the end of December 2001. The project ended on this date, and the technical report is being finalised. The results will be used to develop an ecosystem simulation model. The improved understanding of ecosystem structure and function will permit the enhancement of environmental sustainability and of

ecosystem services in the Ethio-Forum 2002 follow-up projects as discussed below.

5. Scaling and system hierarchy (called 'the new frontier in ecology')

Theory development was initiated and two papers have been written.

6. Empowerment of national institutions

The institutions addressed were the Ethiopian Social Rehabilitation and Development Fund (ESRDF) and the Ethiopian Agricultural Research Organisation (EARO). In collaboration with these institutions, about 30 research proposals, ranging from population management to ecosystem design and implementation, have been developed. A complete list of the projects as well as of the interested donor institutions has been compiled and is available at ICIPE.

Below are some of the more important projects:

ESRDF projects

The most important project at the end of 2001 was the organisation of the Ethio-Forum 2002. ICIPE was given the unique opportunity to integrate its experiences and technologies into a national development agenda and to participate, in the future, in national human health and poverty reduction programmes. The Ethio-Forum 2002 took place from January 15 to January 29 in Addis Ababa, Ethiopia. The plenary session and the workshops, both given by national and international experts, were attended by about 1000 participants. The Forum consisted of the following components: (i) exhibition with ICIPE technologies on display, (ii) plenary sessions with presentations of Drs H. Herren and J. Baumgärtner, (iii) workshops with inputs from ICIPE staff. The participants of the workshops wrote project frameworks for 11 Ethiopian regions.

To assist in project finalisation and implementation, the international experts, presently mainly from the US, UK, Israel and Switzerland, created an organisation named 'Praxis Ethiopia'. The international experts were invited by the Ethiopian Prime Minister, who accepted the patronage of 'Praxis Ethiopia'.

Among the projects of current interest to ICIPE are the USAID/WHO-supported replication of the BioVillage and Biofarm projects in Ethiopia and possibly throughout Africa, and the 'Disease burden and poverty mapping project' developed by Prof. Rogers of Oxford University. The latter is a policy instrument that will permit the identification of key constraints to development.

EARO projects

These deal with pest population control (*Pachnoda*, tsetse flies), biological control (*Trichogramma*, virus) as well as with fodder trees. The renewed interest in weed control will open new possibilities for ICIPE.

Future Outlook

The work on temporal population dynamics will be concluded in 2002. Emphasis will be given to the analysis of the spatial dynamics and on ecosystem structure and function. The Ethiopia Regional Office will be assisted in project preparation and submission. (As discussed in the September meetings, projects will be primarily managed and executed by the Regional Office and by ICIPE's research divisions).

The general objective of the research activities will be to obtain knowledge on population, community and ecosystem processes as a basis for system management design, and to provide appropriate methodologies to the research divisions. A stochastic model on time-distributed ageing and growth processes will be completed by May 2002. The product is a generic model for dealing with the temporal dynamics of physiologically structured populations.

Sampling plans on spatial population dynamics will be continued and papers will be prepared for publication in international journals.

As a follow-up to the proposed project on 'Mitigating effects of biodiversity on pests', guidelines for biodiversity conservation programmes have been formulated and a project proposal for the maize ecosystem is under preparation.

B. Behavioural and Chemical Ecology Department (BCED)

1. Plant Health Division

Locust research

- Limited field trials with the adult pheromone on natural hopper bands to cause disruption and greater susceptibility to predators.
- Development of a large insectary at Port Sudan for trials and training of EMPRES representatives on pheromone technology.
- Identification of the pheromonal signal responsible for maternal transfer of gregarious character to the offspring.
- Workplans on the Madagascar locust (*Locusta m. capito*) in collaboration with CABI and FOFIFA developed.
- Development of an artificial diet for the desert locust. In another initiative, the performance of the insect in constant and variable temperature regimes is being studied.

Habitat management

- The allelochemical mechanism (seed germination with haustorium inhibition) in *Striga* suppression by *Desmodium* has been studied.

Banana weevil

- Identification of some of the allelochemicals of banana varieties shown to contribute to resistance or susceptibility.

2. Animal Health Division

Tsetse

- Identification of repellent constituents from waterbuck.

Ticks

- Survey of plant products in Bungoma district used for traditional on-host control of *Rhicephalus appendiculatus*.
- Ecology and behaviour, especially the signals associated with the foraging behaviour of the hymenopteran wasp *Ixodiphagus hookeri*, which parasitises the tick *Amblyomma variegatum*, has been initiated.

3. Human Health Division

- Bioprospecting for and exploratory use of anti-malaria vector botanicals.
- Chemical ecology of oviposition selection by *Anopheles gambiae*: A detailed hypothesis has been developed.

4. Environmental Health Division

- Pollination chemical ecology: The Department is involved in supervising one PhD student.
- Conservation through biodiversity:
  - Initiation of alternative income-generating activities related to natural products for communities living near biodiversity-threatened areas.
  - Development of partnerships between ICIPE–KWS and advanced laboratories for discovery, development and commercialisation of natural products that ensure flow of benefits to conservation efforts.

5. Capacity building and output

Two patents have been filed. One on the tsetse repellent is pending and the other on a method of disrupting locust gregarisation has been awarded.

Nineteen scientific papers have been written, of which 12 are in print and 7 are in press.

Nine PhD students and over 16 MSc students are being supervised or co-supervised by the Department.

Future Outlook

As a follow up to the surveys for anti-tick plant-derived materials, on-host studies starting in 2002 will integrate selected botanicals (tick repellents, acaricides) with feeding site location behaviour of the adult tick in 'push' and 'push-pull' tactics.

Work on the host-finding behaviour of the tick parasitoid *Ixodiphagus hookeri* will continue during 2002.

A project on the identification of *Anopheles gambiae* attractant blend from foot odours is due to start in 2002.

The Department expects to welcome nine new postgraduate students in 2002.

COMPLETED STUDIES

(Abstracts of papers in refereed journals. Note that most of the publications from the Science Departments are reported under Project reports for the Divisions)

Call No.: 01-1607

Baumgärtner J. and Hartmann J. (2001) **The design and implementation of sustainable plant diversity conservation program for alpine meadows and pastures.** ***Journal of Agricultural and Environmental Ethics*** **14, 67–83.**

ABSTRACT: The paper describes the design and implementation of a plant biodiversity conservation program that was developed under funding and time constraints for diverse ecological, social, and institutional environments. The biodiversity program for alpine meadows and pastures located in the Swiss Canton of the Grisons is used as an example. The design of the sustainable program relied on existing legislation, accounted for limited ecological knowledge and expertise, and considered biodiversity as a common-pool resource. The trend to intensified cultivation of restricted areas required fast action, while the sustainability of the program design had to take into account institutional diversity. Fifteen habitats and plant communities worth conserving were known, and 57 plant species were identified as indicator species for establishing an inventory and for monitoring purposes. A small subset of 16 well known plant species was presented to the farming communities. They were invited to notify the areas in which they observed the presence of these plants. In different regions of the Canton a total number of 39 paraecologists were trained to inspect the areas notified by farmers and to recommend possible incorporation into the Cantonal inventory. This was done once the farmers signed a contract in which they agreed to follow adequate management practices. The farmers received subsidies to compensate for their losses. Communal authorities controlled the fertilizer input and cutting dates,

while the paraecologists were trained to monitor plant biodiversity. The program started in 1992 and the initial phase of the inventory was terminated in 1996. At the beginning of 1996, an inventory of 2617.19 ha, most of which are meadows, was taken and managed according to the rules specified in the contract. The program was considered successful because (i) of the size of the area in the inventory, (ii) about 30% of the farmers participated, and (iii) farmers started cultivating previously abandoned farmland.

Participating scientists: A. Hassanali (Head of BCED), J. Baumgärtner (Head of PE&ESD), W. Lwande, B. Torto, S. Nakamura, P. Njagi, H. Mahamat, M. O. Bashir, G. Tikubet, J. Greiling, N. K. Gikonyo, A. Taro.

Collaborators: University of California, Berkeley; Tulane University, USA; University of Rome, Molise University and University of Reggio di Calabria, Italy; Swiss Federal Institute of Technology, Switzerland; ESRDF; EARO; Oxford University (UK).

Donors: USAID/WHO; Austrian Development Corporation; EARO; ESRDF; Netherlands Embassy, Ethiopia; Univ. of Voterbo; FAO; CSU Stanislaus; ICIPE Core Fund donors (Danish International Development Agency, Swedish International Development Agency, Swiss Agency for Development and Cooperation, Government of Norway, Government of Finland, Government of France, Japanese Society for the Promotion of Science (JSPS), Government of Kenya).

7. Research Support Units and Services

INTRODUCTION

Important to the achievment of ICIPE's research and development mandate are its eight Research Support Units and Services, which perform functions ranging from advanced analytical procedures to publishing services.

The **Molecular Biology and Biotechnology Unit** conducts research in the areas of biochemistry, molecular biology, immunochemistry and population genetics, either in support of existing projects within the Divisions, or as independent, funded activities. It also offers light/electron microscopy services and bloodmeal identification services to ICIPE's projects and a limited number of external collaborators.

The **Entomopathology Unit** has continued the evaluation of fungus-based biopesticides in the field and validation of the results.

The **Information Technology and Bioinformatics Unit**'s aim is to provide better information and communications technology (ICT) and bioinformatics infrastructure and to integrate all ICT-related research, development and training activities for the Centre.

The **Social Sciences Unit** is mandated to undertake research facilitating the development and tailoring of technology to the conditions, needs and demand of ICIPE's clientele, especially resource-limited farmers in the tropics. It is also expected to elucidate the socioeconomic dimensions of research in insect science and its application by participating in priority and policy setting, and by contributing to ICIPE's capacity building and training programmes.

The pest control and income-generating technologies developed at ICIPE require social science input, including the building of entrepreneurial skills, for successful adoption in communities.

The Unit works in partnership with biologists, extensionists, NGOs and end-users in all phases of technology development. It uses a client-oriented approach. The staff collaborate with socioeconomists in NARES and IARCs. The major aim is to make marked improvements in the living standards of ICIPE's low-income clients.

Through its insectary, animal breeding and quarantine facilities, the **Animal Rearing and Quarantine Unit (ARQU)** provides support services to ICIPE's research and capacity building activities, as well as to a number of NARES and universities. The Unit also provides in-house attachment training to several students and interns, and supplies specimens for teaching purposes to local schools.

The major focus of the **Biosystematics Unit** is the provision of the infrastructure—scientific expertise at the research and technical levels, a reference collection, relevant literature and laboratory facilities—to achieve both insect identification and targeted taxonomic research at ICIPE. The Unit also provides networking to the global taxonomic community, and extends its services and facilities to other institutions from time to time.

During the period under review, the **Biostatistics Unit** pursued its objective of providing qualitative biostatistical support to all projects, in terms of efficient design and analysis of experiments. Staff and students were assisted in design of experiments, data analysis, results verification and interpretation, manuscripts/thesis review, and statistical software installation, upgrading and teaching. Essential statistical input into research project proposals were also provided by the Unit during this period. The Head of the Unit left ICIPE in late 2001, after which biostatistics input was limited.

The **Information and Publications Unit**, previously known as Information Services, includes the following five sections:

- Editorial Services
- *Insect Science and Its Application*
- ICIPE Printing Services/Science Press
- Publications
- Information Resources Centre (Library)

The Unit is responsible for writing, compiling, publishing and printing information about ICIPE and its projects, in both printed and electronic formats. This includes writing and/or editing, design and layout of official documents such as Annual Reports, Business Plans, Vision and Strategy documents, brochures, and many Proceedings. In these activities, the Unit liaises closely with the Public Relations Office and the IT Unit of ICIPE. Over the past year, the Unit has become more directly involved in public relations through writing and editing of articles for the local and foreign press, and by liaising with reporters who visit ICIPE to gather news for their stories. The Unit also performs many 'unseen' functions by answering general requests about the Centre, distributing and exhibiting publications, and editing and formatting project proposals and reports, speeches and other material; limited graphics work is also done. The Centre's main photocopying services are managed by the Library staff.

Another important mandate of this Unit is capacity building and stimulating scholarly publishing in the region. This is done through assisting ICIPE scientists in writing up papers and reports for publication in journals and books, and publication of original research papers by tropical insect scientists in the ICIPE-hosted international journal, *Insect Science and Its Application*, now in its 21st volume. Capacity building in printing and publishing and information sciences is also achieved through training of staff and student interns and attachments from both local and regional institutions. The Information Resources Centre serves as a regional resource on information and publications on all areas of insect science, including agriculture, medical entomology and ecology. Interlibrary loan services are operational with local institutions and through the British Lending Library, among others. The Library is intensively used by ICIPE's ARPPIS and other scholars in the vicinity.

Over the past two years, the Unit has sought to become more sustainable financially by converting some sections into self-financing operations. The Printing Services section is now virtually self-supporting, and in 2001 the journal's production work was outsourced to a local private publisher. The journal is now printed in-house at ICIPE, resulting in further cost savings. The Library generates considerable income from recharges for photocopying and a smaller amount from literature searches.

HIGHLIGHTS AND FUTURE OUTLOOK

A. Molecular Biology and Biotechnology Unit

1. Plant Health Division

- Assessment of potential impacts of introducing genetically-engineered (GE) crops into Africa.
- Molecular identification and population genetic analysis of the invasive fruit fly species *Ceratitis* sp.
- Assessing the risk of transgene dissemination associated with the introduction of GM crops in Africa using cowpea as a model.
- Molecular characterisation and phylogenetic studies of parasitoids of the diamondback moth, *Plutella xylostella*.
- Responses of *Chilo partellus* populations in Kenya to *Bacillus thuringiensis*.
- Genetic biodiversity in the banana weevil from different regions of the world.
- Studies on biochemical changes associated with pheromone-induced maternal transfer of gregarious phase to offspring in the desert locust, *Schistocerca gregaria*.

2. Animal Health Division

- Characterisation of factors that influence vectorial capacity in tsetse flies.
- Use of ELISA for identification of bloodmeals in arthropods.
- The role of sheep, goats and pigs in the epidemiology of nagana and sleeping sickness in western Kenya.

3. Human Health Division

- Lectin expression associated with *Plasmodium* infections in *Anopheles* spp.
- Rapid assessment tool for mosquito bloodmeal sources.

4. Capacity Building

- The Unit is supervising 9 MSc and 7 PhD students under the ARPPIS and DRIP programmes *(see Capacity Building report)*.

Future Outlook

A new network for capacity building in the biosciences and biotechnology in Africa, called BiONET-Africa, is set to be launched in early 2002.

B. Entomopathology Unit

1. Plant Health Division

Two isolates of *Metarhizium anisopliae* for the control of thrips in horticulture and termites in maize cropping systems have been field-tested and show great promise as biological control agents of these pests. Metathripol (the *Metarhizium*-based product developed for thrips control) has also proved to be effective against pests of an important African staple, the pigeon pea.

A new strategy is currently being considered, whereby insect pathogens are disseminated among

target pest populations by using devices that attract insect pests into a focus of the pathogens. The Unit has developed and tested with success contamination devices for fruit fly and tsetse fly control. The Unit is also testing other insect pathogens, such as *Bacillus thuringiensis (Bt)* and other bacteria, hyphomycetes fungi and viruses. Applications of Metathripol and other fungal pathogens are described under Plant Pests reports.

2. Capacity building

MSc projects under supervision of the Unit and in collaboration with participating universities in ARPPIS include:

- Evaluation of the potential of native strains of *Bacillus thuringiensis* and *Metarhizium anisopliae* on *Plutella xyllostella* in Kenya.
- Identification of suitable sites for the release of *Neozygites tanajoae (floridana)* (Entomopthorales: Neozygitaceae) for the control of the cassava green mite *Mononychellus tanajoa* (Acari: Tetranychidae).
- Evaluation of hyphomycetes fungi for the control of spider mite, *Tetranychus urticae.*

PhD projects being conducted include:

- Evaluation of the potential of entomopathogenic fungi for the management of the African Tephritidae.
- Evaluation of *Bacillus thuringiensis* and neem extracts for integrated pest management (IPM) of the African armyworm, *Spodoptera exempta* (Walker).
- Experimental control of sandflies (Diptera: Psychodidae) using hyphomycetes fungi in Kenya.

Thirteen research papers were written of which 5 have been published, 3 are in press and 5 are under review. Two chapters in books were contributed during the 2000–2001 period.

Future Outlook

Grant proposals have been written to continue research and permit large-scale production of the entomopathogenic products, which are in high demand by farmers:

- Establishment of a fungus-based biopesticide production unit for large-scale evaluation and demonstration.
- Evaluation and monitoring of the impact of mycopesticides on the environment in different eco-zones in East Africa. Leading institution: BBA Darmstadt, Germany.
- Evaluation of environmental impact of termite control options on tropical forest ecology. Leading institution: BBA Darmstadt, Germany.
- Optimisation and validation of contamination device for the management of *Glossina* spp.
- Feasibility study for large-scale application of biological alternatives to persistent pollutant pesticides in termite control (in collaboration with UNEP-Chemicals/FAO).

C. Information Technology and Bioinformatics Unit

1. Improvement of IT and bioinformatics infrastructure

ICIPE's Mbita Point Field Station has been connected to the Internet via a MIMCom satellite solution since June 2001. Through KENET membership, it is possible to get a low-cost local VSAT link from Duduville to Mbita to improve this connection in future, and to eventually integrate the two local area networks (LANs).

2. Insect informatics R&D

ICIPE has been carrying out the following activities in Insect Informatics:

- The Africa IPM Forum has developed a web-based product, IPMAfrica (http://informatics.icipe.org/IPMAfrica/), as envisaged by the project. IPMAfrica supports unlimited users, unlimited discussion forums/topics and unlimited messages/posts. Powered by Active Server Pages (ASP) and written in server side Java, IPMAfrica features many handy functions, like rich HTML message (supporting picture, sound, video and links); threaded or linear messages; file attachment; automatic-cookie login; email integration; full search; and private messages. The Forum was hacked in September 1999 together with the Africa Remote Sensing Data Bank and lost all its previous registration and posted messages, but it was re-built and restored to full function.
- The Africa Remote Sensing Data Bank (http://informatics.icipe.org/databank/) has been developed. The 20 years of WMO ground observation data for more than 1000 stations in Africa, the 40 years average climatic data from the Australian National University, together with many other data sets are available free to users. More data are under preparation and will be added continuously into the data bank.
- The ICIPE Insect Informatics Initiative home page (http://informatics.icipe.org) has been constructed to provide news and information to end-users.
- The Web-based Intelligent Insect Management Information System is under development, as a priority Insect Informatics activity for the Post-PC Era.
- The Web-based ICIPE Central Management Information System (WICMIS) is under development, as a cross-platform tool for managing all ICIPE in-house data via a browser

from anywhere in the world, therefore enabling tele-working and closer links with the Governing Council and donor community, among others.

- CD-ROM products development: Insect Informatics Initiative assisted the ICIPE African Fruit Fly Initiative (AFFI) in the development of a CD-ROM product titled 'Courtship behaviour of the Mediterranean fruitfly (medfly): Worldwide comparisons'. Both IBM and Macintosh-compatible versions of the CD-ROM are available. Help was also provided in developing the AFFI home page: (http://informatics.icipe.org/fruitfly).

Future Outlook

A Bioinformatics Lab is being established to allow staff and students to conduct Bioinformatics and Functional Genomics applications. It will also be used for training activities.

To implement the eWork strategy at ICIPE, the following areas will be addressed:

- Upgrade of Internet connectivity to faster VSAT link, which requires an in-house LAN upgrade (replacement of old switches/hubs).
- Free or low-cost Voice and fax-over TCP/IP, which will reduce communication costs to the centre.
- A web-based interface for the ICIPE e-mail system.
- A VPN (virtual private network) between Duduville and Mbita, which will integrate the two LANs and reduce the cost of operating Mbita (configuring Mbita phones as extensions of Duduville PBX, direct link of SunSystems, remote administration of LAN from Duduville).
- Development of the Web-based ICIPE Central Management Information System (WICMIS), which will have following modules:
  - Web-based procurement system, which provides on-line requisition, on-line bidding and real-time supply functions.
  - Web-based R&D management system, which allows authorised users to login from anywhere to get information on donors database, conceptual notes database, proposals database, projects database, photos database, presentations database.
  - Web-based access of financial system and HR system.

Pursue following projects with donors:

- *Africa IPM Portal (http://www.ipmafrica.org):* An Integrated Approach for Information Sharing and Exchange *(proposal submitted).*
- *IPM Education Promotes Development and Democracy in Africa:* Establishment of an IPM Virtual Campus *(proposal submitted).*
  - *Information and Modern Technologies Empower Rural Ethiopian Communities:* Developing Multi-purpose Tele-centres and Relevant Information Products for Improved Health, Productivity and Poverty Reduction *(submitted).*
  - *Remote Sensing and Strategic Planning for Better Agriculture Production in Africa:* Development of Web-based Data Bank and Intelligent Geographical Management Information Systems *(submitted).*
  - Projects in bioinformatics and functional genomics will be pursued very actively.

D. Social Sciences Unit (SSU)

In recognition of the sharp shrinkage in the SSU staff component in recent years, research directly funded through the Unit was restricted to three projects, the details of which are found under the respective topic themes.

- Characterisation of banana production prior to the introduction of IPM and soil improvement technologies in central Uganda *(see under Plant Health reports).*
- Incorporation of income-generating activities (IGAs) into community-managed trypanosomosis in western Kenya *(see under Animal Health reports).*
- Incorporation of a new methodology for monitoring and evaluation of community participation into a regional project titled 'Farming in tsetse controlled areas of Africa (FITCA)', coordinated by IBAR and funded by the European Union (EU) in Kenya and Uganda *(see under Animal Health reports).*

Limited backstopping work has been carried out in two ICIPE projects, namely 'Agroecosystem management for community-based malaria control', and 'Community-based conservation of Kakamega Forest' (supervision of baseline study). Other ICIPE projects receiving socioeconomic inputs by researchers based in NARES and IARCs include: (a) Stemborer and striga weed management, (b) Development of options and awareness building models for IPM in major vegetable crops in eastern Africa, and (c) Kakamega Forest conservation project.

1. Capacity and institutional building

Three PhD projects are being supervised under the Unit:

- Socioeconomic factors influencing technology adoption: The case of maize stemborer control in Trans Nzoia District, Western Kenya.
- Production factors and market effects on banana production in three regions of Uganda.
- Participatory research in banana production in Uganda.

Between 2000 and 2001, 11 interns have been affiliated to the Unit. In 2000, courses on the socio-economics of pest/vector management were given to ARPPIS students. Unit staff participated in four training courses for extension workers and two short courses for farmers (2000–2001).

Future Outlook

A major challenge facing the SSU is that of achieving a critical mass of staff supported by a viable funding base.

The Rockefeller Foundation (RF) has awarded a grant to support a review of IPM work at ICIPE with significant social science input. Diagnosis of factors responsible for the decline in funding of the Unit and the preparation of a research agenda for submission to the RF and other donors are part of the review's mandate.

New research projects will include the assessment of the effects of ticks and tick-borne diseases on Zebu cattle. A draft proposal has been completed. A concept paper for another project on understanding the socioeconomics of informal seed systems of major food crops in East Africa has been prepared. Sociocultural factors likely to affect the implementation of the OAU/EU-funded project on 'Farming in Tsetse Controlled Areas of Kenya (FITCA-Kenya)' is also being put forward for funding.

Developing a common socioeconomic framework to serve ICIPE, ILRI and ICRAF will be discussed by the three organisations.

E. Animal Rearing and Quarantine Unit

1. Insectary services and animal breeding

Cereal stemborers

Five species of cereal stemborers—*Chilo partellus, Busseola fusca, Sesamia calamistis, Eldana saccharina* and *Chilo orichalcociliellus*—were reared and supplied to research and training projects during 2000–2001.

In 2000 a total of 604,350 stemborers were supplied, comprising 57.8% eggs and neonates, 37.3% second to sixth instars and 4.9% pupae and adults, while in 2001, 744,365 were supplied, comprising 66% eggs and neonates, 16.4 second to sixth instars and 17.0% pupae and adults.

The Biological Control of Cereal Stemborers Project was the largest internal consumer of mainly fourth instars and pupae while the Kenya Agricultural Research Institute (KARI) was the largest external consumer of mainly *C. partellus* and *B. fusca* eggs.

Locusts

Two species of locusts were maintained during the period. The desert locust, *Schistocerca gregaria* was reared in its gregarious as well as solitarious forms. A total of 19,460 gregarious adults were produced and 13,310 supplied as nymphs and adults, while 1945 solitarious adults were produced and supplied as egg pods, nymphs and adults.

Locusta migratoria was also reared in limited numbers. A total of 8450 adults were produced and 1700 supplied as nymphs to the Migratory Locusts project of the BCED.

Mosquitoes

In 2000, a total of 246,971 individuals of two strains of *Anopheles gambiae* (ex-Ifakara and ex-Mbita) were maintained at the Duduville insectaries. Of these, 127,394 were supplied to the Malaria Vectors Research programme. In 2001, some 585,563 individuals of both strains were produced and 177,308 supplied for research.

The ex-Mbita strain introduced in mid-June 2000 readily adapted to laboratory rearing at the ARQU, resulting in a high population buildup within a relatively short time.

Tsetse flies

Limited colonies of *Glossina fuscipes* and *G. austeni* were maintained, primarily for use by ARPPIS scholars. In 2000 a total of 29,766 pupae of both species were produced and some 7062 pupae/adults supplied for research.

The production level fell in 2001 due to low demand, and only 1145 pupae/adults were supplied to the Molecular Biology and Biotechnology Unit (MBBU) that year.

Ticks

The tick species maintained at the Duduville insectaries comprised *Rhipicephalus appendiculatus, R. evertsi, R. pulchellus, Boophilus decoloratus, Amblyomma gemma, A. variegatum and Hyalomma truncatum*, with *R. appendiculatus* making up 40% of the colony.

Production was kept at a level of about 140,000 ticks per year for all species combined. About 40% were *R. appendiculatus*. Some 20,000 ticks were supplied annually for research.

Galleria mellonella

A small culture of *G. mellonella* was maintained to support nematode culture by the Molecular Biology and Biotechnology Unit. About 3000 pupae were produced annually and about 2000 larvae supplied.

Animal breeding services

During 2000–2001, only rabbits and rats were kept. An average of 400 rabbits were weaned and about 300 supplied for research per year. The rat colony had 50 female and 15 male breeders.

Five steers were maintained to support tick research.

2. Quarantine services

The ICIPE's Quarantine facility has been operational since 1998. So far, importation permits have been obtained from the Kenya Government, and the imported materials being maintained in the facility are indicated below.

Psyttalia concolor *(ex. Italy)*

A second shipment of *P. concolor* which arrived on 22 January 1999, is being maintained in the Quarantine Unit. Experiments on crosses with indigenous species are ongoing.

Xanthopimpla stemmator ***(ex. South Africa)***
The first shipment of the pupal parasitoid *Xanthopimpla stemmator* was received in February 2000. The current work on *X. stemmator* includes: host range, host suitability and preference and is being conducted by an MSc student from Kenyatta University. Other studies include improvement of rearing techniques.

Sturmiopsis inferens ***(ex. India)***
The tachnid fly *Sturmiopsis inferens* was imported as a possible pupal parasitoid of the stemborers *Sesamia calamistis* and *Busseola fusca*. However, mating has been a major problem, and the rearing of this tachnid was suspended.

Sturmiopsis parasitica ***(ex. Zimbabwe)***
The Zimbabwe strain of *Sturmiopsis parasitica* is being reared for comparison with the *S. inferens* from India as a parasitoid of *S. calamistis* and *B. fusca*. The former species is currently confined in the quarantine facility until a permit is granted for its release.

Cotesia flavipes ***iso-lines (ex. India)***
This strain was imported into quarantine facility from ICRISAT, India, in late 1998 and during 2000–2001, was reared mainly for releases in Zanzibar and Pemba Islands of Tanzania.

Diadegma semiclausum ***(ex. Taiwan)***
Consignment of 870 puparia of *D. semiclausum* arrived in the Quarantine Unit on 1st October 2001. The strain is being targeted to control diamondback moth (DBM) on vegetables. Experiments are still confined to the safety laboratory until a permit is obtained for field releases.

Diadegma mollipla
This is the most recent shipment which arrived on the 13 December 2001 for comparison with *D. semiclausum*.

3. Capacity building and training activities

A student from Kilifi Institute of Agriculture was hosted by the ARQU 18 May–16 June 2000. His project was on screening selected antiprotozoal drugs against *Malamoeba locustae* in the desert locust *Schistocerca gregaria*.

A staff member of the Ngong Farmers Training Centre undertook a project to acquire hands-on experience in high quality breeding of small laboratory mammals from 12 March–11 June 2001.

Two research papers have been written and a conference paper presented on rearing of stemborers.

Future Outlook

- Continue to enhance R&D activities at ICIPE, KARI and national universities by providing quality insects and animals for research.
- Continue training scientists, scholars and technicians in insect and animal rearing/handling techniques.
- Develop new cost-effective insect and animal rearing procedures.
- Continue to offer guidance on import and export protocols for biological organisms.
- Continue to support schools with teaching and examination specimens, thereby enhancing learning.

F. Biosystematics Support Unit (BSU)

1. Identification and taxonomic information services

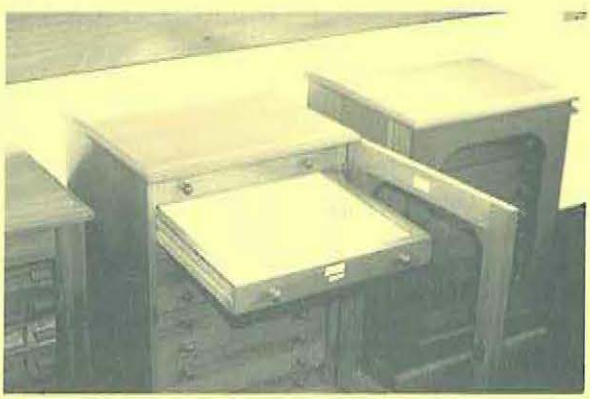
A total of 439,782 specimens were processed by the BSU in the two-year period, as summarised in Table 1 below.

Table 1. Identification and taxonomic information services provided by BSU from Jan 2000–Dec 2001

Project	No. of specimens
African Fruit Fly Initiative (AFFI)	363,478
Other ICIPE projects	75,916
Outside Users	388
Total no. of specimens	**439,782**

2. Voucher collection and computer databasing

A specimen database was created (in Microsoft Access) with the assistance of Dr Mervyn Mansell of PPRI South Africa. The database includes taxonomic, biology and locality data and so far about 260,000 specimens have been entered. The insect reference collection (dry pinned specimens) continued to grow, and now contains about 500 described species, including donations from Dr Lubomir Masner, of



ICIPE's Biosystematics Unit maintains a valuable collection of voucher specimens.

African scelionids from Canadian National Collection of Insects, and Dr Roy Snelling's collection of ants of Mpala Ranch, Laikipia District, Kenya.

3. Systematic revision of *Psyttalia* species (Hymenoptera: Braconidae), parasitoids of fruit-infesting flies (Diptera: Tephritidae) in Africa

Investigations have been carried out on seven populations of *Psyttalia* in Kenya for their potential use as biological control agents. Searches have been made in cultivated (*Coffea arabica, Cucurbita maxima, Mangifera indica)* or wild (*Corrallocarpus ellipticus, Lettowianthus stellatus, Sclerocarya birrea)* crops infested with any of the following tephritids: medfly (*Ceratitis capitata*), mango/marula fly (*C. cosyra*), Natal fly (*C. rosa*), melon fly (*Bactrocera cucurbitae*), cucurbit fly (*Dacus ciliatus*) and *Trirhithrum* spp.

These *Psyttalia* populations were compared, using cross-mating, with *P. concolor* (Szépligeti) from a laboratory culture in Italy used in the augmentative biological control of the olive fly, *Bactrocera oleae* (Gmelin). The results obtained so far have prompted further taxonomic studies at the DNA level, and these are currently underway. An ARPPIS student is conducting this research.

4. Description of two new species

Two new species in the sub-family Opiinae (Braconidae) have been described. Both were reared from puparia of fruit-infesting ceratitidine Tephritidae collected in western Kenya, and their placement relative to the genera *Fopius* Wharton and *Rhynchosteres* Fischer was investigated and discussed. This discovery represents the first host record for the genus *Rhynchosteres*.

5. Research in collaboration with other ICIPE projects

The BSU has continued to collaborate with ICIPE's projects in conducting research in the following areas:

- Non-target effects of fruit fly control using food-baited traps

Identification and databasing of important pests and their natural enemies is a vital support service offered to many projects.

- Testing short-term biodiversity assessments against long-term data sets using fruit-feeding butterflies.
- Conservation of Gramineae and associated arthropods for sustainable agricultural development in Africa.

6. Training in taxonomy

Two PhD scholars are being trained and Group Training workshops conducted for collaborators of the following ICIPE projects:

- African Fruit Fly Initiative (AFFI)
- Stemborer Biological Control
- Biological Control of Diamondback Moth

In addition, 29 parataxonomists have been trained in sampling, identification and preservation of various insect taxa.

(See also reports under Plant Health - Biocontrol of stemborers, Environmental Health - Biodiversity Conservation).

Future Outlook

Revision of the Genus *Psyttalia* (Hym: Braconidae) will be done through a new grant. A proposal on 'Ambo insect identification centre and data bank for crop pests and other insects of Ethiopia' has been written as a basic component of Agrobiodiversity proposals for EARO, Ethiopia.

(See PE&ESD Report)

G. Biostatistics Unit

1. Tsetse trap efficiency redefined

The conventional technique for estimating the efficiency of tsetse traps using an incomplete ring of electrified nets is both expensive and technically demanding. Apart from sometimes yielding efficiency estimates greater than 100%, this technique is subject to many sources of errors and violations of basic underlying assumptions. For instance, too narrow a radius of the ring of nets may result in under-estimates, whereas too wide a radius may similarly result in over-estimation of the efficiency. Flies also 'see' and effectively avoid, or are repelled by, the hitherto presumed transparent electrified nets. Some species also fly over the commonly used 1-m-high nets, resulting in over-estimates of efficiency. Accurate estimation of these biases is both difficult and time consuming.

Based on the knowledge of primary targets of tsetse traps, an alternate definition of the efficiency of the traps was proposed. Appropriate models were then developed to enable the estimation of this efficiency. The models fitted well to different sets of published data, and enabled the estimation of efficiency and comparison of different tsetse trapping devices.

2. Application of a new model for tsetse trapping efficiency

The approach in this study was to represent the distribution of catches in hunger stages by an appropriate probability density function. The corresponding distribution of a natural population of tsetse is similarly represented by another appropriate probability density function. The overlap between the two distribution functions is then used as a measure of efficiency.

The efficiency of a group of baited and unbaited NG2G traps used in published experiments was found, using the developed model, to vary between 44 and 55% for *Glossina longipennis*. For *G. pallidipes*, the efficiency of the same trap baited with cow urine varied between 36 and 47%. The epsilon trap was 37–55% efficient for *G.m. morsitans*, and 26–57% efficient for *G. pallidipes*. The 'refuges' were 52–92% efficient for *G.m. morsitans*, and 67–100% efficient for *G. pallidipes*. The efficiency estimates obtained compared well with expectations. In particular, it is encouraging that our method yielded high efficiency estimates for the 'refuges', which have been shown to give a less biased sample of tsetse flies than traps.

The method proposed here is simple, inexpensive, and not technically demanding. It is based on a few but reasonable assumptions, and subjective to few error sources. In addition, the method will always yield efficiency estimates within the realistic range of zero to 100%. However, the accuracy of the method depends squarely on the accuracy of the method used in classifying the flies into hunger stages. Number of classes of hunger status should essentially be large enough (at least 6) for meaningful fitting of the beta distribution to trap catches of tsetse, to ensure some reasonable degrees of freedom for the error variance.

3. Capacity building and output

The annual five-week course in Biostatistics for the ARPPIS students was carried out by the Unit during the period under review. Training sessions in statistical software use were conducted for both staff and students, both in Nairobi and at Mbita Point. The Unit also provided resource persons for some group training courses held during the year.

The Unit maintained its close partnership with biometrics units in the Consultative Group of International Agricultural Research (CGIAR) Centres, with the ILRI Biometrician participating in the teaching of the biostatistics course to ARPPIS students. Apart from capacity building activities within ICIPE, the Biostatistics Unit participated in training KARI staff during the year. Several students from local and international institutions were offered industrial attachment training and biostatistical support in the Unit. Active roles in the Nairobi Cluster Modelling Group and the International Biometrics Society were maintained during the period.

Three research papers and two conference papers were published in 2000.
(See also report in Tsetse Research under Animal Health Division)

H. Information and Publications Unit (IPU)

The Unit consists of five sections dealing with editorial and public relations functions, publishing, printing, hosting of an international journal, and provision of library and information services.

1. Major publications

(For full list see Publications List)

- *ICIPE Annual Scientific Annual Report 1998–1999*
- *ICIPE Intellectual Property Guide 2000* (written by R. Lettington)
- *Eyes Forward: ICIPE's Business Plan and Research Outlook 2000–2003*
- *ICIPE Year 2000 Highlights and Research Outlook Update 2001–2003*
- *ICIPE Step-by-Step; Mbita Field Station; African Fruit Flies Initiative* (in English and French); *Kakamega Forest* brochures (3)—general information brochures
- *Taxonomy of African Ticks: An Identification Manual*
- *Field Guide to the Stemborer Larvae of Maize, Sorghum and Sugarcane in Eastern and Southern Africa*
- *A Guide to IPM in French Beans Production (with emphasis on Kenya)*

2. Press releases and other public relations materials

Articles about ICIPE and its projects were written and/or edited in the Unit for the local and international media. Some examples are:

- *Pesticide Outlook* (RSC journal): (article on horticulture)
- *INASP Newsletter*—articles on 'grasses project', stemborers, horticulture
- *East African Standard*—2-page colour supplement on ICIPE for the Nairobi Show IPM Supplement
- *Ecoforum*—colour magazine cum journal on environmental issues: articles on Neem (co-authored), Making use of Biodiversity, and Habitat Management
- *Greenpeace Magazine* (Germany)—liaison with reporters and photographers on writing of 3 articles about ICIPE
- Local press (*Daily Nation, EA Standard, Kenya Times, People*): news releases on Habitat Management (2 articles), Grasses and Associated Arthropods, Malaria Research, and other project activities. (available from Public Relations Office).
- Regional and international press: many of the above were sent to other media such as the *East*

African newspaper, Pan-African News Agency (at http://www.allafrica.com, *The Economist*, and others)
- Raitt-Orr and Associates: Liason with this Public Relations consultant to ICIPE has been strengthened over the past year by writing of articles and press releases for distribution by them to publications in the UK and Europe.

3. *Insect Science and Its Application:* The International Journal of Tropical Insect Science

During 2000–2001, Volumes 19 Nos 1–4, Volume 20 Nos 1–4, and Volume 21 Nos 1–3 were published. Volume 21 (No. 4) of 2001 will be distributed in early 2002. Special issues on 'Ecology and management of the red locust, *Nomadacris septemfasciata*' (Vol. 19 No. 4) and on 'Status and advances in biological control of cereal stemborers in Africa' (Vol. 21 No. 4) were among the issues published.

The journal continued to collaborate with Bioline International, University of Toronto (Canada), to achieve the full text on-line hosting of Volumes 20 and 21 (2000 and 2001). All issues of volumes 17–21 are currently full text on-line at the Bioline Web site, http://www.bioline.org.br/ti.

The Tables of Contents and abstracts of all issues from Volume 17 onwards are available on the INASP Africa Journals OnLine (AJOL) website at http://www.inasp.info/ajol/.

Utilising part of a UNESCO grant secured in 2001, a Web page of the journal within the ICIPE Web site was created and launched. This Web page (located at http://www/icipe.org/isa/isa.html), contains frequently sought information about the journal, including the journal's profile, Editorial Board membership, Tables of Contents, Instructions to Authors and subscription information.

4. Printing services

This section printed the majority of the ICIPE stationery, including letterheads, name cards, duplicate and order books, programmes, and small brochures. In addition the section printed some major manuscripts, including:
- *Insect Science and Its Application*—Volumes 20 and 21
- *ICIPE Intellectual Property Guide 2000*
- *ICIPE Annual Scientific Report 1998–1999*
- *Invasive Species in Eastern Africa:A Workshop Proceedings*
- *Taxonomy of African Ticks* (main text)

5. Library

In the past two years, the Library has received over 140 journals, and has added important books to its collection, now totalling about 7000. About 35–40 users on average visit the Library daily and about 7000 user requests are filled annually.

6. Capacity building and networking

Over 15 attachments and interns from local institutions (universities, polytechnics and communication colleges) have been trained in the Printshop, Library, Editorial and Graphics sections during the period.

Two IPU staff were invited to participate and share their experiences in electronic journal publishing at a workshop held in Harare in October 2001, sponsored by INASP (International Network for the Availability of Scientific Publications).

Internal capacity was improved by two staff attending short training courses in web-publishing, and the Head of the Unit attending a short course in Strategic Communication for Development sponsored by the World Bank.

The Unit now participates in a new communications network called the 'Nairobi Group of Development Publishers', which is comprised of all international and national organisations working in development areas, such as ICIPE, ILRI, ICRAF, RELMA, CABI, IIRR, etc. The objectives are to co-publish documents in common areas of interest whenever possible and to share ICT information.

The Unit contributed material rewritten in simple language about ICIPE's stemborer and striga control programmes to the 'Content Development Initiative' of the IDRC Acacia Programme. The material has been translated into four Ugandan language stems for transmission to rural telecentres in that country. A CD on ICIPE's contribution, to include photos,video clips and text, is due to be issued in early 2002.

Future Outlook

Special effort will be made to produce materials in languages other than English and for a wider audience, including end-users. Two manuals on use of IPM in brassicas and tomato production are planned, as is a manual on 'How to Use and Grow Neem'. The biennial Annual Scientific Report and a new Vision and Strategy Document are slated for production in 2002, among others.

Molecular Biology and Biotechnology Unit

Participating scientists: E. Osir (Head of Unit), R. Pasquet.
Collaborators: University of Nairobi, Kenya; Yale University, USA; BiONET-Africa countries (Kenya, Rwanda, Somali, Tanzania, Uganda).
Donors: Rockefeller Foundation, WHO, USDA, USAID, IRD, BMZ, IFAD, BiONET-Africa, IFS, NIH.

Entomopathology Unit

Participating scientists: N. Maniania (Head of Unit), S. Ekesi.
Collaborators: KARI; KEMRI; CABI Bioscience and ICRISAT, Nairobi; IITA, Cotonou; NARO, Uganda; Virginia Polytechnic and State University (VT), USA; Federal Biological Research Centre for Agriculture and Forestry, Institute for Biological Control, Darmstadt, Germany; CSIRO, Australia.
Donors: ICIPE Core Fund donors*.

Information Technology and Bioinformatics Unit

Participating scientist: Y. Xia (Head of Unit).
Collaborators: NSF Centre for IPM, North Carolina State University, USA; Virginia Polytechnic Institute and State University (Virginia Tech), USA; Centre for Pest Information Technology and Transfer (C-PITT), The University of Queensland, Australia; South Africa National Bioinformatics Institute (SANBI), Cape Town, South Africa; The Institute for Genomics Research (TIGR), Maryland, USA; IITA (CGIAR SP-IPM); Africa IPMLink; IPMNet/CICP; IPM/CRSP; IPM Europe; IPM Forum; IPM Globe Facility.
Donors: USAID, ICIPE Core Fund donors*.

Social Sciences Unit

Participating scientist: J. Ssennyonga (Head of Unit).
Collaborators: See under Research Projects.

Animal Rearing and Quarantine Unit (ARQU)

Participating scientist: J. P. R. Ochieng'-Odero (Head of Unit).
Donors: ICIPE Core Fund donors* and recharges to projects.

Biosystematics Unit

Participating scientist: S. W. Kimani-Njogu (Head of Unit).
Collaborators: NMK; NHM (London); PPRI (Pretoria); Royal Museum of Central Africa, Tervuren.
Donors: ICIPE Core Fund donors* and recharges to projects.

Biostatistics Unit

Participating scientist: A. Odulaja (Head of Unit).
Donors: ICIPE Core Fund donors*

Information and Publications Unit

Participating staff: A. Ng'eny-Mengech (Head of Unit), D. Ouya.
Collaborators: Electronic Publishing Trust for Development (UK); Bioline International (University of Toronto); Nairobi Group of Development Publishers.
Donors: ICIPE Core Fund donors*, UNESCO, Swiss Academy of Sciences (gift to Library).

**Danish International Development Agency, Swedish International Development Agency, Swiss Agency for Development and Cooperation, Government of Norway, Government of Finland, Government of France, Japanese Society for the Promotion of Science (JSPS), Government of Kenya.*

8. Finance and Administration

STRUCTURE AND FUNCTIONS

The Finance and Administration department includes Finance, Procurement, Human Resources, Physical Plant and Services, Security, Guest Centres and Nguruman and Muhaka Field Stations. These units are supervised by the Director of Finance and Administration. (See under Professional Staff list for participating staff.)

A. Finance

The principal functions of this department, which has a staff of nine and is managed by the Financial Controller, are:

- Financial management
- Budgetary preparation and control
- Production of management accounts
- Treasury
- Management of debtors, creditors and fixed assets
- Payroll
- Project accounting
- Cash management and stock control.

B. Procurement

In 2000/2001 the Procurement unit had a staff of four, supervised by the Procurement Supervisor. Its main functions are:

- Sourcing and ordering of materials
- Providing progress and status reports
- Handling imports and exports through the clearing agents
- Obtaining duty and VAT exemptions
- Stock management and control
- Processing contracts and tenders
- Handling all immigration affairs

C. Human Resources

The unit consists of a Human Resources Manager and 3 staff members, and handles:

- Recruitment, placement and discharges
- Personnel policies and procedures
- Management of staff benefit policies
- Industrial relations
- Performance evaluation
- Maintenance of the HR database
- Staff training and development.

D. Physical Plant and Services (PPS)

There are two main departments under PPS, namely **Transport** and **Workshop**.

Managed by the PPS Supervisor, the Transport unit had 12 staff in 2000/2001, and handled the operation and maintenance of a fleet of about 100 vehicles.

The maintenance workshop has nine staff members, including the Workshop Supervisor. The workshop is responsible for:

- Buildings maintenance (electrical, plumbing, carpentry, masonry, refrigeration, air conditioning)
- Property management
- Groundskeeping
- Equipment repair
- Fabrication of scientific equipment.

E. Security

The Security Manager and staff members are responsible for:

- Provision of security on the campus
- Supervision of the institutional security guards
- Investigation of security incidents
- Liaison with government and external agencies
- Liaison with USAID.

F. Guest Houses

There are two guest houses, one on the Duduville campus and one at the Mbita Point field station. Both are managed by the Guest House Manager.

- At the Duduville campus, with a staff complement of 26, there is a restaurant and coffee shop, and 34 rooms available for workshops and conferences.
- At Mbita, with a staff of 6, there is a restaurant, bar, and 18 rooms, plus student accommodation

Nguruman Field Station, Magadi township, Kajiado
is located 170 km from Nairobi. This field station has 2 guest houses and a laboratory block.

Muhaka Field Station, Ukunda Kwale district, consists of 320 acres of land with research and ancillary buildings.

9. Publications List

I. ARRANGED BY TYPE

A. ARTICLES IN REFEREED JOURNALS

Published articles

Ajayi O.O., *Odulaja A.*, Nokoe S. and Bamiduro T.A. (1999) Gender specific factors affecting agricultural output of small-scale farmers in sub-Saharan Africa: A case study in western Kenya. *Journal of Tropical Forestry Resources* 15, 130–135. 99-1565

Baliraine F.N., *Osir E.O.*, *Obuya S.B.* and Mulaa F.J. (2000) Protein polymorphism in two populations of the brown ear tick, *Rhipicephalus appendiculatus* Neumann (Acari: Ixodidae). *Insect Science and Its Application* 20, 227–231. 00-1563

Bashir M.O.*, *Hassanali A.*, *Rai M.M.* and *Saini R.K. (2000) Changing oviposition preferences of the desert locust, *Schistocerca gregaria* (Forskål), suggest a strong species predisposition for gregarization. *Journal of Chemical Ecology* 26(7), 1721–1733. 00-1540

***Baumgärtner J.* and Hartmann J.** (2001) The design and implementation of sustainable plant diversity conservation program for alpine meadows and pastures. *Journal of Agriculture and Environmental Ethics* 14, 67–83. 01-1607

Bekele J.* and *Hassanali A. (2001) Blend effects in the toxicity of the essential oil constituents of *Ocimum kilimandscharicum* and *Ocimum kenyense* (Labiateae) on two post-harvest insect pests. *Phytochemistry* 57, 385–391. 01-1566

Bonhof M. J.* and *Overholt W. A. (2001) The impact of solar radiation, rainfall and cannibalism on disappearance of maize stemborers in Kenya. *Insect Science and Its Application* 21, 403–407. 01-1617

Bonhof M. J.*, Van Huis A., *Kiros F. G.* and *Dibogo N. (2001) Farmers' perceptions of importance, control methods and natural enemies of maize stemborers at the Kenya coast. *Insect Science and Its Application* 21, 33–42. 01-1584

Chinwada P.* and *Overholt W. A. (2001) Natural enemies of maize stem borers on the highveld of Zimbabwe. *African Entomology* 9, 67–75. 01-1569

Chinwada P.*, *Omwega C. O.* and *Overholt W. A. (2001) Stemborer research in Zimbabwe and prospects for the establishment of *Cotesia flavipes*. *Insect Science and Its Application* 21, 327–334. 01-1610

Cugala D. and *Omwega C. O.* (2001) Cereal stemborer distribution and abundance and the introduction and establishment of *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) in Mozambique. *Insect Science and Its Application* 21, 281–287. 01-1602

Cugala D., *Overholt W. A.*, Santos L. and Giga D. (2001) Release of *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) for biological control of cereal stemborers in two ecological zones in Mozambique. *Insect Science and Its Application* 21, 303–310. 01-1609

Cugala D., *Overholt W.A.*, Giga D. and Santos L. (1999) Performance of *Cotesia sesamiae* and *Cotesia flavipes* (Hymenoptera: Braconidae) as biological control agents against cereal stemborers in Mozambique. *African Crop Science Journal* 7(4), 497–502. 99-1544

***Demas F.A.*, *Hassanali A.*, *Mwangi E.N.*, Kunjeku E.C. and Mabveni A.R.** (2000) Cattle and *Amblyomma variegatum* odours used in host habitat and host finding by the tick parasitoid, *Ixodiphagus hookeri*. *Journal of Chemical Ecology* 26(4), 1079–1093. 00-1543

Ekesi S.* and *Maniania N.K. (2000) Susceptibility of *Megalurothrips sjostedti* developmental stages to the entomopathogenic fungus *Metarhizium anisopliae* and the effects of infection on feeding and on fecundity, egg fertility and longevity of adults surviving infection as second instar larvae. *Entomologia Experimentalis et Applicata* 94(3), 229–236. 00-1520

***Ekesi S.*, *Maniania N. K.*, *Ampong-Nyarko K.* and Akpa A. D.** (2001) Importance of timing of application of the entomopathogenic fungus, *Metarhizium anisopliae*, for the control of legume flower thrips, *Megalurothrips sjostedti* and its persistence on cowpea. *Archives of Phytopathology and Plant Protection* 33, 431–445. 01-1572

Ekesi S.*, *Maniania N.K.*, *Ampong-Nyarko K.* and *Lwande W. (2000) Susceptibility of the legume flower thrips, *Megalurothrips sjostedti* to *Metarhizium anisopliae* on different varieties of cowpea. *BioControl* 45(1), 79–95. 00-1531

***Emana G. D.*, *Overholt W. A.* and Kairu E.** (2001) Distribution and species composition of cereal stemborers and their natural enemies in maize and sorghum in Ethiopia. *Insect Science and Its Application* 21, 353–359. 01-1618

Fries I., *Shi W.* and *Raina S. K.* (2001) American foulbrood (*Paenibacillus larvae* ssp *larvae*) and African honey bees. *Acta Universitatis Agriculturae Sueciae AGARIA* 291, (IV) 1–8.

Getu E., *Overholt W.A.* and Kairu E. (2001) Distribution and species composition of stemborers and their natural enemies in maize and sorghum in Ethiopia. *Insect Science and Its Application* 21(4), 353–359. 01-1618

Gianoli E.* and *Hannunen S. (2000) Plasticity of leaf traits and insect herbivory in *Solanum incanum* L. (Solanaceae) in Nguruman, SW Kenya. *African Journal of Ecology* 38, 183–187.

Gikonyo N.K.*, *Hassanali A.*, *Njagi P.G.N.* and *Saini R.K. (2000) Behaviour of *Glossina morsitans morsitans* Westwood (Diptera: Glossinidae) on waterbuck *Kobus defassa* Ruppel and feeding membranes smeared with waterbuck sebum indicates the presence of allomones. *Acta Tropica* 77, 295–303. 00-1550

ICIPE staff names are italicised; publications with a 1999 date have not previously been reported in the ICIPE Publications List; reprints of articles with a call number at the end of the citation can be ordered from the Documentalist, ICIPE.

Gohole L. S. **and** *Ngi-Song A. J.* (2001) The chemical ecology of host location by parasitoids of African stemborers. *Insect Science and Its Application* 21, 361–368. 01-1613

Guofa Z., Overholt W.A. **and** *Mochiah M.B.* (2001) Changes in the distribution of lepidopteran maize stemborers in Kenya from the 1950s to 1990s. *Insect Science and Its Application* 21(4), 395–402. 01-1616

Hariyama T. and *Saini R. K.* (2001) Odor bait changes the attractiveness of color for the tsetse fly. *Tropics* 10 (4), 581–589. 01-1593

Hassanali A. **and** *Bashir M.O.* (1999) Insights for the management of different locust species from new findings on the chemical ecology of the desert locust. *Insect Science and Its Application* 19(4), 369–376. 99-1532

Khan Z. R., **Pickett J. A., Wadhams L. and Muyekho F.** (2001) Habitat management for the control of cereal stem borers in maize in Kenya. *Insect Science and Its Application* 21, 375–380. 01-1615

Khan Z.R., **Pickett J.A., van den Berg J., Wadhams L.J. and Woodcock C.M.** (2000) Exploiting chemical ecology and species diversity: Stemborer and striga control for maize and sorghum in Africa. *Pest Management Science* 56, 957–962. 00-1558

Kimani S.M., **Chhabra S.C.,** *Lwande W., Khan Z.R.*, *Hassanali A.* **and Pickett J.A.** (2000) Airborne volatiles from *Melinis minutiflora* P. Beauv., a non-host plant of the spotted stem borer. *Journal of Essential Oil Research* 12, 221–224. 00-1557

Kimani-Njogu S.W., **Trostle M.K., Wharton R.A., Woolley J.B. and Raspi A.** (2001) Biosystematics of the *Psyttalia concolor* species complex (Hymenoptera: Braconidae: Opiinae): The identity of populations attacking medfly in coffee in Kenya. *Biological Control* 20, 167–174. 01-1561

Kioko E.N., Raina S.K. **and Mueke J.M.** (2000a) Phenology and survival of the wild silkmoth, *Argema mimosae* (Saturniidae) in Makueni District, Kenya. *International Journal of Wild Silkmoth & Silk* 5, 318–320. (Proceedings of the 3rd International Conference on Wild Silkmoths 1998. International Society for Wild Silkmoths, Japan & Central Silk Board, India.) ISSN 1340-4725.

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Limonta L., Severini M. and *Baumgärtner J.* (2001) Temperature-dependent development and stage-specific mortality of immature *Oulema duftschmidi* (Redtenbacher) life stages, in comparison to *O. melanopus* (L.) and *O. gallaeciana* (Heyden) (Coleoptera: Chrysomelidae). *Boll. Zool. Agr. Bachic.* Ser. II, 83–91.

Mahamat H., Hassanali A. **and** *Odongo H.* (2000) The role of different components of the pheromone emission of mature males of the desert locust *Schistocerca gregaria* (Forskål) (Orthoptera: Acrididae) in accelerating the maturation of immature adults. *Insect Science and Its Application* 20, 1–5. 00-1537

Malual A. G., Hassanali A., Torto B., Assad Y. O. H. **and** *Njagi P. G. N.* (2001) The nature of the gregarising signal responsible for maternal transfer of phase to the offspring in the desert locust *Schistocerca gregaria*. *Journal of Chemical Ecology* 27, 1423–1435. 01-1587

Masaninga F. **and** *Mihok S.* (1999) (Short communication) Host influence on adaptation of *Trypanosoma congolense* metacyclics to vertebrate hosts. *Medical and Veterinary Entomology* 13, 330–332. 99-1536

Matama-Kauma T., Kyamanywa S., Ogwang J. A., *Omwega C. O.* **and Willson H. R.** (2001) Cereal stemborer species complex and establishment of *Cotesia flavipes* Cameron in Eastern Uganda. *Insect Science and Its Application* 21, 317–325. 01-1619

Mbapila J. C. **and** *Overholt W. A.* (2001) Comparative development, longevity and population growth of exotic and native parasitoids of lepidopteran cereal stemborers in Kenya. *Bulletin of Entomological Research* 91, 347–353. 01-1586

Miller S. E. **and** *Rogo L. M.* (2001) Challenges and opportunities in understanding and utilising African insect diversity. *Cimbebasia* (Journal of the National Museum of Namibia) 17, 197–218. 01-1599

Minakawa N., *Githure J. I., Beier J. C.* **and** *Yan G.* (2001) Anopheline mosquito survival strategies during the dry period in western Kenya. *Journal of Medical Entomology* 38, 388–392. 01-1630

Mochiah M. B., Ngi-Song A. J., Overholt W. A. **and Botchey M.** (2001) Host suitability of four cereal stemborers (Lepidoptera: Crambidae, Noctuidae) for different geographic populations of *Cotesia sesamiae* (Cameron) (Hymenoptera: Braconidae) in Kenya. *Biological Control* 21, 285–292. 01-1573

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B. BOOKS AND MISCELLANEOUS PUBLICATIONS

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HUMAN AND ANIMAL HEALTH: DISEASE VECTORS AND EPIDEMIOLOGY

Disease vectors, general

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Malaria, mosquitoes and *Plasmodium*

Habtewold T., Walker A. R., Curtis C. F., *Osir E. O.* and Thapa N. (2001) The feeding behaviour of *Anopheles arabiensis* mosquitoes in Southern Ethiopia in relation to use of insecticide-treated livestock for malaria control. *Proceedings of the Royal Society of Tropical Medicine and Hygiene* 95, 584–586.

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Ticks

Demas F.A., Hassanali A., Mwangi E.N., **Kunjeku E.C. and Mabveni A.R.** (2000) Cattle and *Amblyomma variegatum* odours used in host habitat and host finding by the tick parasitoid, *Ixodiphagus hookeri. Journal of Chemical Ecology* 26(4), 1079–1093. 00-1543

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Vector control (includes trapping, habitat management, use of repellents, push-pull tactics)

***Baumgärtner J.*, Bieri J., Buffoni G., Gilioli G., Gopalan H.N.B., *Greiling J.*, *Tikubet G.* and Van Schayk I. M. C. J.** (2001) Human health management in sub-Saharan Africa through integrated management of arthropod transmitted diseases and natural resources. *Cadernos de saúde pública* (reports in public health) 17 (suppl), 17–46.

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ENVIRONMENTAL HEALTH

Biodiversity conservation and general ecology *(see also Population ecology under Disciplinary activities)*

Basset Y., Aberlenc H.-P., Barrios H., Curletti G., Béranger J.-M., Vesco J.-P., Causse P., Haug A., Hennion A.-S., Lesobre L., Marques F. and *O'Meara R.* (2000) Stratification and diel activity of arthropods foraging within the upper canopy and understorey of a rain forest at La Makandé, Gabon, pp. 26–39. In *Biologie d'une canopée de forêt tropicale—IV. Rapport de la mission du radeau des cimes à la Makandé, forêt des Abeilles, Gabon, Janvier–Mars 1999* (Edited by F. Hallé). Pro-Natura International & Opération Canopée, Paris.

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Chemical ecology *(see also Behavioural biology)*

Bekele J. **and** ***Hassanali A.*** (2001) Blend effects in the toxicity of the essential oil constituents of *Ocimum kilimandscharicum* and *Ocimum kenyense* (Labiateae) on two post-harvest insect pests. *Phytochemistry* 57, 385–391. 01-1566

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Population ecology and GIS

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Ajayi O.O., ***Odulaja A.,*** **Nokoe S. and Bamiduro T.A.** (1999) Gender specific factors affecting agricultural output of small-scale farmers in sub-Saharan Africa: A case study in western Kenya. *Journal of Tropical Forestry Resources.* 15, 130–135. 99-1565

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10. ICIPE Scientific Seminar Series

INTRODUCTION

A total of 16 seminars were presented in the Scientific Seminar Series of 2000–2001 and these included 13 Special Guest Seminars (outside speakers), one by an ICIPE Research Scientist, and two by an outgoing ARPPIS scholar. The presentations were varied in subject coverage, and were well attended, primarily by ARPPIS and DRIP scholars. Working closely with the Offices of the Director General, Research and Capacity Building and Public Relations, the Seminar Series Coordinator for the period was Sunday Ekesi, a postdoctral fellow at the Entomopathology Unit.

The following recommendations are made, as a means of increasing participation at the ICIPE Scientific Seminar Series.

- Staff assessments might be pegged on seminar attendance/presentation or a rule of at least one seminar per research scientist/scholar/year could be introduced.
- Scientists, fellows and scholars attending conferences should be encouraged to present their papers in a seminar before departing for the conference.
- Proposals of postgraduate scholars, as well as results of the research done, might be presented in a seminar.
- Scientist visitors to ICIPE should be encouraged to deliver a seminar during their visit.

List of 2000–2001 Seminars

Speaker	Title
S.G. Weldessemayat ARPPIS Scholar ICIPE, Nairobi, Kenya	Discovery of an Unusual Parasitism in *Periltus* sp. and Implications for Braconid Biosystematics
Ms C. Ngarachu Nature Kenya Nairobi, Kenya	Nature Kenya, An Illustrated Talk on Its Programmes, Community Projects, Publications and Membership Activities
Prof. F. Omlin Neem Project ICIPE, Nairobi, Kenya	Neem—Quo vadis?
Prof. S. Kannaiyan Vice Chancellor Tamil Nadu Agricultural University Coimbatore, India	Recent Research Progress in Biocontrol Products in Tamil Nadu, India
Prof. J. Smith Biological Control Laboratory Department of Entomology, Texas A & M University, College Station, USA	Patterns of Stemborer Parasitoid Foraging: A Template for Addressing Issues in Contemporary Biological Control

Continued

Continued

Speaker	Title
Dr J. Kannaiyan Technical Director Sun Agro Biotech Products Madras, India	Experience in Commercial Production of Biocontrol Agents in Tamil Nadu, India
Dr S. Dupas IRD/CNRS, Laboratoire Populations Génétique et Evolution, Gif Sur Yvette, France	Genetic Interactions and Geographic Variations in Host–Parasitoid and Plant–Insect Systems
Dr R.J. Rabindra Insect Pathologist and Head Entomology Department Tamil Nadu Agricultural University (TNAU) Coimbatore, India	Potential for Utilisation of Baculoviruses in Management of Lepidopteran Pests
Dr D. Sabitha Director Centre for Plant Protection Studies Tamil Nadu Agricultural University Coimbatore, India	Recent Trends in Biopesticide Research
Dr N. Natarajan Visiting Scientist Behavioural and Chemical Ecology Department/Vegetable IPM Project ICIPE, Nairobi, Kenya	Sex Pheromone Research in *Heliothis*
Linnet Gohole DRIP Scholar ICIPE, Nairobi, Kenya	Future Harvest Ambassadorship in the Flower and Garden Festival at Epcot-Walt Disney World Resort
E. G. Degaga ARPPIS Scholar ICIPE, Nairobi, Kenya	Ecological Analysis of Cereal Stemborers and Their Natural Enemies in Ethiopia
Dr W.W.D. Modder Tea Reseach Institute, Sri Lanka	Tea Research in Sri Lanka
Dr Vasily V. Grebennikov Scarab Research Group, Department of Zoology and Entomology, Faculty of Natural and Agricultural Sciences, University of Pretoria Pretoria South Africa	Larvae of Coleoptera: Immense Morphological Diversity and the Way to Study Them
Dr Gabor Lovei Dept. of Crop Protection Danish Institute of Agricultural Science Flakkebjerg Research Centre DK-4200 Slagelse, Denmark	The Ecosystem Services Concepts and the Ecological Risk Assessment of Transgenic Plants
Dr M. Sallam Sugar Cane Research Institute Melbourne, Australia	Insect Pests of Sugar Cane in Australia and Threat of Stem Borer Invasion
Prof. T. Yilma Professor of Virology and Director International Laboratory for Molecular Biology, University of California,Davis USA	A Modern Vaccine and Diagnostic Kit for an Old Plague Rinderpest

11. ICIPE Professional Staff List

MANAGEMENT AND GENERAL OPERATIONS

Office of the Director General
Hans Rudolf Herren (Switzerland), *Director General and CEO*
Remedios Dela Paz Ortega (Philippines), *Public Relations Officer*

Office of the Director of Research and Partnerships
Onesmo K. ole-MoiYoi (Tanzania) *Director of Res. and Partnerships)*[1]

R&CB Committee
Ellie Osir (Kenya) *Principal Scientist, Chair & Interim Director of Research)*[2]

R&CB Office
James P. Ochieng'-Odero (Kenya), *Senior Scientist and Interim Manager*

ADMINISTRATION AND FINANCE

Christopher Geoffrey Hill (UK), *Director, Finance & Administration*
Willis Harrison Awori (Kenya), *Human Resources Manager*
Dinah Wairimu Njoroge (Kenya), *Financial Controller*
Peter Dickson Kamau Ndirangu (Kenya), *Procurement Supervisor*
Patrick Ngahu Ndiangui (Kenya), *Project Accountant*
Serah Njeri Mungai (Kenya), *Project Accountant***
Anthony Akumu Abogi (Kenya), *Financial Accountant***
Cyrus Kimani Watuku (Kenya), *Systems Analyst*

SPECIAL SERVICES

Kurt Benjamin Iten (Switzerland), *General Manager, Guest Centres*
Alfred Lustenberger (Switzerland), *Head of Physical Plants & Services*#

RESEARCH DIVISIONS

Plant Health Division
Bernhard Löhr (Germany), *Principal Scientist & Division Head*##

Staple Food Crops
William Allan Overholt (USA), *Principal Scientist & Head, Staple Food Crops Sub-Division*
Zeyaur Rahman Khan (India), *Principal Scientist & Habitat Management Programme Leader*
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Ramesh Chandra Saxena (India), *Principal Scientist & Neem Awareness Programme Leader*#
Srinivasan Sithanantham (India), *Senior Scientist & Vegetable IPM Project Leader*
Abdurabi Seif (Kenya), *Scientist***
Lisbeth Riis (Denmark), *Visiting Scientist*
Neil Springate (UK), *Visiting Scientist*
Brigitte Nyambo (Tanzania), *Consultant Entomologist*
Markus Alois Knapp (Germany), *Postdoctoral Fellow*
Nikolaus Johannes Zenz (Germany), *Postdoctoral Fellow***
Nicholas Kamindu Gikonyo (Kenya), *Postdoctoral Fellow***
Sunday Ekesi (Nigeria), *Postdoctoral Fellow*

Locusts and Migratory Pests
Ahmed Hassanali (Tanzania), *Principal Scientist & Head, Locusts and Migratory Pests Sub-Division*

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Baldwyn Torto (Ghana), *Senior Scientist***
Satoshi Nakamura (Japan), *Senior Scientist- JIRCAS*
Peter George Nganga Njagi (Kenya), *Scientist***

Animal Health
Rajinder K. Saini (Kenya), *Principal Scientist & Tsetse Research Programme Leader, Ag Division Head*
David J. Nadel (USA), *Principal Scientist#*
Getachew Tikubet (Ethiopia), *Senior Scientist#*

Human Health
John Githure (Kenya), *Scientist & Malaria Mosquitoes Programme Leader, Ag Division Head (Seconded by KEMRI)*
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Clifford Maina Mutero (Kenya), *Senior Scientist*
John Beier (USA), *Visiting Scientist - Tulane University, USA*
Guiyun Yan (USA), *Visiting Scientist - State University of New York, USA*
Charles Mbogo (Kenya), *Visiting Scientist - KEMRI, Kilifi, Kenya*
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Louis Gouagna (Cameroon), *Visiting Scientist - OCEAC, Cameroon*
Robert R. Jackson (USA), *Visiting Scientist - University of Canterbury, New Zealand*
Gerald F. Killeen (USA), *Visiting Scientist*
Hannah Nadel (USA), *Visiting Scientist*
Joseph Keating (USA), *Visiting Scientist, Tulane University Medical Centre, USA**

Environmental Health
Johann Baumgärtner (Switzerland), *Principal Scientist, Acting Division Head*
Suresh Kumar Raina (India), *Principal Scientist & Commercial Insects Programme Leader*
Lucie Marie Rogo (Kenya), *Scientist & Ag Biodiversity and Conservation Programme Leader***
Susan Wangari Kimani-Njogu (Kenya), *Scientist & Head of Biosystematics Unit*
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Robert Copeland (USA) *Visiting Scientist - Texas A&M University, USA*
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Dirk Schmitt Wagner (Germany) *Visiting Scientist**
Ogor Beloousson (Russia) *Visiting Scientist**
Vladmir Gusarov (Russia) *Visiting Scientist**
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*#Left in year 2000; ##Effective April 2000; *Staff joining in 2001; **Left in 2001; [1]From Oct. 2001; [2] Until Oct. 2001.*

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[Note that postgraduate students are not officially ICIPE staff but are major contributors to ICIPE's R&D effort.]

12. ICIPE Governing Council

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Dunstan Spencer and Associates

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Prof. Barbara Ekbom (Sweden)
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Escola Superior de Agricultura 'Luiz de Queiroz' (ESALQ), University of São Paulo, Piracicaba, Brazil
Plant Health-Red Spider Mites in Small-Holder Tomato Production
Empresa Brasiliera de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation) (EMBRAPA), Brazil
PEESD-Resource Management
Universidade Regional do Cariri, Crato, Brazil
Plant Health-Red Spider Mites in Smallholder Tomato Production

BURKINA FASO
Centre International de recherche et de développement sur l'élevage en zone subhumide (CIRDES)
Animal Health-Epidemiological Studies (Tsetse)
Directorate of Veterinary Services, Burkina Faso
MBBU-Tick Control Strategies; MBBU- Capacity Building; Animal Health-Ticks
Ministry of Agriculture and Livestock, Burkina Faso
Environmental Health-Sericulture

CAMEROON
Universite de Dschang, Cameroon
Capacity Building
Interafrican Phytosanitary Council (IAPSC)/OAU
Plant Health-The African Fruit Fly Initiative

**As at March 2002. Arranged by Country.*

CANADA
International Development Research Centre (IDRC), Canada
Human Health-Malaria
University of Victoria, Victoria
MBBU-Tsetse–Trypanosome Interactions

CHINA
B.t. Research and Development Centre (BtRDC), Hubei, China
Plant Health-HC
Chinese Academy of Agricultural Sciences (CAAS), China
Environmental Health-Apiculture; Environmental Health-Sericulture; Plant Health-African Bollworm Biocontrol
Shanshi Seritech, China
Environmental Health-Sericulture
Wild Silk Research Station, China
Environmental Health-Sericulture

COLOMBIA
Centro Internacional de Agricultura Tropical (CIAT), Colombia
Plant Health-HC

COSTA RICA
University of Costa Rica, Costa Rica
Plant Health-The African Fruit Fly Initiative

CÔTE D'IVOIRE
Centre National de Recherche Agronomique (CNRA), Abidjan, Côte d'Ivoire
Plant Health-The African Fruit Fly Initiative
Ministry of Agriculture and Livestock, Côte d'ivoire
Environmental Health-Sericulture

CZECHOSLOVAKIA
Czech Academy of Sciences, Czechoslovakia
Environmental Health-Biodiversity

DENMARK
University of Copenhagen, Denmark
Plant Health-HC

EGYPT
Assiut University, Egypt
Capacity Building

ERITREA
Ministry of Agriculture and Livestock, Eritrea
Environmental Health-Sericulture
Ministry of Health, Eritrea
Human Health-Bioprospecting for Useful Plants for Cultivation; Human Health-Capacity Building
University of Asmara, Eritrea
Plant Health-Biological Control of Cereal Stemborers

ETHIOPIA
Addis Ababa University, Ethiopia
Capacity Building; PEESD-Apiculture; Animal Health-Tsetse; Environmental Health-Biodiversity; BCED; Human Health-Bioprospecting for Mosquito Repellent and Insecticidal Plants; Human Health-Capacity Building
Alemaya University of Agriculture, Ethiopia
Capacity Building
Ethiopian Agricultural Research Organisation (EARO), Ethiopia-[1]Melkessa Research Centre, Nazareth; [2]Plant Protection Research Centre, Ambo
[1]Plant Health-Biological Control of Cereal Stemborers; [1]Plant Health-IPM for Diamondback Moth; [2]Plant Health-African Bollworm Biocontrol; Capacity Building; PEESD-Apiculture; Animal Health and PEESD-Population Management (Tsetse Flies); Plant Health and PEESD-(Pachnoda, Maize Stemborers and Weeds) As Well As Fodder Tree Establishment; Plant Health-Sorghum Chafer; Plant Health-Habitat Management Project; Plant Health-GEF Grass Project
Ethiopian Health and Nutrition Research Institute, Ethiopia
PEESD-Human Health & Nutrition; Human Health-Bioprospecting for Useful Plants for Cultivation
Ethiopian Science and Technology Commission
Animal Health-Epidemiological Studies (Tsetse)
Ethiopian Social Rehabilitation and Development Fund (ESRDF)
Biovillage Project-Ecosystem Management for Human Health Improvement and Poverty Alleviation
GTZ-LUPO, Ethiopia
PEESD-Resource Management, Apiculture
International Livestock Research Institute (ILRI), Ethiopia
Animal Health-Animal Health & Animal Disease Vectors
Ministry of Agriculture and Livestock, Ethiopia
Environmental Health-Sericulture; Plant Health-GEF Grass Project
Organisation of African Unity (OAU), Ethiopia-[1]The Inter-Africa Bureau for Animal Resources (OAU-IBAR), Ethiopia; [1]International Steering Committee for Trypanosomiasis Research and Control (OAU-ISCTRC), Ethiopia; [2]Farming in Tsetse Controlled Areas (EU) Project of OAU-IBAR
[1]Animal Health-Epidemiological Studies (Tsetse); [2]Animal Health-Training of Farmers, Tsetse Control and Socioeconomic Studies; Social Science
University of Addis Ababa, Ethiopia
BCED

FRANCE
Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), France
Plant Health-The African Fruit Fly Initiative
Centre for Biology and Management of Populations (CBGP), Montpellier
Plant Health-Red Spider Mites in Smallholder Tomato Production
Ecole Nationale Supérieure Agronomique (ENSAM), Montpellier, France
Plant Health-Red Spider Mites in Smallholder Tomato Production

Insect Biological Control Laboratory, France
Plant Health-SF
Institut de la Recherche Agronomique, France
Plant Health-SF
Institut de Recherche pour le Développement
MBBD-Gene Flow and Transgenic Risk Assessment; Environmental Health-Biodiversity (Stemborer Diversity)
INRA, France
Plant Health-SF
ISC & ISA, France
Environmental Health-Sericulture
United States Department of Agriculture/ Agricultural Research Station (USDA/ARS), Montpellier, France
Plant Health-Diamondback Moth Biocontrol Project/Locust Biocontrol Project

GAMBIA, THE
The International Trypanotolerance Centre (ITC), Banjul, The Gambia
Animal Health-Epidemiological Studies (Tsetse)

GERMANY
Biological Research Institute (BBA), Darmstadt, Germany
Plant Health-African Bollworm Biocontrol
Federal Biological Research Centre for Agriculture and Forestry, Germany-[1]Institute for Biological Control, Darmstadt
Social Sciences; [1]Entomopathology Unit
German Centre for Documentation and Information in Agriculture (ZADI), Bonn, Germany
Insect Informatics
Institute for Systematic Zoology at the Museum of Natural History of Humboldt, University of Berlin, Germany
Environmental Health-Biodiversity
Museum Koenig, Bonn, Germany
Environmental Health-Biodiversity
University of Bayreuth, Germany
BCED
University of Bonn, Germany
Environmental Health-Biodiversity
University of Constance, Germany
Capacity Building
University of Hohenheim, Stuttgart, Germany-[1]Institut für Phytomedizin
PEESD-Socioeconomics, Apiculture, Nutrition; Plant Health-African Fruit Fly Initiative; [1]Plant Health-Diamondback Moth Biocontrol Project; Plant Health-African Bollworm Biocontrol
University of Jena, Germany
Capacity Building

GHANA
Ministry of Agriculture and Livestock, Ghana
Environmental Health-Sericulture
University of Cape Coast, Ghana
Capacity Building; BCED
University of Ghana, Legon
Capacity Building

GREECE
University of Crete, Heraklion, Greece
Plant Health-The African Fruit Fly Initiative

GUATEMALA
USDA-APHIS-PPQ Methods Station, Guatemala
Plant Health-The African Fruit Fly Initiative

INDIA
Central Silk Board (CSB), India
Environmental Health-Sericulture
Centre of Sericulture and Biological Pest Management Research (CSBR), India
Environmental Health-Sericulture
Indian Agricultural Research Institute (IARI), New Delhi
Plant Health-African Bollworm Biocontrol
Indian Council of Agricultural Research (ICAR)
Plant Health-African Bollworm Biocontrol
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India
Plant Health-Biological Control of Cereal Stemborers
National Project Directorate for Biological Control (PDBC), Bangalore
Plant Health-Augmentation Biocontrol
Tamil Nadu Agricultural University (TNAU), Coimbatore
Plant Health-African Bollworm Biocontrol
Wild Silk Research Station, India
Environmental Health-Sericulture

ISRAEL
Kimron Veterinary Institute (KVI), Israel
MBBU-Use of Nematodes for Tick Control; Animal Health-Ticks
Tel Aviv University, Israel
Plant Health-Armyworm
The Agricultural Research Organisation (ARO), Israel-Department of Nematology
Animal Health-Ticks
The Hebrew University, Israel
Plant Health-The African Fruit Fly Initiative
The Volcani Centre, Israel
Animal Health-Ticks
University of Haifa, Israel
Plant Health-Armyworm; Plant Health-Habitat Management Project

ITALY
ENEA (Italian Agency for New Technology, Energy and Environment), La Spezia, Italy
PEESD-Ecosystem Modelling
Food and Agriculture Organisation of the UN (FAO), Italy- [1]FAO-EMPRES; [2]Inter-Governmental Sub-Group on Tropical Fruits (IGG-TF), Commodity and Trade Division; [3]IPM Global Facility
Environmental Health-Sericulture; [1]Plant Health-Semiochemical Research for Management and Control of the Desert Locust; [2]Plant Health-The African Fruit Fly Initiative; [3]Insect Informatics; Animal Health-Tsetse and Trypanosomosis
University of Molise

PEESD-Spatio-temporal Population Dynamics and Ecosystem Modelling

University of Pavia, Italy
Plant Health-The African Fruit Fly Initiative

University of Reggio di Calabria
PEESD-Spatio-temporal Population Dynamics and Ecosystem Modelling

University of Rome
PEESD-Spatio-temporal Population Dynamics

JAPAN

Wild Silk Research Station, Japan
Environmental Health-Sericulture

Japan International Research Centre for Agricultural Sciences (JIRCAS)
Plant Health-Stemborers, Desert Locust IPM; Animal Health-Tick Parasitoids

Japan Society for the Promotion of Science (JSPS)
Plant Health-Stemborers, Desert Locust IPM

KAZAKHSTAN, REPUBLIC OF

The Kazakh Scientific Research Institute for Plant Protection
Plant Health-Desert Locust

KENYA

African Butterfly Research Institute, Kenya
Environmental Health-Biodiversity

Centre for Applied Biosciences International (CABI), Kenya
Plant Health-Desert Locust; Entomopathology Unit

Coffee Research Foundation (CRF), Kenya
Biosystematics

Coffee Research Institute, Kenya
Plant Health-The African Fruit Fly Initiative

Department of Resource Surveys and Remote Sensing (DRSRS), Kenya
Environmental Health-Kakamega Forest Conservation Project

Desert Locust Control Organisation for Eastern Africa (DLCO-EA)
Plant Health-Desert Locust; ARQU

Dudutech Limited, Nanyuki
Plant Health-Biological Control Products

East African Wildlife Society, Kenya
Environmental Health-Kakamega Forest Conservation Project

Egerton University, Njoro, Kenya
Capacity Building; BCED; Plant Health-Habitat Management of Cereal Stemborers; MBBU-Capacity Building

Finlay Flowers, Kericho, Kenya
Plant Health-HC

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Kenya
Entomopathology; Plant Health-African Bollworm Biocontrol

IDRC Acacia Initiative, Kenya
Information and Publications-Production of Content for Rural Telecentres in Uganda, E. Africa (Pilot Study)

International Centre for Research in Agroforestry (ICRAF), Nairobi, Kenya
Plant Health-Armyworm; Environmental Health-Sericulture; Environmental Health-Biodiversity; Capacity Building; Biostatistics; Plant Health-Sweet Potato IPM Project

International Livestock Research Institute (ILRI), Nairobi, Kenya
Animal Health-Ticks; Animal Health-Validation of Repellent Technologies (Tsetse); ARQU; Biostatistics

Intermediate Technology Development Group (ITDG), Kenya
Environmental Health-Kakamega Forest Conservation Project

Jestan Herbal Health Clinic Inc., Kenya
Environmental Health-Biodiversity; Human Health-Bioprospecting for Mosquito Repellent and Insecticidal Plants

Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya
Capacity Building; Animal Health-Tsetse; Environmental Health-Biodiversity; BCED; Human Health-Bioprospecting for Mosquito Repellent and Insecticidal Plants; Human Health-Bioprospecting for Useful Plants for Cultivation; Human Health-Capacity Building; Plant Health-Red Spider Mites in Small-Holder Tomato Production; Plant Health-Striga Allelochemicals; MBBU-Capacity Building

Kakuzi Farm, Thika, Kenya
Environmental Health-Apiculture

Kenya Agricultural Research Institute (KARI), Kenya-[1]Coast Regional Agricultural Research Centre, Kikambala; [1]Katumani National Dryland Research Centre, Machakos; [2,5,8]National Agricultural Research Laboratories, Muguga; [3]Regional Agricultural Research Centre, Kisii; [3]National Biological Control Centre, Muguga; [4]National Agricultural Research Centre, Kitale; [6]National Research Centre (NRC), Biocontrol Programme; [7]National Veterinary Research Centre (NVRC)
[1]Plant Health-Biological Control of Cereal Stemborers; [2]Plant Health-The African Fruit Fly Initiative; [3]Plant Health-IPM for Diamondback Moth; [4]Plant Health-Habitat Management of Cereal Stemborers; [5]Biosystematics; [6]Plant Health-African Bollworm Biocontrol; [7]MBBU-Control of Livestock Ticks; [7]Animal Health-Ticks; [8]Plant Health-Red Spider Mites in Smallholder Tomato Production; Environmental Health-Sericulture; Capacity Building; Social Science; ARQU; Plant Health-Sweet Potato IPM Project; Entomopathology Unit

Kenya Forestry Research Institute (KEFRI)
Human Health-Bioprospecting for Useful Plants for Cultivation; Environmental Health-Kakamega Forest Conservation Project

Kenya Medical Research Institute (KEMRI)
ARQU; Human Health-Bioprospecting for Useful Plants for Cultivation; Human Health- Vector Competence, Larval Ecology, Antimalarials, Urban Malaria; Human Health-Bt for Malaria Control; Entomopathology Unit

Kenya Rural Enterprise Programme (K-REP), Kenya
Environmental Health-Kakamega Forest Conservation Project

Kenya Trypanosomiasis Research Institute (KETRI)
ARQU; MBBU; Animal Health-Epidemiological Studies (Tsetse)

Kenya Wildlife Service
MBBU; Environmental Health-Kakamega Forest Conservation Project; Animal Health-Animal Health Issues in the Boundaries of National Parks and Reserves

Kenyatta University, Nairobi, Kenya
Capacity Building; Environmental Health-Biodiversity; Environmental Health-Sericulture; BCED; Animal Health-Ticks; Human Health-Bioprospecting for Mosquito Repellent and Insecticidal Plants; Human Health-Bioprospecting for Useful Plants for Cultivation; Human Health-Capacity Building; Plant Health-Biological Control of Cereal Stemborers; Biostatistics; MBBU-Capacity Building

Ministry of Agriculture, Livestock Development and Marketing (MOALDM), Kenya-[1]Department of Veterinary Services; [2]InterAfrican Bureau of Animal Resources (IBAR); [3]District Agricultural Office, Taita/Taveta District
Plant Health-Habitat Management of Cereal Stemborers; ARQU; [1]Animal Health-Epidemiological Studies (Tsetse); Plant Health-Sweet Potato IPM Project; [2]Social Science; [3]Plant Health-IPM for Diamondback Moth

Ministry of Health, Kenya-Division of Vector Borne Diseases (DVBD)
Human Health-Vector Competence

Ministry of Natural Resources, Kenya-The Forest Department
Environmental Health-Kakamega Forest Conservation Project

Moi University, Kenya
Capacity Building; MBBU-Capacity Building

Mpala Research Centre, Kenya
Environmental Health-Biodiversity

Municipal Council of Kisumu
Human Health-Urban Malaria

Municipal Council of Malindi
Human Health-Urban Malaria

National Council for Science and Technology, Kenya
Human Health-Bioprospecting for Useful Plants for Commercial Cultivation

National Irrigation Board, Kenya
Human Health-Malaria

National Museums of Kenya
Capacity Building; Biosystematics; ARQU; Environmental Health-Kakamega Forest Conservation Project; Plant Health-The African Fruit Fly Initiative; Plant Health-Biological Control of Cereal Stemborers; Plant Health-GEF Grass Project

NGO Council of Kenya
Environmental Health-Sericulture

Ol Jogi Ranch, Nanyuki, Kenya
MBBU

Taita Hills Biodiversity Project, Kenya
Environmental Health-Biodiversity

Tropical Soil Biology and Fertility Programme, Kenya
Environmental Health-Biodiversity

University of Nairobi, Kenya-[1]Department of Botany; [2]Department of Biochemistry
Capacity Building; Animal Health-Tsetse; Animal Health-Ticks; Human Health-Bioprospecting for Mosquito Repellent and Insecticidal Plants; Human Health-Bioprospecting for Useful Plants for Cultivation; Human Health-Capacity Building; EnvironmentaHealth-Biodiversity; Environmental Health-Sericulture; BCED; PEESD; [1]MBBU-Impact Assessment Studies (GE Crops); [2]MBBU-Population Genetics of Fruit Flies; [2]MBBU-Tsetse–Trypanosome Interactions; [2]MBBU-Mosquito–Plasmodium Interactions; [2]MBBU-Diversity of Trypanosomes in Small Ruminants and Pigs in a Sleeping Sickness Endemic Area of Western Kenya; MBBU-Capacity Building; ARQU; Biostatistics

Yoder Farm, Embu, Kenya
Plant Health-HC

LESOTHO

National University of Lesotho, Roma, Lesotho
Plant Health-Biological Control of Cereal Stemborers

LIBYA

Ministry of Agriculture and Livestock, Libya
Environmental Health-Sericulture

MADAGASCAR

Institut de Pasteur, Madagascar
Human Health-Vector Competence

Malagasy Research Centre (FOFIFA)
Plant Health-Desert Locust

Ministry of Agriculture Livestock and Fisheries, Madagascar
Environmental Health-Sericulture; Plant Health-Desert Locust

MALAWI

Ministry of Agriculture and Livestock, Malawi-[1]Chitidze Research Station; [1]Bvumbwe Agricultural Research Station
[1]Plant Health-Biological Control of Cereal Stemborers; [1]Plant Health-Habitat Management of Cereal Stemborers; Environmental Health-Sericulture

University of Malawi, Malawi
Capacity Building

MALAYSIA

Tropical Fruit Network (TFNet), Kuala Lumpur, Malaysia
Plant Health-The African Fruit Fly Initiative

MALI

Malaria Research and Training Centre, Bamako, Mali
Human Health-Bioprospecting for Useful Plants for Cultivation; Human Health-Behavioural Ecology (Malaria Mosquitoes); Human Health-Capacity Building

The Institute of Rural Economy, Bamako
Plant Health-GEF Grass Project

MEXICO
International Maize and Wheat Improvement Centre (CIMMYT), Mexico
ARQU; Plant Health- Sweet Potato IPM Project
El Colegio de la Frontera Sur (ECOSUR), Tapachula, Mexico
Plant Health-The African Fruit Fly Initiative

MOROCCO
Ministry of Agriculture and Livestock, Morocco
Environmental Health-Sericulture

MOZAMBIQUE
Eduardo Mondlane University, Mozambique
Plant Health-Biological Control of Cereal Stemborers
Food for Hungry International, Mozambique
Plant Health-Biological Control of Cereal Stemborers
Instituto Nacional de Investigaçao Veterinaria (INIVE), Mozambique
MBBU-Ticks and Tick-Borne Diseases Control; MBBU-Capacity Building; Animal Health-Ticks
Ministry of Agriculture and Rural Development, Maputo, Mozambique
Plant Health-Biological Control of Cereal Stemborers
Sasakawa Global 2000, Mozambique
Plant Health-Biological Control of Cereal Stemborers
World Vision, Mozambique
Plant Health-Biological Control of Cereal Stemborers

NAMIBIA
University of Namibia, Namibia
Animal Health-Ticks

NETHERLANDS, THE
Netherlands Institute of Cooperative Entrepreneurship, Nijenrode University, the Netherlands
Animal Health-Tsetse
University of Nijmegen, the Netherlands
Human Health-Vector Competence (Malaria Mosquitoes)
Wageningen Agricultural University, the Netherlands
Capacity Building; Plant Health-Biological Control of Cereal Stemborers; Human Health-Behavioural Ecology (Malaria Mosquitoes); Biosystematics

NIGERIA
Ahmadu Bello University, Nigeria
Capacity Building
Enugu State University, Nigeria
Capacity Building
International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria
Biosystematics; Insect Informatics; Biostatistics; Plant Health-Sweet Potato IPM Project
Ministry of Agriculture and Livestock, Nigeria
Environmental Health-Sericulture
Nnamdi Azikiwe University, Nigeria
Capacity Building
Ogun State University, Nigeria
Capacity Building
Rivers State University of S & T, Nigeria
Capacity Building
University of Agriculture, Makurdi, Nigeria
Capacity Building
University of Ibadan, Nigeria
Capacity Building; Biostatistics

PAPUA NEW GUINEA
Bishop Museum, Papua New Guinea
Environmental Health-Biodiversity
University of Papua New Guinea, Papua New Guinea
Environmental Health-Biodiversity

REUNION
CIRAD-FLHOR, Reunion
Plant Health-The African Fruit Fly Initiative
Station de Bassivi Martin, Reunion
Plant Health-The African Fruit Fly Initiative
Laboratorie d'Entomologie, Reunion
Plant Health-The African Fruit Fly Initiative

RWANDA
Universite Nationale du Rwanda, Rwanda
Capacity Building

SENEGAL
Direction de la Protection des Végétaux, Senegal
Plant Health-SF
Institut de Recherches pour le Développement (IRD), Dakar, Senegal
Environmental Health-Biodiversity
Foundation CERESLOCUSTOX, Senegal
Plant Health-SF
Ministry of Agriculture and Livestock, Senegal
Environmental Health-Sericulture
Senegalese Institute for Agricultural Research (ISRA), Senegal
MBBU-Tick Control Strategies; Animal Health-Ticks

SIERRA LEONE
Rice Research Station, Sierra Leone
Capacity Building

SOUTH AFRICA, REPUBLIC OF
Agricultural Research Council (ARC), Republic of South Africa-[1,3]Plant Protection Research Institute, Pretoria, Republic of South Africa; [1]Institute for Tropical and Subtropical Fruits, Nelspruit, Republic of South Africa; [2]Grain Crops Institute, Republic of South Africa
[1]Plant Health-The African Fruit Fly Initiative; [2]Plant Health-Biological Control of Cereal Stemborers; [2]Plant Health-Habitat Management of Cereal Stemborers; [2]MBBD-Impact Assessment Studies (GE Crops); [3]Plant Health-Red Spider Mites in Small-Holder Tomato Production; [3]Biosystematics; [3]Plant Health-Diamondback Moth Biocontrol Project; Environmental Health-Biodiversity
Centre for Advanced Study of African Society (CASAS), Cape Town, Republic of South Africa
Information and Publications-Production of Content for Rural Telecentres in Uganda, E. Africa (Pilot Study)

International Service for the Acquisition of AgriBiotechnology Application (ISAAA), Republic of South Africa
Plant Health-SF
Natal Museum, Pietermaritzburg, Republic of South Africa
Plant Health-The African Fruit Fly Initiative
Onderstepoort Veterinary Institute (OVI), Republic of South Africa
Animal Health-Ticks
South Africa Museum, Cape Town, Republic of South Africa
Biosystematics
University of Cape Town, Republic of South Africa
Plant Health-SF
University of Fort Hare, Republic of South Africa
Plant Health-Biological Control of Cereal Stemborers; Plant Health-Habitat Management of Cereal Stemborers
University of Natal, Republic of South Africa
Environmental Health-Capacity Building
University of Pretoria, Republic of South Africa
Capacity Building

SRI LANKA
International Water Management Institute (IWMI), Colombo-[1]CGIAR Systemwide Initiative on Malaria and Agriculture (SIMA), Sri Lanka
[1]Human Health-Malaria; Plant Health-African Bollworm Biocontrol

SUDAN
Agricultural Research Corporation, Sudan
Plant Health-The African Fruit Fly Initiative
Arab Organisation for Agricultural Development (AOAD), Khartoum, Sudan
PEESD; BCED; Plant Health-Desert Locust, Red Palm Weevil
Ministry of Agriculture and Livestock, Sudan
Environmental Health-Sericulture
Sudanese Department of Plant Protection, Sudan
Plant Health-SF
University of Gezira, Sudan
Capacity Building; Plant Health-The African Fruit Fly Initiative; Plant Health-Neem, Capacity Building
University of Khartoum, Sudan
Capacity Building

SWAZILAND
Ministry of Agriculture and Cooperatives-Malkerns Research Station, Malkerns, Swaziland
Plant Health-Biological Control of Cereal Stemborers
University of Swaziland, Kwaluseni, Swaziland
Plant Health-Biological Control of Cereal Stemborers

SWEDEN
Swedish Agricultural University, Sweden
Environmental Health-Biodiversity
Swedish University of Agricultural Sciences, Sweden
Capacity Building
University of Sweden, Sweden
Human Health-Vector Competence (Malaria Mosquitoes)

SWITZERLAND
Claro, Switzerland
Environmental Health-Sericulture
ETH (Swiss Federal Institute of Technology) Zürich, Switzerland
PEESD-Resource Management; BCED
University of Bern, Switzerland
Animal Health-Tsetse; MBBU-Tsetse–Trypanosome Interactions
World Health Organisation, Geneva, Switzerland
Human Health-Malaria; Animal Health-Tsetse and Trypanosomosis

TAIWAN
Asian Vegetable Research and Development Centre (AVRDC), Taiwan
Plant Health-Red Spider Mites in Smallholder Tomato Production; Plant Health-Diamondback Moth Biocontrol Project

TANZANIA
Ifakara Health Research and Development Centre, Tanzania
Human Health-Malaria
Ministry of Agriculture and Livestock, Tanzania-[1]IFAD Integrated Rural Development in Kagera Region; [1, 3]GTZ-IPM Project, Tanzania; [1,3, 5]Kibaha Biocontrol Station; [1,2]Plant Protection Division, Zanzibar; [2,3]Agricultural Research Institute, Mikocheni, Dar es Salaam; [3]Plant Protection Department; [4]Horticultural Research and Training Institute (HORTI), Arusha, Tanzania
[1]Plant Health-Biological Control of Cereal Stemborers; [1]Plant Health-Habitat Management Project; [2]Plant Health-The African Fruit Fly Initiative; [3]Plant Health-IPM for Diamondback Moth; [4]Plant Health-Red Spider Mites in Small-Holder Tomato Production; [5]Plant Health-African Bollworm Biocontrol; Environmental Health-Sericulture
National Institute for Medical Research, Tanzania
Human Health-Larval Ecology (Malaria Mosquitoes); Human Health-Behavioural Ecology (Malaria Mosquitoes)
Selian Agricultural Research Institute, Tanzania
Plant Health-HC
Sokoine University of Agriculture, Tanzania
Capacity Building
Tropical Pesticides Research Institute (TPRI), Arusha, Tanzania
Animal Health-Epidemiological Studies (Tsetse); PEESD-Animal Health & Animal Disease Vectors; Human Health-Bioprospecting for Useful Plants for Cultivation
Tropical Products Research Institute, Arusha, Tanzania
Plant Health-African Bollworm Biocontrol
University of Dar es Salaam, Tanzania
BCED; Environmental Health-Biodiversity; Human Health-Bioprospecting for Mosquito Repellent and Insecticidal Plants; Plant Health-Biological Control of Cereal Stemborers

TUNISIA
Ministry of Agriculture and Livestock, Tunisia
Environmental Health-Sericulture

UGANDA
International Institute of Tropical Agriculture (IITA), Uganda
Plant Health-HC; MBBU; Social Sciences; Plant Health-Banana Weevil
Livestock Health Research Institute (LIRI), Uganda
Animal Health-Ticks
Makerere University, Uganda
Capacity Building; BCED; Environmental Health-Biodiversity; Human Health-Bioprospecting for Mosquito Repellent and Insecticidal Plants; Human Health-Capacity Building; Plant Health-Biological Control of Cereal Stemborers
Ministry of Agriculture Livestock Development and Fisheries, Uganda
Environmental Health-Sericulture; Social Science
National Agricultural Research Organisation (NARO), Uganda-[1,3,4]Namulonge Agricultural and Animal Research Institute; [2]Kawanda Agricultural Research Institute, Kampala; [5]Uganda National Banana Research Programme; [6]National Biocontrol Programme, Namulonge
[1]Plant Health-Biological Control of Cereal Stemborers; [2]Plant Health-The African Fruit Fly Initiative; [3]Plant Health-Diamondback Moth Biocontrol Project; [4]Plant Health-Habitat Management of Cereal Stemborers and Striga; [5]Social Science; [6]Plant Health-African Bollworm Biocontrol; Entomopathology Unit
The Coordinating Office for the Control of Trypanosomiasis in Uganda (COCTU), Uganda
Animal Health-Epidemiological Studies (Tsetse)
Uganda Trypanosomiasis Research Council (ESTC), Uganda
Animal Health-Epidemiological Studies (Tsetse)
USAID-CRSP Project, Uganda
Plant Health-Biological Control of Cereal Stemborers

UNITED KINGDOM
Bionet International, UK
Environmental Health-Biodiversity
CAB International, London, UK
Biosystematics
Institute for Arable Crops Research (IACR)-Rothamsted, UK
BCED; Environmental Health-Sericulture; Plant Health-Habitat Management of Cereal Stemborers
International Bee Research Association (IBRA), UK
Environmental Health-Apiculture
IPM Europe, UK
Insect Informatics
John Innes Centre, UK
Plant Health-HC; Plant Health-SF
Natural History Museum, London, UK
Biosystematics; Environmental Health-Biodiversity; Plant Health-The African Fruit Fly Initiative
Natural Resources Institute (NRI), UK
Plant Health-African Bollworm Biocontrol
Royal Botanic Gardens, Edinburgh, UK
Environmental Health-Biodiversity
University of Aberdeen, Scotland, UK
MBBU-Expression of Mosquito Lectins
University of Bristol, UK
Capacity Building
University of Oxford
Biovillage Project-Disease Burden and Poverty Mapping

USA
California State University at Stanislaus
Biovillage Project-Ecosystem Management, Poverty Alleviation and Human Health Programmes
Carnegie Museum of Natural History, Pennsylvania, USA
Environmental Health-Biodiversity
Ecological Society of America, USA
Environmental Health-Biodiversity
Entomological Information Services, USA
Environmental Health-Biodiversity
Global Biodiversity Institute (GBDI), USA
Environmental Health-Biodiversity
Harvard University, USA
Human Health-Larval Ecology
International Organisation of Chemical Sciences in Development (IOCD), USA
BCED; Environmental Health-Biodiversity
Michigan State University, USA
Human Health-Behavioural Ecology
National Institutes of Health (USA)
Human Health-Botanicals for Malaria Control
Natural History Museum of Los Angeles County, USA
Environmental Health-Biodiversity
North Carolina State University, USA-[1]IPMNet/CICP; [1]NSF Centre for IPM
[1]Insect Informatics; MBBU-Impacts Assessment Studies (GE Crops)
Ohio State University, Columbus, USA
MBBU-Gene Flow and Transgenic Risk Assessment
San Diego Supercomputer Center, USA
Environmental Health-Biodiversity
Smithsonian Institution, USA
Environmental Health-Biodiversity
State University of New York (SUNY, Buffalo), USA
MBBU; Human Health-Population Genetics (Malaria Mosquitoes)
Texas A&M Research Foundation, USA
MBBU-Invasive Species
Texas A&M University, USA
Biosystematics; Plant Health-The African Fruit Fly Initiative; Plant Health-Biological Control of Cereal Stemborers
Tulane University, USA
Human Health-Ecology and Behaviour of Mosquitoes
United States Department of Agriculture (USDA), USA-[1]Pacific Basin Agricultural Research Center, Hilo, Hawaii; [1]Agricultural Research Center, Gainesville, Florida, USA
Plant Health-SF; [1]Plant Health-The African Fruit Fly Initiative
University Experimental Station, Kauai, Hawaii, USA
Plant Health-HC

University of California at Berkeley, USA
PEESD-Modelling Temporal Dynamics of Populations
University of California, Davis, USA
MBBU-Gene Flow and Transgenic Risk Assessment
University of Florida, USA
Plant Health-The African Fruit Fly Initiative
University of Hawaii, USA
Plant Health-The African Fruit Fly Initiative
University of Illinois, USA
Human Health-Larval Ecology (Malaria Mosquitoes)
University of Vermont, USA
Plant Health-Armyworm
University of Washington, Seattle, USA
Human Health-Larval Ecology (Malaria Mosquitoes)
US National Center for Ecological Synthesis and Analysis, USA
Environmental Health-Biodiversity
Virginia Polytechnic Institute and State University (Virginia Tech), USA
Insect Informatics; Plant Health-Locust Biocontrol Project; MBBU/Entomopathology Unit-Locust and Grasshopper Biocontrol
Xerces Society, USA
Environmental Health-Biodiversity
Yale University, USA
Animal Health-Tsetse

ZAMBIA
International Red Locust Control Organisation for Central and Southern Africa (IRLCO-CSA), Zambia
ARQU
Ministry of Agriculture and Livestock, Zambia-[1]Mt Makulu Research Station, Lusaka; [1]Mochipapa Research Station; [2]National Irrigation Research Station, Mazabuka
[1]Plant Health-Biological Control of Cereal Stemborers; [2]Plant Health-Red Spider Mites in Small-Holder Tomato Production; Environmental Health-Sericulture
University of Zambia, Zambia
Capacity Building

ZIMBABWE
Agricultural Training and Extension Service (Agritex), Harare, Zimbabwe
Plant Health-Red Spider Mites in Smallholder Tomato Production
Department of Research & Specialist Services, Harare, Zimbabwe
Plant Health-HC
Horticultural Research Centre, Marondera, Zimbabwe
Plant Health-Red Spider Mites in Small-Holder Tomato Production
Ministry of Agriculture and Livestock, Zimbabwe
Environmental Health-Sericulture; Plant Health-Red Spider Mites in SmallHolder Tomato Production
Ministry of Home Affairs, Zimbabwe-The National Museums and Monuments
Plant Health-Diamondback Moth Biocontrol Project
Plant Protection Research Institute, Harare, Zimbabwe
Capacity Building; Plant Health-Biological Control of Cereal Stemborers; Plant Health-Red Spider Mites in Small-Holder Tomato Production; Plant Health-Diamondback Moth Biocontrol Project
Regional Tsetse and Trypanosomiasis Control Programme (RTTCP), Zimbabwe
Animal Health-Epidemiological Studies (Tsetse)
University of Zimbabwe
Capacity Building;
Environmental Health-Sericulture

14. Audited Financial Statement–2001*

INCOME AND EXPENDITURE ACCOUNT

FOR THE YEAR ENDED 31 DECEMBER 2001

	2001 US $	2000 US $
INCOME		
Unrestricted Core Grants	**2,733,671**	2,941,401
Restricted Projects Grants	**6,662,372**	7,352,345
Miscellaneous Income	**438,214**	460,212
Currency Translation Gain	**72,632**	111,589
Total Income	**9,906,889**	10,865,547
EXPENDITURE		
Project and Support costs		
Centre Management	**645,445**	603,586
Research & NRES Strengthening	**7,394,847**	8,120,261
Administration & Finance	**680,938**	671,637
Other Support Units	**457,484**	643,879
Utilities	**467,517**	430,331
Extraordinary item	**37,822**	–
Overhead Recovery	**(551,440)**	(560,273)
Total Project & Support Expenses	**9,132,613**	9,909,421
Purchase of Fixed Assets		
Land and Buildings	**–**	7,667
Scientific Equipment	**30,758**	60,866
Office Equipment & Furniture	**69,554**	78,649
Vehicles	**142,074**	122,550
Total	**242,386**	269,732
Total Expenditure	**9,374,999**	10,179,153
SURPLUS FOR THE YEAR	**531,890**	686,394

BALANCE SHEET

AS AT 31 DECEMBER 2001

	2001 US $	2000 US $
FIXED ASSETS		
Net Book Value	**134,516**	225,368
ICIPE Riverside House	**215,368**	224,342
Total Fixed Assets	**349,884**	449,710
CURRENT ASSETS		
Consumable Stores	**71,259**	49,745
Grants Receivable	**770,555**	466,806
Debtors & Prepayments	**683,772**	697,548
Bank Balances and Cash	**1,026,637**	849,686
Total Current Assets	**2,552,223**	2,063,785
CURRENT LIABILITIES		
Bank Overdraft (Secured)	**–**	18,635
Creditors and Accruals	**1,984,171**	1,521,643
Unexpended Operating Grants	**2,109,844**	2,444,694
Total Current Liabilities	**4,094,015**	3,984,972
NET CURRENT LIABILITIES	**(1,541,792)**	(1,921,187)
TOTAL ASSETS LESS CURRENT LIABILITIES	**(1,191,908)**	(1,471,477)
FINANCED BY:		
Reserves	**(1,779,550)**	(2,128,184)
Provision for Staff Separation	**577,586**	636,591
Deferred financing	**10,056**	20,116
Total	**(1,191,908)**	(1,471,477)

The financial statements were approved by the Governing Council on 19th April 2002 and signed on its behalf by:

Dr Dunstan Spencer
Chair of the Governing Council

Dr Hans R Herren
Director General

**Audited Financial Statements for 2000 are published in* ICIPE Year 2000 Highlights and Research Outlook Update 2001–2003.

SCHEDULE OF GRANTS

	Balance brought forward 01.01.01	Receipts during the year	Adjust-ments	Receivable balance 31.12.01	Unused balance 31.12.01	Income for the year 2001
	US $	US $	US $	US $	US $	US $
UNRESTRICTED						
Danish International Development Agency		594,873				594,873
Swedish International Development Agency		760,136				760,136
Swiss Agency for Development and Cooperation		709,497				709,497
Government of Norway		438,972				438,972
Government of Finland		157,860				157,860
Government of France		39,975				39,975
Japanese Society for the Promotion of Science (JSPS)		18,000				18,000
Government of Kenya		12,338				12,338
Miscellaneous donor		2,020				2,020
TOTAL CORE UNRESTRICTED	0	2,733,671	0	0	0	2,733,671
RESTRICTED						
African Development Bank	16,926					16,926
Austrian Government	-259,672	395,103	0	63,877		199,308
Australian Centre for International Agricultural Research (ACIAR)	4,651				5,187	(536)
Danida International Development Agency		32,434			2,302	30,132
Directorate for NGO, International Education and Research programme (DPO) of Netherlands Government	275,926	1,725,206			460,109	1,541,023
DFID	14,221	20,880			24,141	10,960
DUPONT	17,268					17,268
European Union	29,431			8,553		37,984
Food and Agricultural Organisation (FAO)		35,115			12,782	22,333
Gatsby Charitable Foundation	175,505	131,996		50,104	35,428	322,178
Government of Finland	45,792					45,792
Government of Japan	208,459	230,544			233,957	205,046
German Academic Exchange Programme (DAAD)	76,540	161,057			73,847	163,750
German Technical Cooperation	230,556	1,054,927			633,246	652,238
Hebrew University of Jerusalem	14,591					14,591
International Fund for Agri-cultural Development (IFAD)	338,565	714,975	181,618			1,235,158
International Institute of Tropical Agriculture (IITA)	3,414	57,753		3,801		64,968
ICRISAT	7,642				1,913	5,729
International Development Research Centre	52,678	54,820		1,217		108,715
International Labour Organisation (ILO)	2,563				3,096	(533)

(Continued)

SCHEDULE OF GRANTS *(continued)*

	Balance brought forward 01.01.01	Receipts during the year	Adjust-ments	Receivable balance 31.12.01	Unused balance 31.12.01	Income for the year 2001
	US $	US $	US $	US $	US $	US $
International Potato Centre	7,289					7,289
ICIPE/IFAD/ILRI	23,570	34,000		69,551		127,121
IWMI	858	5,975			3,350	3,483
MacArthur Foundation	45,781	99,900			12,706	132,975
National Library of Medicine		50,000			45,890	4,110
NIH	-60,614	390,993		216,693		549,655
NSF		21,592		8,408		30,000
Sundry Grants	11,039	110,538		1,895	59,296	64,176
Spring Pharmacy	3,870					3,870
Swiss Government special grant	109,589			13,611		123,200
Third World Academy of Sciences	1,781	7,180			5,028	3,933
UNDP	24,025	8,669		1,316	1,135	32,875
UNEP	3,191	150,000			145,046	8,145
United States Agency for International Development (USAID)	108,413	175,949	11,150	33,540	74,082	254,970
University of Hawaii, Florida, USA	(4,800)	24,700			137	19,763
USDA		45,950		19,023		64,973
World Health Organisation (WHO)	63,061	85,904		82,447	3,278	228,134
World Laboratory		16,038		14,901		30,939
TOTAL RESTRICTED GRANTS	1,977,888	6,010,945	12,056	770,555	2,109,844	6,662,372
Total Grant Income	**1,977,888**	**8,744,616**	**12,056**	**770,555**	**2,109,844**	**9,396,043**

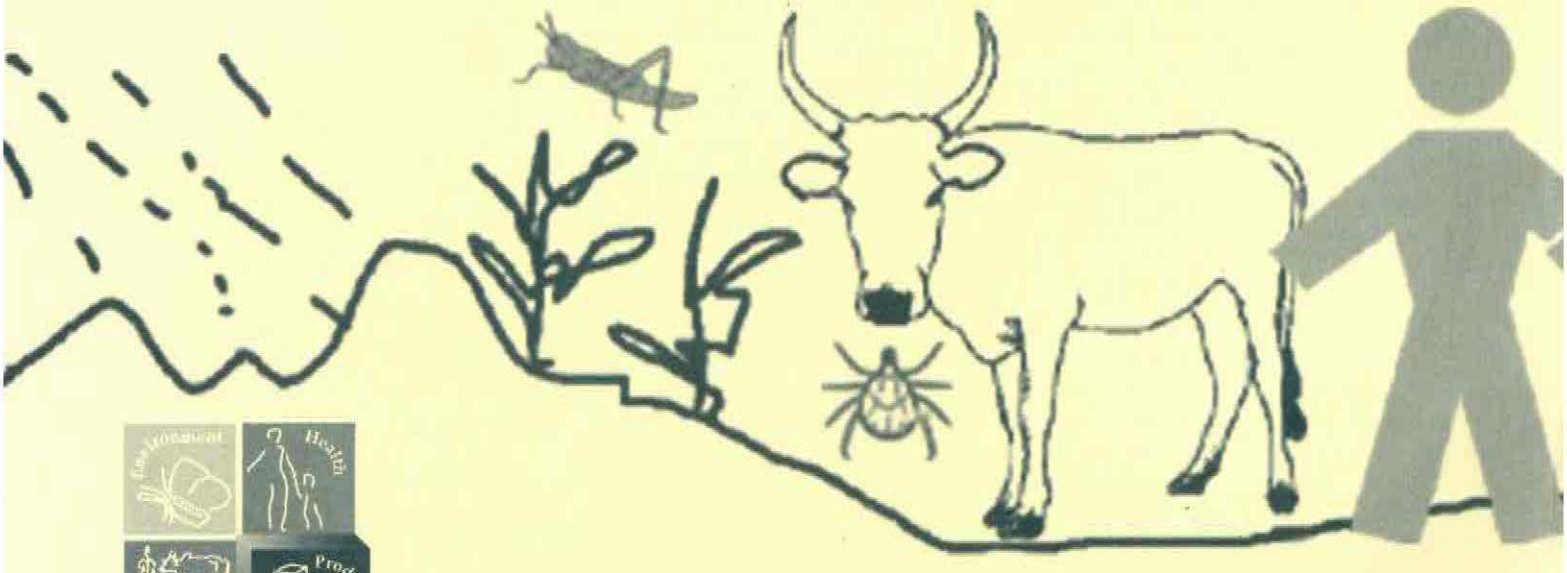
15. Acronyms and Abbreviations

AAIS	African Association of Insect Scientists
ACIAR	Australian Centre for International Agricultural Research
ADB	African Development Bank
AJOL	African Journals On-Line (INASP project)
ARPPIS	African Regional Postgraduate Programme in Insect Science (ICIPE)
AVRDC	Asian Vegetable Research and Development Centre (Taiwan, China)
AWF	African Wildlife Fund
BiONET	Capacity Building Network in Biotechnology and Biosafety for African Universities (ICIPE)
BMZ	Bundesministerium für Wirtschaftliche und Entwicklung Zusammenarbeit (Bonn, Federal Republic of Germany)
BtRDC	Bt Research and Development Centre (China)
CAAS	Chinese Academy of Agricultural Sciences
CABI	Commonwealth Agricultural Bureau International
CGIAR	Consultative Group on International Agricultural Research (Washington DC, USA)
CPI	Country Project Implementaters
DAAD	German Academic Exchange Service
DRIP	Dissertation Research Internship Programme (ICIPE)
DSO	Direct Support to Training Institutions in Developing Countries Programme (the Netherlands)
EARO	Ethiopian Agricultural Research Organisation (Ethiopia)
EU	European Union
ESRDF	Ethiopian Social Rehabilitation and Development Foundation
FAO	Food and Agriculture Organisation of the United Nations (Rome)
FITCA	Farming in Tsetse Controlled Areas
FOFIFA	Centre National de Recherche Appliquée au Développement Rural (Madagascar)
FPEAK	Fresh Produce Exporters Association of Kenya
FSA	Financial Services Association (Village Bank)
GTZ	Gesellschaft für Technische Zusammenarbeit (Germany)
IACR	Integrated Approach to Crop Research (Rothamsted, UK)
IARC	international agricultural research centres
ICAR	Indian Council of Agricultural Research
ICRAF	International Centre for Research in Agroforestry (Nairobi)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
IFAD	International Fund for Agricultural Development (Italy)
IFS	International Federation of Science (Sweden)

IGG-TF	Inter-Governmental Sub-Group on Tropical Fruits (FAO)
IIRR	International Institute for Rural Reconstruction (Kenya)
IITA	International Institute of Tropical Agriculture (Nigeria and Benin)
ILO	International Labour Organisation
ILRI	International Livestock Research Institute (Kenya and Ethiopia)
INASP	International Network for the Availability of Scientific Publications
INIVE	Instituto Nacional De Investigaçao Veterinaria (Mozambique)
IPM	integrated pest management
IPVM	integrated pest and vector management
IRD	Institut de Recherche pour le Développement (Montpellier, France)
IWMI	International Water Management Institute (Colombo)
JIRCAS	Japan International Research Centre for Agricultural Sciences
JKUAT	Jomo Kenyatta University of Agriculture and Technology (Juja, Kenya)
KARI	Kenya Agricultural Research Institute
KEMRI	Kenya Medical Research Institute
KETRI	Kenya Trypanosomiasis Research Institute
K-REP	Kenya Rural Enterprise Programme
KSTCIE	Kenya Standing Technical Committee on Imports and Exports
KWS	Kenya Wildlife Service
LUBILOSA-IITA/CABI	Lutte Biologique Contre les Locustes et Sauteriux (Benin)
MIM-TDR	Multilateral Initiative on Malaria/Tropical Diseases Research
NARES	National Agricultural Research and Extension Services
NARS	National Agricultural Research Services
NARO	National Agricultural Research Organisation (Uganda)
NGO	nongovernmental organisation
NIH	National Institutes of Health (USA)
NRI	Natural Resources Institute (UK)
NSF	National Science Foundation (USA)
OAU/IBAR	Organisation of African Unity/Inter-Africa Bureau for Animal Resources (Ethiopia)
PPRI	Plant Protection Research Institute (Pretoria, South Africa)
RELMA	Regional Land Management Unit/Sida
SIMA	CGIAR System-Wide Initiative on Malaria and Agriculture (spearheaded by IWMI)
TNAU	Tamil Nadu Agricultural University (Coimbatore, India)
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USAID	United States Agency for International Development
USDA/ARS	United States Department of Agriculture/Agricultural Research Station (Montpellier, France)
WHO/MIM	World Health Organisation/Multilateral Initiative on Malaria (USA)
WHO/AFRO	World Health Organisation/Africa Regional Office
WMO	World Meteorological Association

ICIPE's mandate is to help alleviate poverty, improve general food security and nutrition, and promote better human health for peoples of the tropics through research and development of environmentally-friendly management strategies for arthropod pests and disease vectors. ICIPE also promotes biodiversity conservation and sustainable use of natural resources through better management of beneficial insects and indigenous plant life. Capacity building, from postgraduate training to farmer level, is an integral aspect of all R&D activities.

The Centre, founded in Kenya in 1970, is an inter-governmental organisation staffed by international multi-disciplinary teams of natural and social scientists. ICIPE's approach to applying tropical insect science for development is summarised by the motto, "Effective prevention—smart cures".



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